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EVALUATION OF BONE THICKNESS OF HARD PALATE FOR ORTHODONTIC MINI IMPLANT PLACEMENT BY CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

The present study investigated total bone thickness using cone-beam computed tomography. In this descriptive analytical trial, 150 eligible CBCTs were selected from the males and females in two group 19-40 and 8-18 years old, and evaluated. Total bone thickness was measured on 8 coronal slices (with 3 mm distances from the incisive foramen) on the 0, 3 and 6 mm from the palate midline using On Demand 3D software. The data were analyzed by student t test between two age groups and genders while the analysis of variance test for the repeated measurements was used to analyze the data on anterior, middle and posterior areas of the palate. The mean total bone thickness was significantly higher in the anterior region compared to middle ($p<0.001$) and posterior areas ($p<0.001$) while the mean total bone thickness was higher in the middle area than posterior region ($p<0.02$). Total bone thickness was more in the males than female ($p<0.001$ for three areas). No significant differences were observed between two age groups regarding total bone thickness. Under the study limitation, palate anterior area showed the most total bone thickness and the bone thickness were higher in the males than females.

KEYWORDS: Hard Palate, Cone-Beam Computed Tomography, Orthodontic Appliance

Today, mini-implants are known as general type of Orthodontic Skeletal Anchorage; however, yet there is no certain view about factors effective in their success. New systematic view of study, couldn't find correlation between type of mini-implant, patients characteristics, placement site, surgery technique, implant survival factors, orthodontic, and the rate of mini-implant treatment success (1). Mini-implants break is their main limitation for use (2-4).

In general, important factors that should be considered during choosing the mini0implants location, includes anatomical factors such as intra-root space, sinus morphology and nerve location, soft-tissue anatomy, total thickness of bone, and thickness and density of cortical bone (5). Therefore, knowing the bone condition and soft tissue of considered area, allow the clinician to adopt more conscious decision for the location of mini-implants placement. Furthermore, the role of age and gender factors in success of mini-implants is still open for discussion.

Cone-beam computed tomography is relatively new technology, which uses a 2-dimensional sensor and a cone-beam instead of fan-shaped X-ray beam is used in conventional CT-scan (6). The lower patient dose in axial areas in comparison to conventional CT-scan method is main advantage of this technique. The use of computer tomography with cone- beam to measure the soft-tissue thickness has also been considered (7-10).

Current study was conducted for measurement and comparison of total thickness of bone in palate, using cone- beam computed tomography images.

MATERIALS AND METHODS

In this descriptive- analytical study, cone-beam computer tomography or CBCT was randomly selected among 150 patients referred to oral and maxillofacial radiology clinic. Teenagers' category of investigation included 24 boys and 20 girls in the age range of 8-18 years, and adults' category included 56 men and 50 women in the age range of 19-40 years.

CBCT image was provided by soredex-scanora3D-finland having flat panel COMOS sensor. Further, medium imaging field of 100 * 75 mm, high resolution (voxel size 0.25 mm), and maximum 90 kilo volt, 12.5 milliamp and 2.5 second time was used for most images.

Selected CBCT images were assessed in On Demand 3D software (version 1), and calculations of total bone thickness was performed using Software millimeter ruler (accuracy of hundredth of millimeter). All measurements were performed in coronal section with thickness of 0.5 millimeter. Initially, patient head position correction was performed in software, then designed

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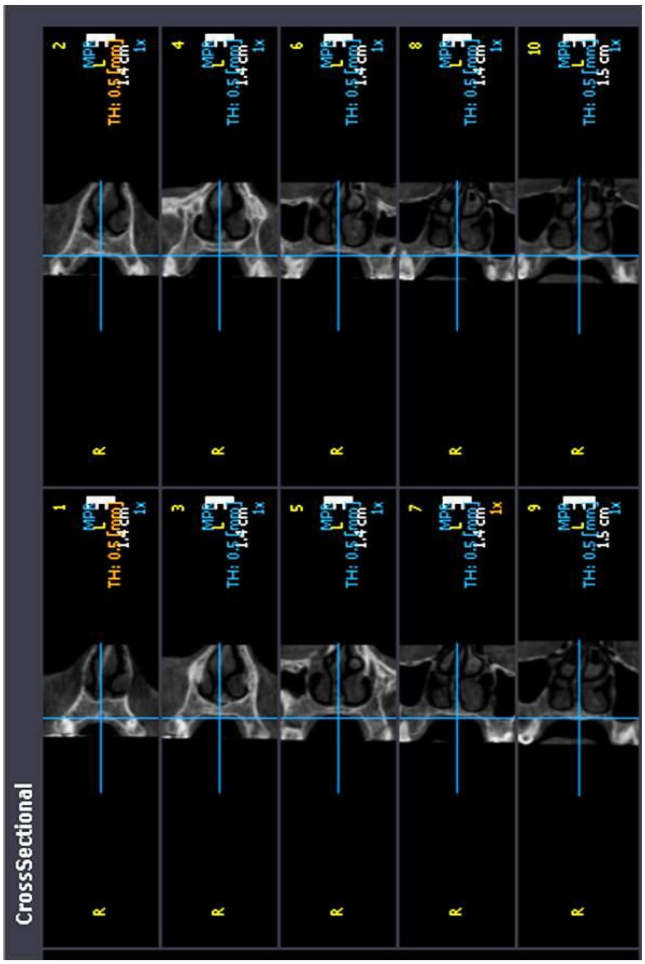
linear sagittal sections of the posterior border of the hole Thistle incisive canal to the posterior nasal (PNS), then 8 sections with intervals 3 mm were considered on the line. Totally, 8 coronal sections were obtained from images. The sections placed at 3, 6, 9, 12, 15, 18, 21, and 24 millimeter posterior than incisive canal (figure 1). At the next step, in each of the above sections, total thickness of bone respectively in the regions zero (midline), 3, and 6 millimeter of lateral to palate medial suture was measured by millimeter ruler of software (figure 2). In order to measure the intra-observer reliability, all samples were re-evaluated, after one month of the initial measurement. The agreement between two-measurements was obtained 97 %.

Variables difference in two age-group and two-genders was compared by t student test. Also, difference in the examined variable values of frontal, medial, and parietal of palate, was compared using ANOVA test with repetitive values.



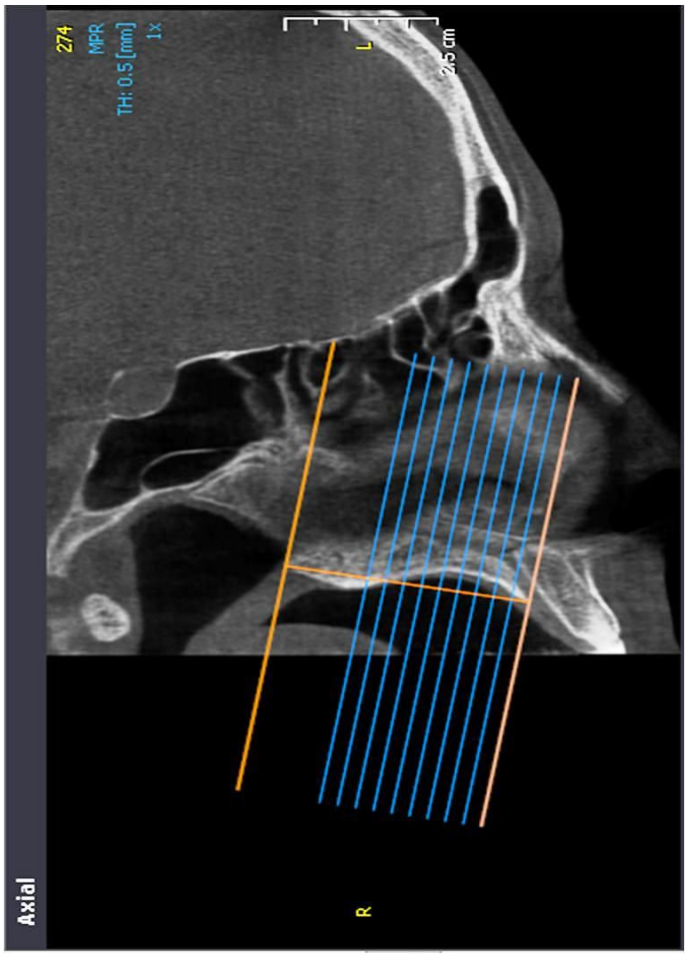


Figure 1(a): Representation of reference line design in the sagital section of posterior border of incisive canal to post nasal spine (PNS) and inserted sections with 3 mm distances on it

Figure 1(b): Ontained sections in distances 3 mm on square line

Figure 2: An example of measuring total bone thickness of a selected coronal section in one of patients

FINDINGS

Mean and standard deviation of bone total thickness, is presented in table 3-1, at zero, 3, and 6 millimeter distances of midline in different sections according to gender and age groups.

On the midline (table 1), total thickness of bone at section 2 (average 10.74 against 7.88 millimeter, p< 0.001), 3 (average 8.62 against 6.88 millimeter, p<0.001), 4 (average 7.18 against 5.82 millimeter, p<0.001), and 5 (average 6.34 against 5.59 millimeter, p<0.009) in men was significantly more than women, but in sections 6 (p=0.3), 7 (p=0.14), 8 (p=0.57), and 9 (p=0.57) there was no significant difference between two groups.

In the 3 millimeter distance of midline (table 2), total thickness of bone at sections 2 (average 9.63 against 6.38 millimeter, p<0.001), 3 (average 6.66 against 4.42 millimeter, p<0.001), 4 (average 4.63 against 3.31 millimeter, p<0.001), 5 (average 3.70 against 2.75 millimeter, p<0.001), 6 (average 3.33 against 2.63 millimeter, p<0.003), and 7 (average 3.23 against 2.76 millimeter, p<0.04) in men was significantly more than women. In sections 8 (p=0.16) and 9 (p=0.76) despite the higher total thickness of bone in men than women, the difference has not been statistically significant. At a distance of 6 mm of midline (table 3), total thickness of bone in all investigated sections, include sections 2 (average 10.13 against 7.64 millimeter, p<0.001), 3 (average 6.85 against 4.64 millimeter, p<0.001), 4 (average 4.34 against 2.87 millimeter, p<0.001) 5 (average 3.11 against 2.14 millimeter, p<0.001), 6 (average 2.44 against 1.85 millimeter, p<0.002), and 9 (average 1.65 against 1.31 millimeter, p<0.008) in men was significantly more than women.

Considering the total thickness of bone, there could not be seen any significant differences in two age groups 8-18 year and 19-40 year in sections 2 (p=0.34), 3 (p=0.71), 4 (p=0.68), 5 (p=0.25), 6 (p=0.28), 7 (p=0.62), 8 (p=0.13), 9 (p=0.13).

Also, at the distance 3 millimeter of midline (table 2), there could not be seen any significant difference in two age group 8-18 years and 19-40 years in sections 2 (p=0.4), 3 (p=0.64), 4 (p=0.4), 5 (p=0.41), 6 (p=0.43), 7 (p=0.88), 8 (p=0.89), and 9 (p=0.88), considering the total thickness of bone.

At distance of 6 millimeter from midline (table 3), there could not be seen any significant difference in two age groups 8-18 years and 19-40 years in sections 2 (p=0.25), 3 (p=0.46), 4 (p=0.27), 5 (p=0.11), 6 (p=0.19), 7 (p=0.27), 8 (p=0.69), and 9 (p=0.3), considering the total thickness of bone; but total thickness of bone in age group 8-18 years has been significantly more than age group 19-40 years (average 1.69 against 1.4 years, p<0.05).

Table 1: Average and standard deviation of total bone thickness on the midline in different coronal sections, according to gender and age

9 mean±sd	8 mean±sd	7 mean±sd	6 mean±sd	5 mean±sd	4 mean±sd	3 mean±sd	2* mean±sd	Number of age group section	Gender
7.17±0.67	6.08±2.39	6.38±1.44	6.71±1.66	6.54±1.46	7.32±2.81	8.64±4.5	10.49±4.32	8-18 years	Man
6.16±2.08	6.72±2.67	6.37±1.93	6.13±1.81	6.25±1.76	7.11±1.91	8.61±3.04	10.85±4.35	19-40 years	
6.48±1.81	6.53±2.59	6.38±1.79	6.31±1.78	6.34±1.68	7.18±2.2	8.62±3.51	10.74±4.32	Total	
6.82±1.52	5.86±2.01	6.17±1.53	5.57±2.01	5.9±1.52	5.87±1.99	6.49±1.47	6.98±2.78	8-18 years	Woman
6.61±2.57	6.49±2.02	5.85±1.89	5.49±1.83	5.46±1.96	5.81±2.03	7.04±2.11	8.24±3.78	19-40 years	
6.67±2.3	6.31±2.03	5.94±1.79	5.52±1.87	5.59±185	5.82±2.01	6.88±1.95	7.88±3.55	Total	
7.01±1.14	5.98±2.21	6.29±1.47	6.19±1.89	6.25±1.51	6.66±2.56	7.67±3.6	8.89±4.07	8-18 years	Total
6.38±2.33	6.62±2.38	6.13±1.92	5.83±1.84	5.88±1.89	6.49±2.07	7.87±2.74	9.62±4.28	19-40 years	
6.57±2.06	6.43±2.34	6.17±1.79	5.94±1.86	5.99±1.79	6.54±2.21	7.81±3.01	9.4±4.22	Total	

* Measurements are done from section 2, which is 3mm posterior the section 1

Table 2: Average and standard deviation of total bone thickness at distance 3 millimeter of midline at various coronal sections according to gender and age

9 mean±sd	8 mean±sd	7 mean±sd	6 mean±sd	5 mean±sd	4 mean±sd	3 mean±sd	2 mean±sd	Number of age group section	Gender
2.79±0.27	3.18±0.51	3.41±0.78	3.47±0.92	3.75±1.07	4.57±1.05	6.42±1.82	9.62±1.96	18-18 years	Man
2.77±1.5	3.03±1.	3.16±1.52	3.27±1.52	3.68±1.52	4.66±1.67	6.76±2.28	9.64±2.61	19-40 years	
2.77±1.25	3.07±1.41	3.23±1.34	3.33±1.36	3.70±1.39	4.63±1.51	6.66±2.15	9.63±2.42	Total	
2.64±0.85	2.56±0.67	2.6±0.64	2.77±0.79	3.01±0.91	3.73±1.1	4.94±1.29	6.96±1.59	18-18 years	Woman
2.74±1.36	2.83±1.55	2.82±1.68	2.58±1.62	2.64±1.6	3.14±1.51	4.21±1.53	6.14±2.21	19-40 years	
2.71±1.23	2.75±1.35	2.76±1.45	2.63±1.43	2.75±1.44	3.31±1.43	4.42±1.49	6.38±2.07	Total	
2.72±0.6	2.89±0.66	3.04±0.82	3.15±0.92	3.41±1.06	4.19±1.14	5.75±1.75	8.41±2.23	8-18 years	Total
2.76±1.43	2.93±1.59	3.01±1.59	2.94±1.59	3.19±1.64	3.94±1.76	5.56±2.34	7.99±2.98	19-40 years	
2.75±1.23	2.92±1.39	3.01±1.41	3.01±1.43	3.26±1.49	4.02±1.61	5.62±2.18	8.11±2.78	Total	

Table 3: Mean and standard deviation of total bone thickness at distance 6 millimeter of midline at various coronal sections according to gender and age groups

89 mean±sd	8 mean±sd	7 mean±sd	6 mean±sd	5 mean±sd	4 mean±sd	3 mean±sd	2 mean±sd	Number of age group section	Gender
1.87±0.25	2.05±0.28	2.39±0.61	2.63±0.59	3.29±0.65	4.29±1.12	6.63±1.52	10.06±1.56	18-18 years	Man
1.55±1.06	1.96±1.22	2.12±1.35	2.36±1.37	3.03±1.56	4.36±1.79	6.94±2.14	10.15±2.43	19-40 years	
1.65±0.89	1.99±1.03	2.2±1.18	2.44±1.19	3.11±1.35	4.34±1.61	6.85±1.97	10.13±2.19	Total	
1.46±0.67	1.51±0.51	1.78±0.72	2.06±1.01	2.55±1.09	3.45±1.46	5.29±1.65	8.48±1.91	8-18 years	Woman
1.25±0.51	1.48±1.02	1.62±1.21	1.76±1.35	1.98±1.5	2.64±1.67	4.37±1.83	7.29±2.45	19-40 years	
1.31±0.57	1.49±0.9	1.66±1.09	1.85±1.25	2.14±1.41	2.87±1.64	4.64±1.82	7.64±2.36	Total	
1.69±0.52	1.81±0.48	2.12±0.73	2.37±0.85	2.96±0.94	3.91±1.34	6.02±1.69	9.34±1.89	8-18 years	Total
1.4±0.85	1.74±1.15	1.88±1.31	2.08±1.38	2.53±1.62	3.55±1.93	5.73±2.37	8.81±2.82	19-40 years	
1.49±0.78	1.76±0.99	1.95±1.17	2.16±1.25	2.66±1.46	3.65±1.46	5.82±2.19	8.96±2.58	Total	

Total bone thickness was estimated 6.66 ± 2.09 in the anterior palate, in the medial zone was 3.83 ±1.37, and in the posterior zone was 3.71±1.29 millimeter, in CBCT images. Variance analysis test with repetitive values revealed a significant difference between anterior, medial, and posterior zone of samples considering total thickness of bone (p<0.001). Also, post hoc LSD test determined that average of total bone thickness at the frontal zone is significantly more than medial zone (p<0.001) and posterior zone (p<0.001) and average to total bone thickness at medial zone is significantly higher than posterior zone (p<0.02).

Average and standard deviation of total bone thickness according to anterior, medial, and posterior

zone is presented in two groups of age and gender in table 5.

According to independent T test results, values of total bone thickness at anterior zone of bone (p<0.001), total thickness of bone at medial zone (p<0.001) and total bone thickness in all zones, in men was significantly more than women. In the other cases, there was no significant difference between men and women, considering the total thickness of bone in the posterior zone (p= 0.18) between two genders.

Independent t-test revealed significant differences between two age groups regarding the total bone thickness in the anterior zone (p=0.71), total bone thickness in the medial zone (p=0.2), total bone thickness in the posterior zone (p=0.89) and also total bone thickness in all zones (p=0.52).

Table 5: Average and standard deviation of total bone thickness in anterior, medial, and posterior zones regarding age and gender groups

Total bone: all mean±sd	Total bone: posterior mean±sd	Total bone: medial mean±sd	Total bone: Anterior mean±sd	Variable: region of age group	Gender
5.29±1.07	3.93±0.66	4.39±0.92	7.56±1.95	8-18 years	Man
5.2±1.39	3.8±1.53	4.12±1.39	7.68±2.06	19-40 years	
5.23±1.3	3.84±1.33	4.2±1.27	7.64±2.02	Total	
4.31±0.88	3.49±0.63	3.64±0.98	5.79±1.35	8-18 years	Woman
4.11±1.4	3.58±1.43	3.32±1.49	5.43±1.64	19-40 years	
4.17±1.27	3.55±1.25	3.41±1.37	5.54±1.56	Total	
4.85±1.09	3.73±0.67	4.06±1.01	6.76±1.9	8-18 years	Total
4.69±1.49	3.69±1.48	3.74±1.49	6.62±2.18	19-40 years	
4.73±1.39	3.71±1.29	3.83±1.37	6.66±2.09	Total	

Total bone thickness (average and standard deviation) overall and on the midline was 6.87±1.69 millimeter, at distance of 3 meter was estimated 4.11 ± 1.47 millimeter and at a distance of 6 meter was estimated about 3.59±1.4 millimeter (with significant difference of P<0.001). in mutually comparison of distances from midline with LSD test, significant differences between distances zero and 3 millimeter to midline (p<0.001), zero and 6 millimeter distances of midline (p<0.001) and also distances of 3 and 6 millimeter to midline (p<0.001), regarding the total bone thickness values were recorded (table 6).

Total bone thickness on the midline (average 7.33 against 6.34 millimeter, p<0.001), 3 millimeter of midline (average 4.66 against 3.48 millimeter, p<0.001) and 6 millimeter of midline (average 4.13 against 2.97 millimeter, p<0.001), in men was significantly more than women (table 6).

Regarding the total bone thickness, there was no significant differences on midline (p=0.99), 3 millimeter of midline (p=0.65), and 6 millimeter of midline (p=0.29) among two age groups of 8-18 years and 19-40 years.

Table 6: Average and standard deviation of total bone thickness in all sections on distances zero, 3, and 6 millimeter of midline according to age and genders groups

Total bone: 6 millimeter	Total bone: 3 millimeter	Total bone: on the midline	Variable: region of age group	Gender
4.15±0.77	4.65±0.98	7.42±1.95	8-18 years	Man
4.11±1.39	4.66±1.5	7.29±1.64	19-40 years	
4.13±1.24	4.66±1.36	7.33±1.73	Total	
3.32±0.96	3.65±0.81	6.21±1.18	8-18 years	Woman
2.84±1.44	3.42±1.52	6.39±1.63	19-40 years	
2.97±1.33	3.48±1.35	6.34±1.51	Total	
3.78±0.95	4.19±1.03	6.87±1.74	8-18 years	Total
3.51±1.55	4.07±1.63	6.87±1.69	19-40 years	
3.59±1.4	4.11±1.47	6.87±1.69	Total	

DISCUSSION

According to the results of investigation, total bone thickness in the frontal zone was estimated 6.66±2.09 millimeter, in the medial zone was estimated 3.83±1.37 millimeter, and in the parietal zone was estimated 3.71±1.29 millimeter. However, total bone thickness on the midline was equal to 6.87 ± 1.69 millimeter, at distance 3 millimeter was equal to

4.11±1.47 millimeter and at distance 6 millimeter was equal to 3.59±1.4 millimeter.

Total bone thickness on the midline (average 7.33 against 6.34 millimeter), 3 millimeter of midline (average 4.66 against 3.48 millimeter), and 6 millimeter of midline (average 4.13 against 2.97 millimeter), in men was significantly more than women. However, regarding the total bone thickness values on the midline, 3 millimeter of midline, and 6 millimeter of midline, there was no significant differences among 8-18 years and 19-40 years age groups.

Regarding that enough bone thickness should be available for placement of temporary skeletal anchorage tools; evaluation of bone thickness is of great importance in the age and gender groups.

Gracco et al (2008), regarding the palatal bone thickness, didn't observe significant differences between adult and teenager people (11). In a recent study, younger groups were more than 10 years. Also, in the Ryu and coworkers investigation, individuals with complex dental system, compared with other age groups, had lower total bone thickness (12). The difference in the results of various investigations can be correlated to difference in applied methodologies.

In order to successfully application of anchorage tools in palate, clinicians should consider the mediolateral and anterior-posterior positions; because always a significant correlation exists between mediolateral positions and anterior-posterior, and age groups. Results of current study can be a guide for suitable placement of mini-implants. However, it might be necessary to conduct other clinical studies aimed at determination of correlation between rate of break and thickness of bone.

Minimum thickness of bone required for insertion of mini-implants is still open to discus, especially in relation to constancy of mini-implants and prevention of damage to other anatomic structures, the issue needs more evaluations.

Differences in the studies can also be correlated to individuals ethnic. Mineral density of the bone can also influence the anchorage systems, as it seems, density of considered zones of bones for systems should be measured before treatment.

Kuroda et al (2007) have concluded that proximity of temporary skeletal anchorage tools to root is a critical risk factor for their breakdown (13). Also, Poggio and colleagues (2006) suggested that subtracting 1mm of bone around skeletal anchorage tool is very important for its safety (14). According to results of Ryu et al (2012) investigation, bone thickness is suitable for safety and constancy of temporary skeletal anchorage tool (12).

Results of some studies about the study field, should cautiously interpreted, however using obtained results, it can achieve a template of bone thickness for insertion of mini-implants. If orthodontic mini-implants are placed in mid-palatal suture, inserting mini-implant stuck will increase in the same thicknesses of soft tissue (11, 15, 16). Due to differences in measuring areas, using various reference structures and also increasing palatal soft tissue thickness in the considered regions, it is possible with increasing the age differences exist between different studies results.

Different techniques are available to investigate the thickness of soft and hard tissue (17, 18). Ueno et al (2011), have revealed a high and direct relationship among spiral tomography results and direct calculations on mucosal tissues of mouth maxilla, and due to high radiation dose, didn't suggest using spiral tomography to measure mucosal thickness alone (10).

Nowadays, cone-beam computer tomography has vast applications in orthodontic treatments and its radiation doses are reduced for the short expose time. The main disadvantages of the technique include high noise of image and low resolution contrast due to emitted radiation (10). CBCT has been applied as superior technique to measure dentinogingival soft tissue (19, 20).

CONCLUSION

Regarding the values of bone total thickness, significant difference was recorded in the anterior, medial, and posteriors zones. Total bone thickness in men is more than women, but there couldn't be seen significant difference regarding total bone thickness in two age groups of adults and teenagers.

REFERENCES

Reynders R, Ronchi L, Bipat S. Mini-implants in orthodontics: a systematic review of the literature. Am J Orthod Dentofacial Orthop 2009;135:564.e1-564.e19.

Farnsworth D, Rossouw PE, Ceen RF, Buschang PH. Cortical bone thickness at common miniscrew implant placement sites. Am J Orthod Dentofacial Orthop 2011;139:495-503.

Motoyoshi M, Yoshida T, Ono A, Shimizu N. Effect of cortical bone thickness and implant placement torque on stability of orthodontic mini-implants. Int J Oral Maxillofac Implants 2007;22:779-784.

Chen YJ, Chang HH, Huang CY, Hung HC, Lai EH, Yao CC. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. Clin Oral Implants Res 2007;18:768-775.

Mohamad Salah Fayed M, Pazera P, Katsaros C. Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. Angle Orthod 2010;80:939-951.

Bianchi SD, Lojacono A. 2D and 3D images generated by cone beam computed tomography (CBCT) for dentomaxillofacial investigations. In: Lembe HU, Vannier MW, Inamuson K, Farman A (eds). CARS '98 Computer Assisted Radiology and Surgery. Amsterdam: Elsevier 1998:792–797.

Vu T, Bayome M, Kook Y-A, Han SH. Evaluation of the palatal soft tissue thickness by cone-beam computed tomography. Korean J Orthod 2012;42(6):291-296.

Barriviera M, Duarte WR, Januario AL, Faber J. Bezerra AC. A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography. J Clin Periodontol 2009;36:564-568.

Song J-E, Um Y-J, Kim C-S, Choi S-H, Cho K-S, Kim C-K, Chai J-K, Jung U-W. Thickness of posterior palatal masticatory mucosa: the use of computerized tomography. J Periodontol 2008;79:406-412.

Ueno D, Sato J, Igarashi C, Ikeda S, Morita M, Shimoda S, et al. Accuracy of oral mucosal thickness measurements using spiral computerized tomography. J Periodontol 2011;82:829-836.

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;134:361-369.

Ryu J-H, Park JH, Thi Thu TV, Bayome M, Ji Kim Y, Kook Y-A. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement. Am J Orthod Dentofacial Orthop 2012;142:207-212.

Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung HM, Takano-Yamamoto T. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007;131(Suppl):S68-73.

Poggio PM, Incorvati C, Velo S, Carano A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod 2006;76:191-197.

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:S74-S81.

Kim H-J, Yun H-S, Park H-D, Kim D-H, Park Y-C. Soft-tissue and cortical bone thickness at orthodontic implant sites. Am J Orthod Dentofacial Orthop 2006;130:177-182.

Januario AL, Barriviera M, Duarte WR. Soft tissue cone-beam computed tomography: a novel method for the measurement of gingival tissue and the dimensions of the dentogingival unit. J Esthet Restor Dent 2008;20:366-373.

Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong DJ, Wang HL. Tissue biotype and its relation to the underlying bone morphology. J Periodontol 2010;81: 569-574.

Kyung SH, Lim JK, Park YC. A study on the bone thickness of midpalatal suture area for miniscrew insertion. Korean J Orthod 2004;34:63-70.

Barriviera M, Duarte WR, Januario AL, Faber J. Bezerra AC. A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography. J Clin Periodontol 2009;36:564-568.