Research Article

Alveolar bone changes around upper incisors in Class I non extraction patient after orthodontic treatment using cone beam computed tomography

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ABSTRACT

Introduction: The position and movement of incisors play important role in orthodontics. Efficient tooth movement and stable position cannot be ensured without adequate alveolar bone support. The bone loss estimated by traditional radiograph is always less than real bone loss so CBCT is currently best to evaluate bone changes. The purpose of this study was to use CBCT to evaluate and compare changes in alveolar bone thickness and Vertical alveolar bone height around maxillary anterior teeth of Class I malocclusion patient after orthodontic treatment.

Materials and Method: Forty patients with Class I occlusion between ages of 12 to 18 years were selected. The cone beam computed tomography (CBCT) and lateral cephalograms were taken before treatment (T0) and after treatment (T1). The lateral cephalograms were used to assess the change in tooth inclination whereas CBCT was used to assess the alveolar bone change. All the data were statistically analyzed using paired sample t-test and independent sample test.

Result: Significant changes in alveolar bone thickness and vertical bone height were found on the palatal surface of the anterior teeth compared to that of labial surface with significant change in tooth inclination.

Conclusion: Based on the results, we can conclude that the palatal alveolar bone loss and vertical bone loss was greater than that of the labial alveolar bone.

KEYWORDS: Alveolar bone loss, Cone Beam Computed Tomography (CBCT), Vertical bone loss

INTRODUCTION

The purpose of orthodontic therapy is to establish a good occlusion, an efficient masticatory apparatus, enhancement of the periodontal health, stable treatment results and to improve dental and facial esthetics.[1,2] Response of alveolar bone to orthodontic treatment depends on various factors such as force levels, the type and extent of tooth movement, and oral hygiene maintained by the patient.[1]

The upper incisor is one of the fundamental parameter for orthodontic treatment. The upper incisor is esthetically important as it defines the position of upper lip which is a relevant factor for a pleasant smile.[3]

During orthodontic treatment, torque control of anterior is very important as it correlates with the inclination of the associate alveolar bone.[4,5,6] Excessive movement may lead to resorption of cortical bone and root exposure. There is controversy whether remodeling capacity of alveolar bone can compensate for the bone loss in every case. Studies have shown that excessive movement of tooth can lead to irreversible distraction of alveolar bone leaving tooth with less bone support.[4]

Optimal stability can be obtained when tooth roots are positioned in the medullary portion of the bone and when there is a good musculature balance.[4] However, efficient orthodontic tooth movement and stable tooth position cannot be acquired without adequate alveolar bone support.[7] Most studies have focused on orthodontically induced root resorption but the factors that cause root resorption can negatively affect the alveolar bone.[8]

Studies have shown increase in distance between Cemento-Enamel Junction (CEJ) and alveolar marginal bone after orthodontic treatment.[9] However, oral condition of the patient before and during the treatment, and oral hygiene maintained by patient during the treatment also plays an important role.

The bone loss estimated by traditional radiograph is always less than the real bone loss and about 80% of bone defect is unidentifiable on traditional radiograph than that on the CT.[5,9] Cone Beam Computed Tomography (CBCT) is currently the best tool to acquire accurate radiographic image allowing quantitative evaluation of bone changes in three dimensions (3D) with minimal distortion and low radiation and without superimposition of structures.[5,10]

Thus the purpose of this study was to use CBCT to evaluate and compare changes in alveolar bone thickness and vertical alveolar bone loss around maxillary anterior teeth of Class I malocclusion patient after orthodontic treatment.

MATERIALS AND METHOD

PATIENT SELECTION

For this study forty patient with Class I malocclusion of age ranging from 12 to 18 years was selected from different clinics during September 2018 to December 2019. The maxillary anterior four teeth (central incisors, lateral incisors) were included in the study.

Inclusion criteria for the study

1. Class I molar relationship
2. Anterior crowding less than 5mm
3. Overjet less than 5mm
4. Non-Extraction

Exclusion criteria for the study

1. Missing or decayed anterior teeth
2. Prosthetic crowns
3. Noticeable periodontal disease
4. Craniofacial malformations
5. Evidence of previous trauma
6. Anterior spacing more than 1mm

For maintenance of oral hygiene, patients were asked to use chlorhexidine mouthwash daily before bed. Oral prophylaxis was done on every 3 month and gingival index was measured on every visit.

IMAGE PROCESSING

The lateral cephalograms and CBCT were used for the analysis. The CBCT and lateral cephalograms were taken before the start of the treatment (T0) and at the end of the treatment (T1). The lateral cephalograms were used to assess the changes in tooth inclination before and after treatment whereas CBCT was used to access the alveolar bone change.

MEASUREMENTS

The Frankfort Horizontal plane and the long axis of the tooth were used as reference line in the lateral cephalograms for the determination of tooth inclination.

The cementoenamel junction, apex of the tooth and the long axis of the tooth were used as reference points and the line for determination of alveolar bone changes in CBCT. The alveolar crest (AC) was described as the most coronal level of the alveolar bone.[7] The distance between the cementoenamel junction (CEJ) and alveolar crest (AC) represented the amount of vertical bone loss. The distance was measured at the labial and the palatal surfaces of the four anterior teeth, perpendicular to CEJ. The alveolar bone thickness was measured in terms of area.

The area to be measured was determined on pretreatment CBCT which involved the length from CEJ to 2mm above the apex of the tooth. The same measurement was used for the post treatment of the tooth. The apex cannot be considered as reference point while comparing between before and after treatment, as many studies have found some degree of root resorption after orthodontic treatment. The root resorption can be detected during early stages of orthodontic treatment with no relationship between age and gender.[11,12]

The Image J software version 2 was used to calculate the alveolar bone thickness.

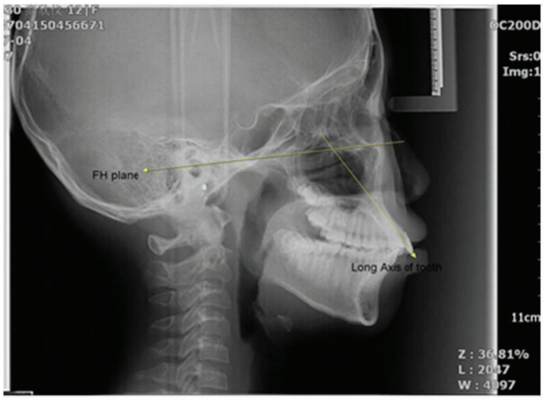

Image 1: Determination of tooth inclination on lateral cephalogram

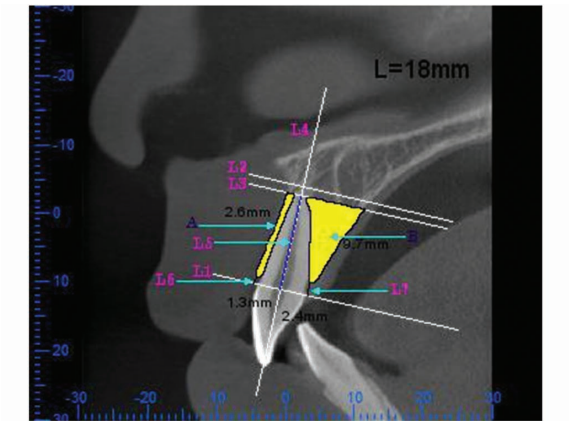

Image 2: Illustration of reference lines and measurement used in the study

Reference line and measurement	Definition
L1	Line along the CEJ of the tooth
L2	Line perpendicular to the long axis of tooth at the apex of tooth
L3	Line perpendicular to the long axis of tooth 2mm above the apex of the tooth
L4	Long axis of the tooth
L5	Length of the root 2mm above the apex
L6	Vertical bone loss on labial side of the tooth
L7	Vertical bone loss on palatal side of the tooth
A	Labial alveolar bone area
B	Palatal alveolar bone area

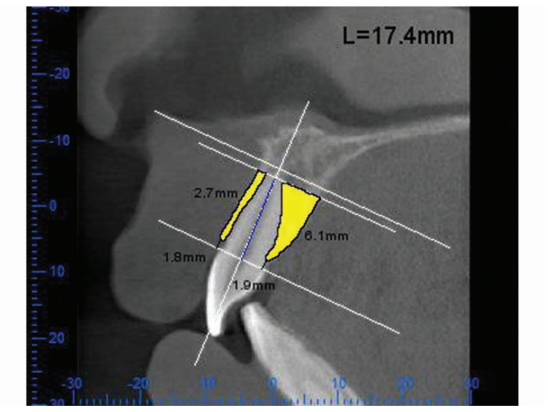

Image 3: Measurement of alveolar bone thickness and vertical bone loss before treatment

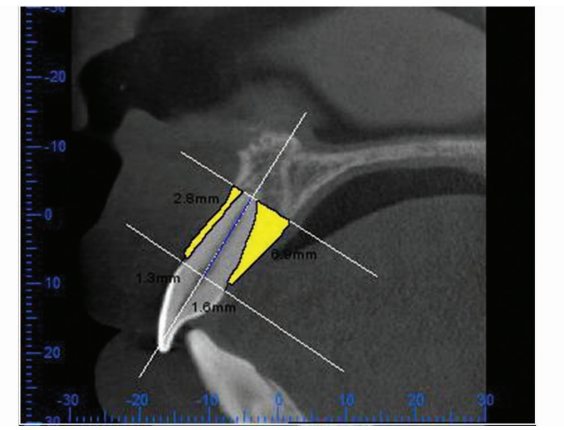

Image 4: Measurement of alveolar bone thickness and vertical bone loss after treatment

STATISTICAL ANALYSIS

Our study is Cohort (cohort is a type of longitudinal study) type, sampling is Non Probability sampling method.

Sample size determination formula: N=z2pq/d2
where z = level of confidence
p = expected proportion of sample
q = 100-p
d = margin of error

The means and standard deviation of all the measurements were calculated. All the data were statistically analyzed using paired sample t-tests and independent sample tests. The significance level was set at 0.05. Statistical Package for Social Sciences (SPSS version 17.00, Chicago, Inc.) software was used for the statistical analysis.

RESULTS:

The distance between CEJ and the alveolar crest (measured in mm)

The study showed significant vertical bone loss except for left central incisor and buccal side of left lateral incisor. However, palatal bone loss is more significant than that of the labial side.

The alveolar bone thickness (measured in mm²)
Significant change in alveolar bone thickness was found on the palatal surface of the anterior teeth compared to that of labial surface, more in the lateral incisor than central incisor.

The tooth inclination
There was significant change in tooth inclination after orthodontic treatment.

TABLE1. ALVEOLAR BONE LOSS OF INCISORS

TOOTH	Pre Mean	Post Mean	Mean difference	Standard Deviation	p-value
Right central incisor labial	2.55	2.33	0.225	0.839	0.098
Right central incisor palatal	6.94	5.38	1.565	1.087	0.000
Left central incisor labial	2.19	2.51	-0.320	0.917	0.033
Left central incisor palatal	6.89	4.93	1.965	1.423	0.000
Right lateral incisor labial	2.29	2.16	0.130	0.777	0.297
Right lateral incisor palatal	5.74	4.10	1.645	1.300	0.000
Left lateral incisor labial	1.94	1.97	-0.030	0.349	0.590
Left lateral incisor palatal	5.76	4.22	1.540	1.423	0.000

TABLE2. VERTICAL BONE LOSS OF INCISORS

TOOTH	Pre Mean	Post Mean	Mean difference	Standard Deviation	p-value
Right central incisor labial bone loss	1.14	1.79	-0.655	0.637	0.000
Right central incisor palatal bone loss	1.27	1.65	-0.380	0.584	0.000
Left central incisor labial bone loss	1.44	1.35	0.090	0.633	0.375
Left central incisor palatal bone loss	1.39	1.51	-0.120	0.529	0.160
Right lateral incisor labial bone loss	1.67	2.11	-0.445	0.994	0.007
Right lateral incisor palatal bone loss	1.41	2.17	-0.760	1.528	0.003
Left lateral incisor labial bone loss	2.17	2.32	-0.150	0.677	0.169
Left lateral incisor palatal bone loss	1.48	1.86	-0.375	0.942	0.016

TABLE3. TOOTH INCLINATION

TOOTH	Pre Mean	Post Mean	Mean difference	Standard Deviation	p-value
Inclination	109.20	113.15	-3.950	6.392	0.000

DISCUSSION

Successful Orthodontic treatment can be achieved by moving the teeth into the planned position; efficient tooth movement and stable position cannot be ensured without adequate alveolar bone support.[7] It is a known fact that during orthodontic tooth movement the bone around the alveolar socket remodels but it is not clear whether the tooth movement to bone modeling ratio is 1:1 in all orthodontic tooth movements.[4,13,14]

The orthodontic tooth movement is limited by the cortical walls of the alveolar bone and defined as "orthodontic walls" by Handelman.[4] The tooth can be moved labially or palatally only to this limit. Therefore the goal of this study was to evaluate the changes in labial and palatal alveolar bone of maxillary incisors after orthodontic treatment. The results showed after orthodontic movement of anterior tooth reduced the thickness of palatal alveolar bone. However, more alveolar bone loss in seen lateral incisor than that of central incisor.

Bimsetein et al suggested that the amount of anterior labial cortical bone increased during orthodontic treatment involving retraction of protruded teeth. However, some studies claim the apposition process is much slower than resorption process and some apposition or plastic deformation also takes place on the compression side.[4] This is in contrast to the study which shows that there was significant bone loss in labial cortical bone after treatment than that of palatal cortical bone. According to Melsen, most of the resorption occurs on the compression side than that on the tension side. But this does not hold true to orthodontic biomechanics which says that mechanical compression will stimulate bone formation and tension side will stimulate bone resorption.[2] This controversy is explained by Epker and Frost according to whom the circumferential shape of alveolar bone changes when periodontal ligaments (PDL) are stretched and hence will decrease the radius of the alveolar bone (bending the bone on tension side) leading to new bone formation.

Among the four incisors; lateral incisors showed more reduction in the alveolar bone although same force was being used. This might be explained by the fact that the periodontal ligament of central incisors are much thicker than that of lateral incisors, thus more concentrated pressure will be applied on the alveolar bone of the lateral incisors causing greater reduction in the thickness of the alveolar bone.[13,15]

Duterloo observed shortening of marginal aspect of the palatal cortex after orthodontic treatment but did not find any repair or modeling even after several years of treatment. However, Ten Hoeve and Mulie examined patients several years after orthodontic treatment and found well defined dense cortical plate in association with relapse of torque of anterior teeth. So, during movement of anterior teeth, torque control as well as the stability of the result is very important.[5]

The study showed significant changes in tooth inclination after orthodontic treatment. Vardimon et al disclosed that retraction with torque was never a pure translation but rather a combined movement with some tipping. Various other authors have also demonstrated more alveolar bone loss at the marginal and mid root region as compared to that of apical region since retraction force were mostly controlled tipping and concentrated on alveolar crest leading to more pressure on that region.[4] So it might be possible that alveolar bone change is directly related to the degree of tooth inclination

The AC height can be measured by a linear or a relative method. Linear method, where height is determined in relation to CEJ, is more reliable as relative method determines AC height in relation to root or tooth length.[1] There is statistically significant difference in CEJ-AC distance when comparing orthodontically treated and untreated group.[1] But, Bondemark used bitewing radiographs to demonstrate no statistically significant difference in CEJ-AC distance between orthodontically treated and untreated group.[8]

Earlier studies have considered CEJ-AC distance of 2mm or less as normal.[7] Considering this vertical bone loss was not severe (within 2mm range), however, more vertical bone loss was found on the palatal side than that of labial. Previous studies have revealed that excessive labial or palatal movement can lead to irreversible bone loss.[10] Thus, more attention should be paid when large amount of retraction of anterior teeth is planned.

According to Aass and Gjermo, most of the alveolar bone changes, characterized by transitional occurrence of bone modeling process, take place during or immediately after the orthodontic treatment; so long term evaluation of alveolar bone is recommended after orthodontic treatment. There may be loss of marginal bone height immediately after orthodontic treatment, as movement of anterior segment causes modeling of

the alveolar bone.[8]

A study conducted by Garib et al concluded that alveolar bone morphology is a limiting factor for orthodontic treatment and should be considered individually for different patient.[10]

CONCLUSION

Based on the results, we can conclude that the palatal alveolar bone loss and vertical bone loss was greater than that of the labial alveolar bone. More attention should be paid when substantial movement of anterior teeth is planned. Moreover long term evaluation of alveolar bone is required.

RECOMMENDATION

The sample size of the study was relatively small. The study had been made immediately after orthodontic treatment. Long term evaluation of the alveolar bone after orthodontic treatment is necessary for confirmation of resorption pattern.

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REFERENCES

1. Janson, G., et al., Comparative radiographic evaluation of the alveolar bone crest afterorthodontic treatment. Am J Orthod Dentofacial Orthop, 2003.124(2): p. 157-64.
2. Chang, H.W., et al., Effects of orthodontic tooth movement on alveolar bone density. Clin Oral Investig, 2012. 16(3): p. 679-88.
3. Gracco, A., et al., Upper incisor position and bony support in untreated patients as seenon CBCT. Angle Orthod, 2009.79(4): p. 692-702.
4. Sarikaya, S., et al., Changes in alveolar bone thickness due to retraction of anterior teeth.Am J Orthod Dentofacial Orthop, 2002. 122(1): p. 15-26.
5. Nahm, K.Y., et al., Alveolar bone loss around incisors in Class I bidentoalveolarprotrusion patients: a retrospective three-dimensional cone beam CT study. Dentomaxillofac Radiol, 2012. 41(6): p. 481-8.
6. Yu, Q., et al., The association between lower incisal inclination and morphology of thesupporting alveolar bone--a cone-beam CT study. Int J Oral Sci, 2009.1(4): p. 217-23.
7. Kook, Y.A., G. Kim, and Y. Kim, Comparison of alveolar bone loss around incisors innormal occlusion samples and surgical skeletal class III patients. Angle Orthod, 2012.82(4): p. 645-52.
8. Lund, H., K. Grondahl, and H.G. Grondahl, Cone beam computed tomographyevaluations of marginal alveolar bone before and after orthodontic treatment combined with premolar extractions, in Eur J Oral Sci. 2012. p. 201-11.
9. Nauert, K. and R. Berg, Evaluation of labio-lingual bony support of lower incisors inorthodontically untreated adults with the help of computed tomography. J Orofac Orthop,1999. 60(5): p. 321-34.
10. Lee, K.M., et al., Alveolar bone loss around lower incisors during surgical orthodontictreatment in mandibular prognathism. Angle Orthod, 2012.82(4): p. 637-44.
11. Artun, J., et al., Apical root resorption six and 12 months after initiation of fixedorthodontic appliance therapy. Angle Orthod, 2005.75(6): p. 919-26.
12. Jung, Y.H. and B.H. Cho, External root resorption after orthodontic treatment: a study of contributing factors. Imaging Sci Dent, 2011.41(1): p. 17-21.
13. Yu-lou Tian, Fang Liu, Hong-Jing Sun, Pin Lv, Alveolar bone thickness around maxillary central incisors of different inclination assessed with central cone-beam computed tomographys. KJO , 2015-372X.
14. Campos, M.J., et al., The role of orthodontic tooth movement in bone and root mineraldensity: a study of patients submitted and not submitted to orthodontic treatment. MedSci Monit, 2012. 18(12): p. CR752-7.
15. Zhou Z, Chen W, Shen M, Sun C, Li J, Chen N. Cone beam computed tomographic analyses of alveolar bone anatomy at the maxillary anterior region in Chinese adults. J Biomed Res 2014;28:498-505.
16. Ma J, Huang J, Jiang J-h (2019) Morphological analysis of the alveolar bone of the anterior teeth in severe high-angle skeletal Class II and Class III malocclusions assessed with conebeam computed tomography. PLoS ONE ,2019,14(3): e0210461. .
17. Masumoto, T., et al., Relationships among facial type, buccolingual molar inclination,and cortical bone thickness of the mandible. Eur J Orthod, 2001.23(1): p. 15-23.
18. Hsu, J.T., et al., Bone density changes around teeth during orthodontic treatment. Clin Oral Investig, 2011. 15(4): p. 511-9.
19. Huang, H., et al., Effects of orthodontic treatment on human alveolar bone densitydistribution. Clin Oral Investig, 2012.
20. Greatrex, P.A., et al., The extraction of permanent second molars and its effect on thedentofacial complex of patients treated with the Tip-Edge appliance. Eur J Orthod, 2002.24(5): p. 501-18.