ORIGINAL ARTICLE

Relationship of bone and soft tissue thickness with age and gender for orthodontic mini-implant placement by CBCT

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Abstract:

Background and aim: The aim of the present study was to measure the thicknesses of bone and soft issues in the mid-palatal area at certain points for the placement of orthodontic mini-implants using CBCT and evaluate their relationships with age and gender

Materials and methods: A total of 161 subjects were evaluated in the present study, consisting of males (31.9%) with a mean age of 41.46±13.88 years and females (60.9%) with a mean age of 38.47±11.66 years. In all the samples 20 points were evaluated. First, the incisive foramen was located. Then para-coronal cross-sections were prepared at 4-, 8-, 16- and 24-mm distances from the posterior wall of the incisive foramen; in addition, on each cross-section, the mid-sagittal and para-sagittal areas were determined at 3- and 6-mm intervals bilaterally (5 points on the whole). The soft tissue and bone thickness were measured at these points.

Results: The soft tissue thicknesses were significantly different at all the 20 sample points between males and females ($P<0.05$). In other words, at all the points the soft tissue thicknesses were significantly greater in males compared to females. In some areas there was a positive relationship between age and soft tissue thickness ($P<0.01$), i.e. the soft tissue thickness increased with age. In addition, in the majority of points the overall bone thickness was significantly higher in males compared to that in females; however, in the majority of points, no positive relationship was found between age and bone thickness..

Conclusion: Age was not a determining factor for bone thickness, while where was a stronger relationship between soft tissue thickness and age. In addition, the most appropriate locations for the placement of orthodontic mini-implants were paramedian area at 3- and 6-mm distances from the suture, 4 mm posterior to the incisive foramen.

Keywords: Cone beam CT, Mini implant, Anchorage, Mid palatal

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INTRODUCTION

Provision of anchorage is one of the most challenging aspects of orthodontic treatment planning. Routine and conventional anchorage techniques are generally dependent on patient compliance and usually result in untoward reciprocal tooth movements. To overcome such a problem, 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; therefore, a large number of studies have been carried out to determine appropriate locations for and stability of mini-implants. It is necessary to have knowledge about the thickness of bone to select a proper length for mini-implants to avoid perforation of the nasal cavity. In addition, knowledge about bone thickness is useful for the determination of the length of mini-implants and the height of mini-implant neck.1-9

In recent years, CBCT technique has been used to place mini-implants accurately because the technique provides high-resolution images with less patient radiation or comparable to that of the CT technique.Due to lack of enough data in this respect, the aim of the present study was to evaluate the relationship between the soft tissue and bone thicknesses on one hand and age and gender on the other at mid-palatal area using the CBCT technique.10-13

MATERIAL AND METHODS

The present descriptive study was carried out on CBCT images of patients referring to the Department of Radiology, Tabriz Faculty of Dentistry, in 2013–2014. The inclusion criteria consisted of all the patients referring to the radiology department for any reason necessitating CBCT imaging, with favorable image quality. The exclusion criteria consisted of the following: malformations or syndromes, anomalies with potential effects on facial height, systemic diseases and use of specific medications, a history of trauma to and surgery of the study area, images in which the patient had placed his/her tongue on the palate because the real thickness of the soft tissue cannot be determined in such conditions, patients in the mixed dentition period and presence of impacted teeth in the palatal area.

The CBCT images of all the subjects were taken using a NewTom V&I CBCT unit with the following specifications: 15×15-cm field of view; 110 kVp, 1–20mA, scan time = 18 seconds and slice thickness: 0.3 mm. Then the images were reconstructed with NNT viewer software. Twenty points were evaluated in all the samples (Figure 1).

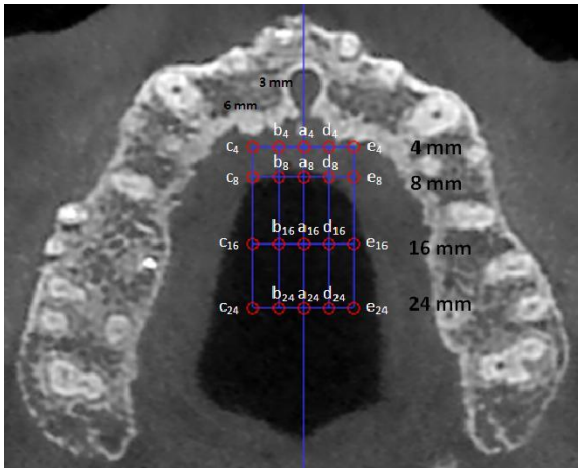

Figure 1. Reference points and lines for measuring bone and soft tissue thicknesses.

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 para-sagittal areas were determined bilaterally at 3- and 6-mm intervals (5 points on the whole) (Figure 2). At the pre-determined areas the thicknesses of soft tissue and bone were (Figure 3).

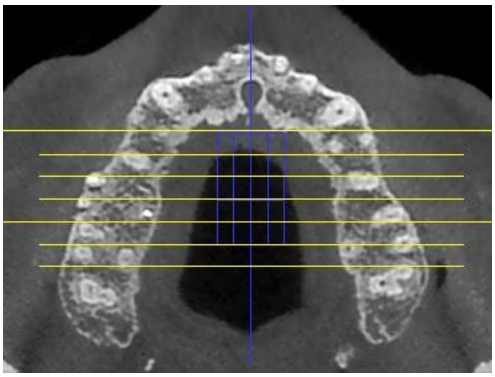

Figure 2. Reconstructed coronal cross-sections at 4-, 8-, 16- and 24-mm distances distal to the posterior wall of the incisive foramen.(from left to right)

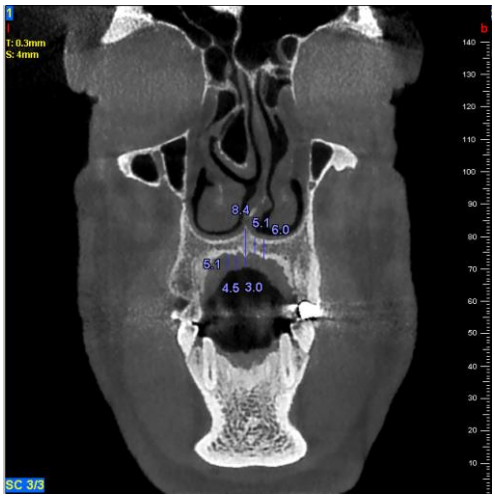

Figure 3. A sample of measurements on each cross-section**.**

All the measurements were made perpendicular to the tissue surface, in mm. The images were displayed on a 19-inch Philips LCD (liquid crystal display) monitor of a desktop computer, with a resolution of 1208 ×1024 and 32-bit and visualized by an observer twice with an interval of 2 weeks in a windowless dimly light room.

SPSS 17 was used for data analysis, using descriptive statistics, independent samples t-test to determine soft tissue and bone thicknesses in terms of age and correlation coefficient test to determine soft tissue thickness in terms of age. Statistical significance was defined at P<0.05.

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 and the relevant soft tissue 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

In the present study, 161 subjects were evaluated, including males (31.9%) with a mean age of 41.46±13.88 years and females (60.9%) with a mean age of 38.47±11.66 years. The results showed significant differences in all the 20 points evaluated between males and females (P<0.05). In other words, in all the points the thickness of soft tissue in males was higher than that in females. In addition, the overall thickness of soft tissue (a mean of all the 20 points) was 2.66 in males compared to 2.17 in females (P<0.01) (Table 1).

Table 1. Comparison of soft tissue thicknesses at the sample points in terms of gender

	Male	Female	T-test	
	Mean± SD	Mean± SD	t	P-value
a_4	2.54±0.97	2.18±0.78	2.63	0.01
a_8	2.25±0.86	1.77±0.67	4.06	<0.001
a_{16}	1.83±0.85	1.35±0.57	4.33	<0.001
a_{24}	1.62±0.81	1.29±0.55	3.06	<0.001
b_4	3.11±1.14	2.77±0.86	2.15	0.03
b_8	2.43±0.95	1.93±0.63	4.00	<0.001
b_{16}	1.9±0.81	1.39±0.50	4.90	<0.001
b_{24}	1.82±0.87	1.52±0.72	2.33	0.02
c_4	4.52 ±1.62	4±1.30	2.24	0.03
c_8	3.79±1.44	3.01±1.01	4.06	<0.001
c_{16}	2.64±1.19	1.97±0.76	4.39	<0.001
c_{24}	2.47±0.91	2.01±0.76	3.49	<0.001

d_4	2.98±0.99	2.67±0.88	2.08	0.04
d_8	2.45±0.89	1.94±0.66	4.23	<0.001
d_{16}	1.85±0.87	1.41±0.54	4.18	<0.001
d_{24}	1.85±0.85	1.53±0.66	2.65	0.01
e_4	4.3±1.32	3.83±1.25	2.24	0.03
e_8	3.74±1.44	3±1.09	3.71	<0.001
e_{16}	2.6±1.07	1.92±0.68	4.91	<0.001
e_{24}	2.45±0.87	2±0.74	3.48	<0.001
Soft tissue thickness	2.66±1.34	2.17±1.12	11.07	<0.001

Evaluation of the relationship between the soft tissue thickness and age at each point showed that there was a positive relationship between age and soft tissue thickness at all the points except for points c_8, d_8, e_4 and e_8 (P<0.01), i.e. the thickness of soft tissue increased with age. In addition, there was a positive relationship between the overall mean of soft tissue thickness and age (P<0.01) (Table 2).

Table 2. Evaluation of the relationship between soft tissue thickness and age at the samples points

	No.	Pearson's coefficient	P-value
a_4	161	0.23	<0.001
a_8	161	0.26	<0.001
a_{16}	161	0.23	<0.001
a_{24}	161	0.23	<0.001
b_4	161	0.20	0.01
b_8	161	0.24	<0.001
b_{16}	161	0.27	<0.001
b_{24}	161	0.28	<0.001
c_4	161	0.17	0.03
c_8	161	0.16	0.05
c_{16}	161	0.22	0.01
c_{24}	161	0.28	<0.001
d_4	161	0.18	0.02
d_8	161	0.14	0.08
d_{16}	161	0.24	<0.001
d_{24}	161	0.22	0.01
e_4	161	0.12	0.14
e_8	161	0.15	0.05
e_{16}	161	0.23	<0.001
e_{24}	161	0.17	0.03
Total	161*4*5	0.151	<0.001

There were significant differences in bone thickness between males and females at all the sample points except for points a_{16}, a_{24}, b_{24} and d_{24} (P<0.05), i.e. at all the sample points the bone thickness was significantly higher in males compared to females. In addition, the results showed that the overall bone thickness (a mean of 20 points) in males was 4.41 compared to 3.45 in females, which was statistically significant (P<0.01) (Table 3).

Table 3. Comparison of mean bone thickness at sample points in terms of gender

	Male Mean± SD	Female Mean± SD	T-test t	P-value
a_4	8.02±1.99	6.39±1.62	5.72	<0.001
a_8	6.3±1.73	5.28±1.37	4.15	<0.001
a_{16}	5.61±1.72	5.25±1.51	1.39	0.17
a_{24}	5.72±1.65	6.01±1.63	-1.09	0.28
b_4	6.61±2.32	4.77±1.73	5.75	<0.001
b_8	4.46±1.8	3.2±1.29	5.16	<0.001
b_{16}	2.97±1.33	2.5±1.2	2.34	0.02
b_{24}	2.72±1.22	2.62±1.2	0.65	0.52
c_4	6.65±2.51	4.87±1.99	4.98	<0.001
c_8	3.91±1.82	2.47±1.27	5.88	<0.001
c_{16}	2.02±1.16	1.42±0.77	3.93	<0.001
c_{24}	1.55±0.86	1.24±0.66	2.61	0.01
d_4	6.8±2.27	4.94±1.82	5.76	<0.001
d_8	4.48±1.84	3.05±1.34	5.70	<0.001
d_{16}	3±1.45	2.41±1.1	2.93	<0.001
d_{24}	2.71±1.43	2.49±1.15	1.06	0.29
e_4	7.08±2.54	4.96±2.06	5.82	<0.001
e_8	3.9±1.85	2.54±1.31	5.43	<0.001
e_{16}	2.07±1.21	1.43±0.80	4.04	<0.001
e_{24}	1.56±0.93	1.21±0.64	2.88	0.01
Bone thickness	4.41±2.65	3.45±2.14	11.25	<0.001

Evaluation of relationship between bone thickness and age at each sample point showed a positive relationship between age and bone thickness at points c_8 and b_8 (P<0.01), i.e. the overall bone thickness increased with age. However, no significant relationship was found in other points (Table 4).

Table 4. Evaluation of the relationship between bone thickness and age at sample points

	No.	Pearson's coefficient	P-value
a_4	161	0.05	0.54
a_8	161	0.11	0.17
a_{16}	161	-0.03	0.70
a_{24}	161	-0.03	0.69
b_4	161	0.10	0.20
b_8	161	0.18	0.02
b_{16}	161	0.10	0.19
b_{24}	161	0.04	0.65
c_4	161	0.07	0.41
c_8	161	0.16	0.04
c_{16}	161	0.12	0.13
c_{24}	161	0.10	0.23
d_4	161	0.06	0.46
d_8	161	0.11	0.16
d_{16}	161	0.05	0.54
d_{24}	161	0.05	0.50
e_4	161	0.05	0.56
e_8	161	0.06	0.45
e_{16}	161	0.04	0.61

e_{24}	161	0.04	0.63
Total	161*4*5	0.046	0.01

DISCUSSION

Based on the results of different studies, the palate is an appropriate area for the placement of orthodontic mini-implants, with advantages such as easy access, proper distance from the roots and no traumas to them and no inference with tooth movements.[14] In order to place stable mini-implants in this area, the amount of bone available in the area is very important; in this context, inadequate bone thickness in this area affects the stability of bone, increasing the risk of perforation into the incisive canal or the nasal cavity[1,5]. Recently, the accuracy of CBCT has been confirmed for measuring the amount of hard and soft tissues. CBCT is widely used in comprehensive orthodontic treatment due to its low radiation dose.[14]CBCT images were used in the present study to determine soft tissue and bone thicknesses, and their relationships with age and gender were evaluated.

Base on the results of the present study, there were significant differences between males and females in the thicknesses of soft tissues, consistent with the results of a study by Song et al [13]; however, Cha et al[15] and Wara-aswapati et al [16]did not report any differences between males and females, which might be attributed to different factors, including racial differences, differences in measurement points and locations and the measuring techniques used.

In the present study, there was a significant relationship between age and soft tissue thickness at all the sample points except for points c_8, d_8, e_4 and e_8, and the thickness of soft tissue increased with age. Wave used bone sounding technique and showed that older patients (38.7±6.8 years) had thicker palatal masticatory mucosa compared to younger subjects (16.8±2 years) ($P<0.01$). However, Song et al[13] reported thicker masticatory palatal mucosa only in the 41–60 age group compared to the younger and older age groups. Eger et al[17] reported no differences between the age groups. The differences might be attributed to differences in the measurement points and locations and increases in soft tissue thickness with age in the areas under study.

In male and female subjects, at cross-section 4mm from the incisive foramen decreased at the distance of 3 mm paramedially and then increased at the distance of 6 mm.But this thickness at cross-sections 8,16 and 24 mm decreased gradually from suture up to 3-6 mm distances paramedially.Based on the results of a study by Marquezan et al [14] the bone thickness decreased at cross-sections 4,16 and 24 mm from the suture up to a distance of 3 mm and then increased at a distance of 6 mm.

In addition in all the points ,the mean bone thickness decreased in a anteroposterior direction; however, in males only at a distance of 24 mm placed midpalatally,the mean thickness increased a little.In females at the distance of 24 mm placed midpalatally and 3 mm paramedially the mean thickness increased too.Based on the results of a study by Marquezan et al[14] the bone thickness decreased in an antero-posterior direction,which is consistent with the results of the present study.

In both males and females the soft tissue thickness in all points increased from medial to the lateral aspect.From an antero-posterior point of view,the soft tissue thickness decreased from the anterior to the posterior region.In females ,the soft tissue decreased in an antero-posterior direction too but at paramedian areas the mean thickness increased at 24 mm distance a little.Based on a study by Marquezan et al[14] soft tissue thickness decreased from the lateral to the medial aspect and from the anterior to the posterior region,consistent with the results of the present study.

Based on the results of the present study, at all the points bone thickness was significantly higher in men compared to that in women except for points a_{16}, a_{24}, b_{24} and d_{24}, consistent with the results of studies by Kang et al[6]. In addition, King et al[18]showed that in male adolescents the bone thickness was higher than that in female adolescents, which is contrary to the results of studies by Ryu et al[19]and Gracco et al[7], who reported no significant differences between the two groups. Such a discrepancy in the results might be attributed to differences in sample sizes and the methodologies. In the present study, no significant relationship was found between age and bone thickness except for points b_8 and c_8. Therefore, based on the results of the present study, age was not a factor effective in bone thickness, almost consistent with previous studies. King et al[18] reported that except for one point, there was no relationship between age and bone thickness in 8 other points.

Gracco et al[7], either, did not report any differences in bone thickness between adults and adolescents.

CONCLUSIONS

Age is not an effective factor in bone thickness; however, there is a strong relationship between age and soft tissue thickness. The most appropriate locations for the placement of orthodontic mini-implants are in the suture area and at the paramedian points at 3- and 6-mm distances from the suture, 4 mm posterior to the incisive foramen.

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