

Assessment of Supporting Bone Thicknesses Related to Lower Incisors/ACBCTStudy

Nibras Souliman Dayoub*¹, Rabab Al-Sabbagh**²

¹MSc, Department of Orthodontics, Faculty of Dentistry, Hama University, Syria

²Professor, Department of Orthodontics, Faculty of Dentistry, Hama University, Syria

Abstract: The aim of this study was to assess the supporting bone tissue thickness of 68 lower central incisors and to investigate the impact of gender on the alveolar bone thickness.

Thirty-four healthy patients with no previous orthodontic were evaluated by Cone Beam Computed Tomography. Sagittal sections views were analyzed to check the thickness of supporting bone on the cervical, middle of the root and apical for both surfaces buccal and lingual. The results showed that buccal apical and lingual apical regions had the greatest values of bone tissue thickness, and the lowest values were in lingual cervical, buccal cervical and buccal middle of the root for both lower central incisors. There was no significant effect of gender on supporting bone thickness.

Key words: lower incisors_ supporting bone thickness_ Cone Beam Computed Tomography.

Introduction:

Radiographic assessment of the mandible has become an important part of the orthodontic diagnosis and deciding the proper treatment plan. There are two main reasons, which show the importance of evaluating the mandible morphology.

First, the mandible is considered as the most effective factor on the facial appearance, and growth pattern that the mandible follows affects mainly on the facial growth in general.

Second, it seems that the morphology of the mandible, especially the symphysis, reflects the previous growth stages and the future tendency of growth.¹

The position of the lower incisors in relation with their supporting bone is an important factor in determining the orthodontic treatment plan, assessment of the progress of treatment, and identify the treatment requirements during the treatment stages.

Therefore, the initial position of the lower incisors can be considered as the main key to the right diagnosis and decide the proper treatment plan because of its dramatic impact on the aesthetics, stability of the treatment results, and the space available in the lower arch.

The importance of the supporting tissue:

Contemporary orthodontics is not about biomechanical procedures only, but it is also including periodontal physiology too, since the mutual influence between the periodontal and teeth exceeds the physiological aspects to the mechanism of the treatment.

The alveolar bone is that part of the jaws which contains the roots, the periodontal ligament and cortical plates, and it's the part of the jaws where all physiological procedures are done.²

The support of the alveolar bone is an important factor to save the periodontal tissue, and it is necessary to maintain the stability of the anterior teeth and so provide acceptable aesthetic appearance. The ideal stability is achieved when the roots of the anterior teeth are located in the center of the alveolar bone and in good balance with the buccal and lingual musculature.^{3,4}

The mechanism of tooth movement:

The orthodontic tooth movement is a process in which the application of the force causes absorption in the compressed side and formation of new bone in the tensile side.⁵

There is a key role says that bone traces tooth movement which suggests that whenever the orthodontic movement occurs, the bone remodels in accordance with this movement.³

The applied pressure within the periodontal ligament which is produced by the orthodontic forces is considered as the main factor for tooth movement, and the exceeding forces cause the so-called External Apical Root Resorption (EARR).⁶

So many researches mentioned the effect of the alveolar bone on the orthodontic treatment where the insufficient thickness of the alveolar bone prevents obtaining a successful treatment. Moreover, short distance between the apical root and anterior cortical plates is considered as a risk factor of occurring root absorption and losing of periodontal tissue.^{7,8}

Factors affecting the thickness of the alveolar bone:

Numerous studies showed the relationship between the morphology of the alveolar bone and the facial pattern.^{9,10}

The tissue response to the orthodontic forces allows the teeth to move through the bone. But in return, it may cause many complications such as gingival recession, fenestration, bone dehiscence and root resorption.

Nauert et al¹¹ suggested that the accurate analysis of bone condition before starting the treatment is a very important thing to identify the proper biomechanics that will be used during all stages of treatment especially for adult patients who are most likely to have a bone loss around the roots of anterior teeth.

We can say that radiographic is one of the most important tools used to study the craniofacial structures. The main goal of radiographic in orthodontics is to copy the real anatomical structures. Before providing the computed tomography to the dental use, studies made by traditional radiographs were considered as a limiting factor, because of dental and skeletal superimposition, and it was hard to evaluate the accurate position of the incisors' roots without falling into many mistakes, and thus the assessment of treatment results was limited.

With producing cone beam computed tomography (CBCT) as a diagnostic tool, it became possible to obtain high accurate and reliable radiographs for teeth and surrounding bone tissue with minimal radial exposure compared to the old generation of CT scanners.

Periago et al.¹² noted that Linear measurements taken from three-dimensional images are considered clinically accurate and realistic.

Many scientific papers have discussed the supporting bone of the lower incisors, but no one has taken the subject of untreated adult patients with normal growth in the vertical dimension and skeletal I in the sagittal direction with cone beam computed tomography CBCT.

Only Berlanga et al.¹³ published a paper about the morphology of the mandible among class I and III malocclusion patients with different facial vertical skeletal patterns with lateral cephalometric x-ray.

Therefore, this study of 34 adult patients who did not take any orthodontic treatment with class one skeletal and normal growth pattern in the vertical dimension is the first scientific paper of evaluating the supporting bone tissue thickness of the lower central incisors.

Materials and methods:

This study was made under the approval of orthodontic department, University of Hamah, Syria

The inclusion criteria were:

1. Class I skeletal.
2. Normal vertical growth.
3. Both males and females.
4. No previous orthodontic treatment.
5. Existing of Both left and right lower central incisors.
6. Absence of root resorption.
7. Absence of bone pathologies.
8. Age between 16-40 years.

And the exclusion criteria were:

1. Bone pathologies.
2. Previous orthodontic treatment.
3. Patients less than 16 or above 40 years.
4. Periodontal disease.
5. periodontal disease.
6. Root resorption.

Only 34 patients were selected to be part of the sample group with a mean age of 20.3 years, of which 20 were females (58.80%) and 14 were males (41.20), with a total of 68 lower central incisors.

Images were obtained from 3d*scanora tomography from soredexfinland. With 15 -mA, 85 kV, 12-sec exposure time. The resolution of images was 0.25 voxel and 13*140-cm field of view. The study was carried out directly on sagittal sections by using OnDemand 3D program.

In order to include the required skeletal pattern in both sagittal and vertical dimensions, we calculated the following measurements:

Skeletal I: ANB= 2-4 degree. ¹⁴

BJORK= 396 ± 6 degree ; Y axis= 66 ± 3 degree. ¹⁴

In order to measure bone thicknesses in the most central slice of the incisor in the sagittal section, the long axis of each of the lower incisors (the references plane) was determined by drawing a line extended from the middle of the Incisal edge to the end of the apical root passing the middle of root canal. fig.1

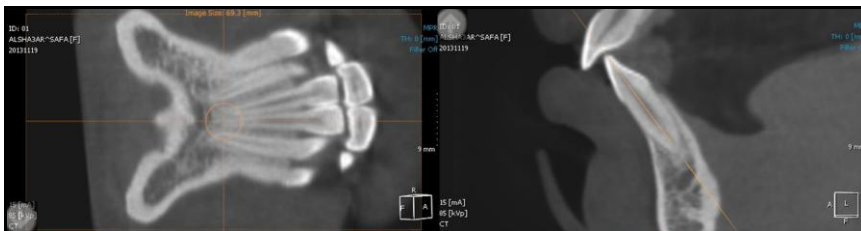


Fig.1: creating a sagittal section passing from the long axis of lower central incisor.

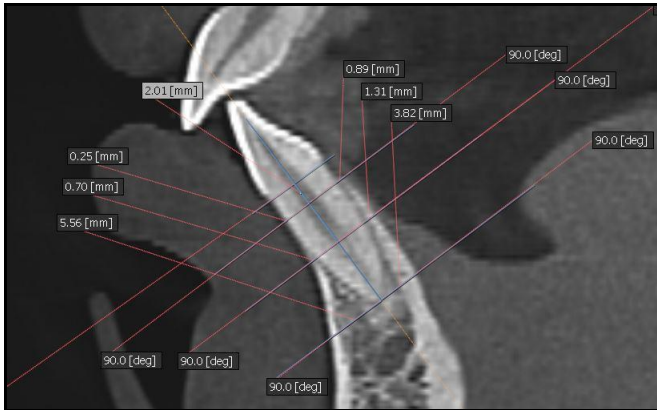


Fig.2: Buccal and lingual bone tissue amounts of the upper central incisor.

From this sagittal section, three points were defined on the reference plane in: cervical (after 2 mm from the cemento-enamel junction), middle of the root and apical regions.

Then three perpendiculars were created from the previous points on the reference plane in order to calculate the bone thickness through them. Fig.2

Statistical analysis:

Spss v.19 was used to analyze the data we obtained. And we used excel 2010 for the completion of the charts.

After 14 days, the examiner repeated the analysis of 17 randomly selected tomographs to estimate the error of measurement by using paired sample student t-test analysis.

To obtain the statistical analysis, first a descriptive analysis was performed to show the mean amount of the bone tissue in the six studied areas of the lower incisors.

To compare bone tissue amounts in the studied areas, we used one way ANOVA, followed by Bonferroni analysis.

To compare measurements of bone tissue amounts between genders, we used independent sample t-test.

Results:

According to paired t-test, analysis showed no statistical differences between the first and second measurements, which represented acceptable method.

Table (1): paired t-test analysis to verify the reliability of the method. L1: Lower right central incisor axis / L2: Lower left central incisor axis/ P value <0.05 indicates significant difference.

variable	Mean difference	t-test	P value	result
L1/buccal/cervical	0.058	1.370	0.189	No difference
L2/ buccal/cervical	0.699	1.1903	0.251	No difference
L1/ buccal/middle	0.022	1.268	0.222	No difference
L2/ buccal/middle	-0.011	-0.994	0.334	No difference
L1/ buccal/apical	-0.014	-1.409	0.177	No difference
L2/ buccal/apical	-0.003	-0.156	0.877	No difference
L1/lingual/cervical	0.008	0.316	0.755	No difference
L2/lingual/cervical	0.026	0.841	0.412	No difference
L1/lingual/middle	-0.021	-1.270	0.222	No difference
L2/lingual/middle	0.005	0.040	0.968	No difference
L1/lingual/apical	0.065-	0.668-	0.514	No difference
L2/lingual/apical	0.019	1.258	0.226	No difference

Table (2) shows the Means and Standard Deviation of bone tissue amounts in each region (cervical, middle and apical) on both surfaces buccal and lingual for both teeth L1,L2.

Table (2): means and standard deviation of bone tissue thickness in all regions studied

Variable (mm)	Tooth	mean	SD	minimum	maximum
buccal/cervical	L1	0.650	0.436	0.00	1.60
	L2	0.559	0.356	0.00	1.28
buccal/middle	L1	0.695	0.507	0.17	1.86
	L2	0.765	0.534	0.07	1.96
buccal/apical	L1	3.979	1.964	0.28	9.05
	L2	4.210	2.452	0.21	11.55
lingual/cervical	L1	0.665	0.465	0.00	1.87
	L2	0.614	0.388	0.00	1.20
lingual/middle	L1	1.213	0.723	0.20	3.12
	L2	1.192	0.735	0.20	3.12
lingual/apical	L1	4.035	1.132	1.10	6.80
	L2	3.724	3.724	1.10	6.81

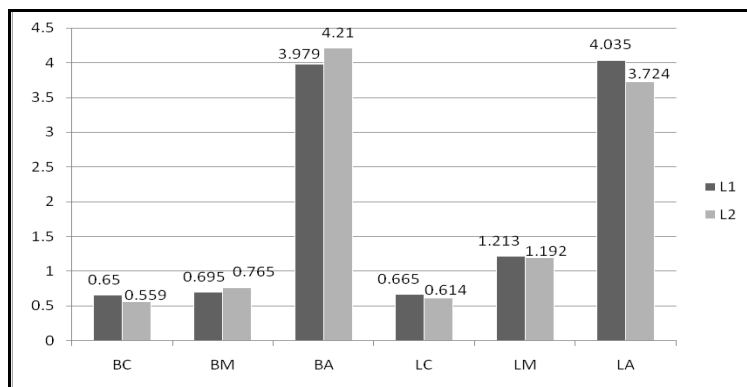


Chart (1): shows the means of bone tissue amounts in cervical, middle and apical regions on both surfaces lingual and buccal for both teeth L1,L2.

BC, buccal/cervical thickness; BM, Buccal/Middle; BA, Buccal/Apical thickness; LC, Lingual/Cervical thickness; LM, Lingual/ middle thickness; LA, Lingual/ apical thickness.

Table (3) shows the results of one way ANOVA for both teeth L1, L2. Significant differences were found between regions in both teeth.

Table (3): ANOVA analysis to compare between regions

tooth	F-test	P value	result
L1	105.279	0.000 *	Significant differences
L2	74.600	0.000 *	Significant differences

Results stated that there are no significant differences between the following variables: buccal/cervical and buccal/ middle, between buccal/cervical and lingual/ cervical, between buccal/middle and lingual/cervical and between buccal/apical and lingual/apical. All other variables were significant.

Table(4) shows the results of Bonferroni which compares bone tissue amounts between each two regions.

Table (4): Bonferroni analysis between each region for both teeth L1,L2 . P value > 0.05 indicates significant difference.

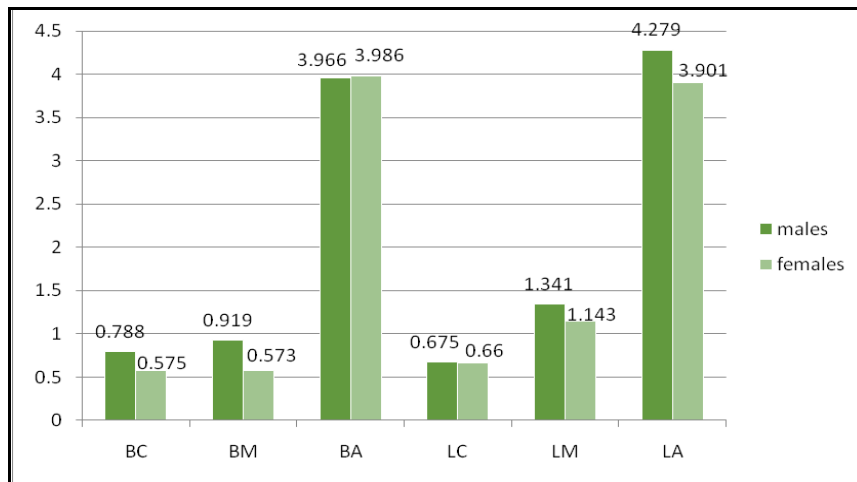
Variables (mm)		tooth	Mean difference	P value	result
buccal/cervical	buccal/middle	L1	-0.045	0.999	No Significant
		L2	-.207	0.919	No Significant
buccal/cervical	buccal /apical	L1	-3.329	0.000 *	Significant
		L2	-3.652	0.000 *	Significant
buccal/cervical	lingual/cervical	L1	-0.015	0.999	No Significant
		L2	-0.056	0.999	No Significant
buccal /cervical	lingual /middle	L1	-0.563	0.018 *	Significant
		L2	-0.634	0.001 *	Significant
buccal /cervical	lingual /apical	L1	-3.385	0.000 *	Significant
		L2	-3.166	0.000 *	Significant
buccal /middle	buccal/apical	L1	-3.284	0.000 *	Significant
		L2	-3.445	0.000 *	Significant
buccal /middle	lingual /cervical	L1	0.030	0.999	No Significant
		L2	0.151	0.999	No Significant
buccal /middle	lingual /middle	L1	-0.518	0.002 *	Significant
		L2	-0.427	0.007 *	Significant
buccal /middle	lingual /apical	L1	-3.340	0.000 *	Significant
		L2	-2.959	0.000 *	Significant
buccal /apical	lingual /cervical	L1	3.314	0.000 *	Significant
		L2	3.596	0.000 *	Significant
buccal /apical	lingual /middle	L1	2.766	0.000 *	Significant
		L2	3.018	0.000 *	Significant
buccal /apical	lingual /apical	L1	-0.056	0.999	No Significant
		L2	0.486	0.999	No Significant
lingual /cervical	lingual /middle	L1	-0.548	0.000 *	Significant
		L2	-0.578	0.000 *	Significant
lingual /cervical	lingual /apical	L1	-3.370	0.000 *	Significant
		L2	-3.110	0.000 *	Significant
lingual /middle	lingual /apical	L1	-2.822	0.000 *	Significant
		L2	-2.532	0.000 *	Significant

Tables(5) shows descriptive analysis of bone tissue amounts for males and females.

Table (5): means and standard deviation of bone tissue for males and females.

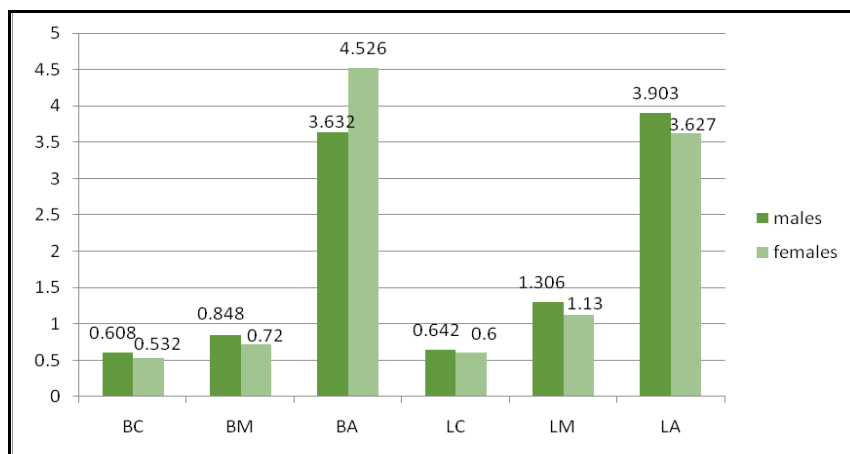
Variable (mm)		males		females	
		mean	SD	mean	SD
Buccal/cervical	L1	0.788	0.454	0.575	0.418
	L2	0.608	0.413	0.532	0.328
Buccal /middle	L1	0.919	0.588	0.573	0.421
	L2	0.848	0.539	0.720	0.539
Buccal /apical	L1	3.966	1.862	3.986	2.060
	L2	3.632	2.025	4.526	2.647
lingual/cervical	L1	0.675	0.349	0.660	0.526
	L2	0.642	0.364	0.600	0.408
lingual/middle	L1	1.341	0.769	1.143	0.705
	L2	1.306	0.889	1.130	0.650
lingual/apical	L1	4.279	1.006	3.901	1.196
	L2	3.903	1.776	3.627	1.222

Charts(2,3) shows means of bone tissue amounts considering gender for L1: lower right central incisor(chart.2) and L2:lower left central incisor (chart.3)



Chart(2): shows means of bone tissue amounts considering gender for tooth L1.

BC, buccal/cervical thickness; BM, Buccal/Middle; BA, Buccal/Apical thickness; LC, Lingual/Cervical thickness; LM, Lingual/ middle thickness; LA, Lingual/ apical thickness.



Chart(3): shows means of bone tissue amounts considering gender for tooth L2.

BC, buccal/cervical thickness; BM, Buccal/Middle; BA, Buccal/Apical thickness; LC, Lingual/Cervical thickness; LM, Lingual/ middle thickness; LA, Lingual/ apical thickness.

Table(6) shows student t-test considering all variables for both upper teeth comparing between genders. Results showed that there is no significant difference between males and females in the studied regions.

Table (6) shows student t-test considering all variables for both upper teeth comparing between genders. P value < 0.05 indicates significant difference.

Variable (mm)	tooth	Mean difference	t-test	P value	result
Buccal/cervical	L1	0.213	1.375	0.179	No significant diff.
	L2	0.076	0.586	0.562	No significant diff.
Buccal/middle	L1	0.346	1.990	0.055	No significant diff.
	L2	0.127	0.657	0.516	No significant diff.
Buccal/apical	L1	-0.020	-0.028	0.978	No significant diff.
	L2	-0.894	-1.017	0.317	No significant diff.
lingual/cervical	L1	0.016	0.091	0.928	No significant diff.
	L2	0.042	0.298	0.768	No significant diff.

lingual/middle	L1	0.198	0.756	0.455	No significant diff.
	L2	0.176	0.661	0.513	No significant diff.
lingual/apical	L1	0.378	0.928	0.360	No significant diff.
	L2	0.277	0.536	0.595	No significant diff.

Discussion:

Regarding to bone tissue amounts, statistical results showed that the buccal apical and lingual apical had the greatest values of supporting bone among all other regions. On the other hand, the buccal cervical, buccalmiddle of the root and lingual cervical had the lowest values of bone thickness among the other regions for both teeth L1,L2. fig.3

It seems that the greatest amounts of supporting bone are located in the apical region of the root for both lower central incisors and this is considered as a good indicator of supporting in this region, while the regions which have the least thickness were located in the cervical region especially on the buccal side for both lower incisors and we can say that this might be an index for complications resulting from orthodontics treatment in case we didn't consider these indications.

It is worth to mention here that Enhos et al.¹⁵ found that bone dehiscence and fenestration have been seen in all three vertical skeletal patterns, but most in patients with normal and long vertical growth.

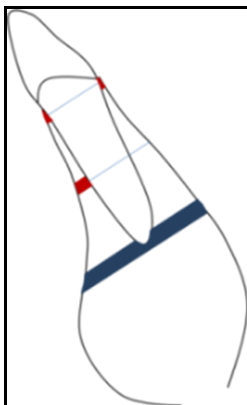


Fig.3 ■ regions with most thickness of bone tissue. ■ regions with least thickness of bone tissue.

In clinical projection of these results, it seems that moving the roots of both lower central incisors will be relatively in safe range in the apical region because of the sufficient bone tissue amounts existing in this area, whereas there is a high risk in the cervical region especially on the buccal side which indicates the possibility of the occurrence of bone dehiscence or fenestration in case we apply an exceeding labial inclination of lower central incisors during orthodontic treatment.

In the light of these results, we recommend to avoid buccal inclination of lower central incisors in patients with class I skeletal with normal vertical growth pattern to avoid the occurrence of bone dehiscence or fenestration.

Dealing with this issue by moving the roots of incisors by torque movements (center of rotation is located in the Incisal edge) which affect the roots with maintaining the initial position of the crowns could be much safer than moving the crowns by uncontrolled inclination (center of rotation is located in unknown area between the center of resistance and the root apical). fig.4

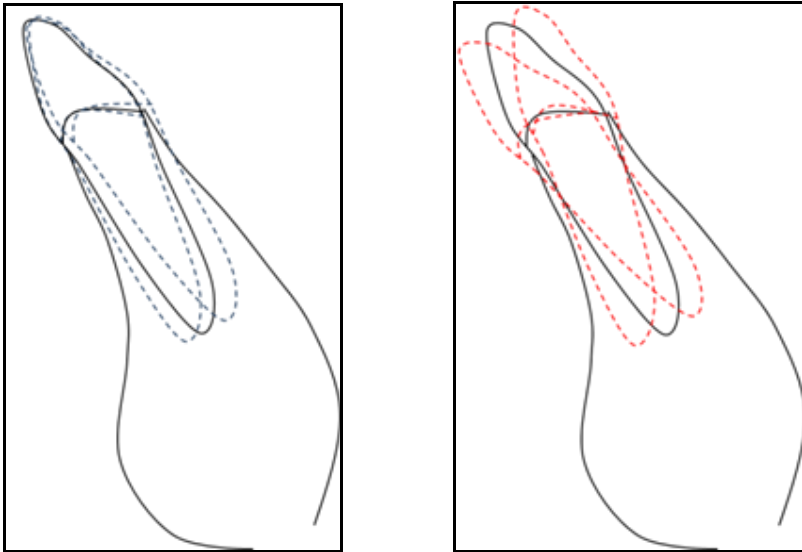


Fig.4: The difference between torque movement and uncontrolled inclination in affecting the position of the root and crown. ■Torque movement. ■ Uncontrolled inclination.

These findings are consistent with those of Nahas et al.^[16] who documented that the greatest amounts of bone tissue were located in the apical region of the upper central incisors.

This study also showed that there are no significant differences in bone thickness between males and females. These findings are in agree with Yu et al.^[17] and Gracia et al.^[9] who found no differences in bone thickness between males and females. Also, we disagree with Uysal.^[18] and Dempsey et al.^[19] who documented that males have greater dimensions in bone tissue than females in lower central incisors.

Despite the fact that males have greater biting forces than females (190 newton for males and 50 newton for females) as Osborne & ma^[20] mentioned, but maybe the large density of the mandible bone is the reason that there is no significant differences between males and females in bone thickness.

These results support the suggestion says that the individual anatomical differences should be taken into account when assessing the iatrogenic effects which are expected to occur.

It's very important before starting the orthodontic treatment to pay attention to the anatomical borders for each patient individually with accurate assessment of the initial morphology of the alveolar bone and roots position in order to identify the proper biomechanical technique and the allowed tooth movement during all treatment stages.

In addition to the foregoing, it can be considered that moving the lower central incisors in the buccal direction is a risk factor for occurring injuries in periodontal such as bone dehiscence and fenestration due to the lack of bone tissue thickness in the buccal cervical and buccal middle of the root comparing with the other regions surrounding the incisors' root.

And also it's recommended that patients who are seeking for an orthodontic treatment with periodontal disease to be radiographed by CBCT to insure obtaining more accurate diagnostic information.

Conclusion:

The greatest value of bone thickness was in the apical region for both upper and central incisors.

The lowest value of bone thickness was in the cervical region especially the buccal surface.

There was no significant effect of gender on the thickness of both upper and lower central incisors.

References:

1. Ricketts CM. Cephalometric Synthesis. Am J OrthodDentofacialOrthop. 1960;46:647–673.

2. Bohm B, Hirschfelder U (2000). Localization Of Lower Right Molars In A Panoramic Radiograph, Lateral Cephalogram And Dental CT. *J OrofacOrthop*, 61(4): 237–245.
3. Bollen AM, Cunha-Cruz J, Bakko DW, Huang GJ, Hujoel PP. The Effects Of Orthodontic Therapy On Periodontal Health: A Systematic Review Of Controlled Evidence. *J Am Dent Assoc*. 2008;139:413–422.
4. Sarikaya S, Haydar B, Ciger S, Ariyurek M. Changes In Alveolar Bone Thickness Due To Retraction Of Anterior Teeth. *Am J OrthodDentofacialOrthop*. 2002;122:15–26.
5. Angelis V. Observations On The Response Of Alveolar Bone To Orthodontic Force. *Am J Ortho*. 1970; 85:284_294
6. Apajalahti S, Peltola JS. Apical Root Resorption After Orthodontic Treatment—A Retrospective Study. *Eur J Orthod*.2007;29:408–412.
7. Horiuchi A, Hotokezaka H, Kobayashi K. Correlation Between Cortical Plate Proximity And Apical Root Resorption. *Am J OrthodDentofacialOrthop*. 1998;114:311–318.
8. Handelman CS. The Anterior Alveolus: Its Importance In Limiting Orthodontic Treatment And Its Influence On The Occurrence Of Iatrogenic Sequelae. *Angle Orthod*. 1996;66:95–109.
9. GARCIA, R.M.; CLARO, C.A.A.; CHAGAS, R.V.; ALMEIDA, G. Espessura Do Processo Alveolar Da Região Anterior Da Maxila E MandíbulaEmPacientes Com DiscrepânciaÓsseaÂntero-Posterior. *Rev Dent Press OrtodontOrtop Facial*. 2005; 10(5): 137-48.
10. Gracco A, Lombardo L, Mancouso G, Gravina V, Sicilian G. Upper Incisors Position And Bony Support In Untreated Patients As Seen On Cbct.*AngleOrthod*. 2010;79:692–702
11. NAUERT, K.; BERG, R. Evaluation Of Labio-Lingual Bony Support Of Lower Incisors In Orthodontically Untreated Adults With The Help Of Computed Tomography. *J OrofacOrthop*. 1999, 60(5): 321-34.
12. Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear Accuracy And Reliability Of Cone Beam CT Derived 3-Dimensional Images Constructed Using An Orthodontic Volumetric Rendering Program. *Angle Orthod*. 2008;78:387–395. Doi: 10.2319/122106-52.1.
13. Berlanga N, Perez J, Mir C, Puigdollers A. Lower incisor dentoalveolar compensation and symphysis dimensions among Class I and III malocclusion patients with different facial vertical skeletal patterns. *Angle Orthod*. 2013;83:948–955.
14. JACOBSON, A., JACOBSON, R., 2006-Radiographic Cephalometry From Basics To 3d Imaging. Second Edition.
15. Enhos S, Uysal T, Yagci A, Veli İ, Ucar F I, Ozer T 2012 Dehiscence And Fenestration In Patients With Different Vertical Growth Patterns Assessed With Cone-Beam Computed Tomography. *The Angle Orthodontist* 82: 868–874
16. Naha S-Scocate A, Brandao A, Patel M, Ximenez M, Chilvaque I, Valle-Corotti K. Bone Tissue Amount Related To Incisors Inclination.2014 .*Angle Orthod*. 0000;00:000–000
17. Yu Q, Pan XG, Ji GP, Shen G. The Association Between Lower Incisal Inclination And Morphology Of The Supporting Alveolar Bone—A Cone-Beam CT Study. *Int J Oral Sci*. 2009; 4:217–223.
18. UYSAL T, YAGCI A, OZER T, VELI L, OZTURK A. Mandibular anterior bony support and incisors crowding: is there a relationship. *Am J OrthodDentofacial Orthop*.2012; 142:645-53
19. Dempsey PJ, Townsend GC, Martin NG, Neale MC. Genetic Covariance Structure Of Incisor Crown Size In Twins. *J Dent Res* 1995;74:1389-98.
20. Osborne JW, Mao J. A Thin Bite Force Transducer With Threedimensional Capabilities. *Arch Oral Biol* 1993;38:139-44.
