A Retrospective Study on the Labial Maxillary and Mandibular Alveolar Bone after Anterior Retraction

Hilda Fitria Lubis[1,2*], Aditya Rachmawati[1,2], Stephani Tanius[2]

1. Department of Orthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia.
2. Orthodontics Specialist Program, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia.

Abstract

Correction of anteroposterior discrepancy requires proper alveolar bone thickness to move the incisors to the desired place and harmonious facial profile is achieved. Proving the bone remodeling ability of the alveolar bone is very important to avoid unwanted side effects. The study design was retrospective study. The sample size included in our study was 22.

This study used pre- and post-treatment lateral cephalometry radiographs of patients that was diagnosed as Class I skeletal with bimaxillary protrusion and treated with first premolar extraction. All the linear measurements of pretreatment (T1) and post retraction (T2) lateral cephalometric radiographs were measured using ImageJ software. The measurement results are recorded, and all the data were analyzed using SPSS 24. This study showed that changes in bone thickness were increased equally between the maxillary and mandibular labial alveolar bones.

The labial alveolar bone thickness at Mx1, Mx2, Mx3, Mn1, Mn2, Mn3 levels was increased when the retraction of anterior teeth was carried out. However, this difference was not statistically significant ($p<0.05$). This data is essential for advancing in a further understanding of labial bone remodelling in anterior retraction treatment.

Clinical article (J Int Dent Med Res 2022; 15(2): 771-775)

Keywords: Labial alveolar bone thickness, protrusion, mandibular, maxilla, Lateral cephalographs.

Received date: 14 April 2022 **Accept date:** 08 May 2022

Introduction

Maxillary and mandibular protrusions are the most common dentognathic deformities.[1,2] Patients with Class II malocclusion or dento-alveolar protrusion require bilateral extraction of the first premolars and followed by anterior retraction with maximum anchorage.[3,4]

Dental extraction is a commonly performed procedure to treat dental crowding and provide space for anterior tooth retraction.[5] Anterior tooth retraction can reduce the convexity of the face and can change the morphology of the alveolar bone surrounding the anterior teeth.[6] Treatment of anterior retraction is highly dependent on biologic tooth movement.[7]

Orthodontic tooth movement is the process of tooth movement caused by a force that induce the resorption of alveolar on the compression side and alveolar bone apposition on the tension side.[8,9] A classical theory in orthodontics is "bone follows tooth movement" which states that the alveolar bone follows the direction of tooth movement, and the width of the alveolar bone remains the same. Alveolar bone around the tooth socket will undergo remodeling at the same rate as orthodontic tooth movement with (ratio of bone remodeling to tooth movement (W/D) 1:1).[10]

It is controversy whether the changes that occur in the anterior alveolar bone during orthodontic tooth movement always follow the direction and extent of tooth movement.[10] If this theory is correct, then the tooth can be moved to any required position in the mouth.[6] Non-orthodontic tooth movement do not show conformity with this theory. The ability to move teeth within the alveolar bone is limited. Many studies measuring periodontal status after orthodontic treatment reported that excessive retraction of anterior teeth can cause iatrogenic damage such as alveolar bone loss, dehiscence and gingival recession.[6,11,12]

Corresponding author:
Hilda Fitria Lubis
Department of Orthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia.
E-mail address: hildadrgusu@gmail.com

The dimensions of anterior alveolar bone appear to limit orthodontic treatment. Proving the true bone remodeling ability of the alveolar bone is very important to avoid unwanted side effects. Therefore, a study was conducted to evaluate the changes of alveolar bone remodeling after incisor retraction.

Materials and methods

The study design was retrospective study. The sample size included in our study was 22. This study used pre- and post-treatment lateral cephalometry radiographs of patients that was diagnosed as Class I skeletal with bimaxillary protrusion and treated with first premolar extraction in the orthodontic specialist clinic of the Universitas Sumatera Utara Dental Hospital from 2010 – 2020. The study protocol was approved by the Health Research Ethics Committee (Approval no. 638/KEP/USU/2020) at the Universitas Sumatera Utara, and the Faculty of Dentistry Universitas Sumatera Utara, Medan.

The participants were selected based on the inclusion and exclusion criteria designed for the study. The inclusion criteria of the study were participants with age 18-30 years, treated with extraction of two maxillary premolars using edgewise and/or roth straight wire prescription techniques, the retraction technique uses a retraction loop, good and clear cephalometric.

Figure 1. Landmarks to measure labial alveolar bone thickness.

The exclusion criteria of the study were no loss of anterior or posterior teeth other than extraction for the indication for orthodontic treatment, patients with medical history related to bone metabolism problems, severe gingival or periodontal disease, history of upper and lower incisor trauma, hormonal imbalance and patients undergoing orthopedic or orthognatic history.

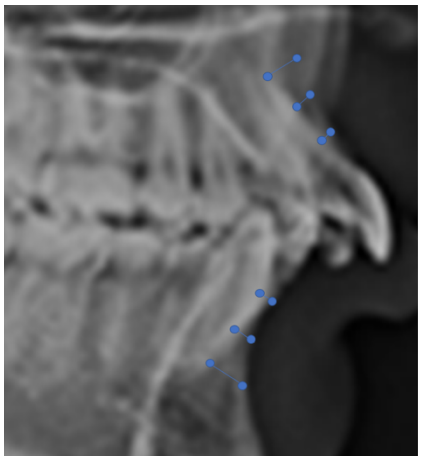


Figure 2. Measurement of alveolar bone thickness at different levels.

All the linear measurements of pretreatment (T1) and postretraction (T2) lateral cephalometric radiographs were measured. The mean and standard deviation (SD) were calculated, the data were tabulated, and comparison of T1 and T2 readings was made utilizing paired Student's t-test and Wilcoxon for statistical significance between the two sets of measurements.

The thickness of the labial alveolar bone of anterior teeth in three levels on radiographs was determined by the following landmarks:[13]

Mx1 : distance from the cervical third of maxilla labial incisor root surface to cortical plate
Mx2 : distance from the middle third of maxilla labial incisor root surface to cortical plate
Mx3 : distance from the apical third of maxilla labial incisor root surface to cortical plate
Mn1 : distance from the cervical third of mandibular labial incisor root surface to cortical plate
Mn2 : distance from the middle third of mandibular labial incisor root surface to cortical plate
Mn3 : distance from the apical third of mandibular labial incisor root surface to cortical plate.

The distance was measured by triple magnification for accuracy and then returned to a 1:1 scale. The measurement taken from the outermost point using ImageJ software. The measurement was carried out twice by two operators.

The measurement results were recorded, and all the data were analyzed using Statistical Package for the Social Sciences software version 24 (SPSS Inc; Chicago, Illinois, USA). Results were presented as mean ± SD. The results thus obtained will be statistically analyzed using paired Student's t-test and Wilcoxon to compare T1 and T2 values. The significance level of $p < 0.05$ was selected

Results

Medical and dental records of 22 subjects (10 men and 12 women) who received orthodontic treatment with anterior retraction were included. These subjects had no history of a medical condition that could impact bone metabolism. The subjects' ages between 18 and 28 years (means: 22.68 years). lateral cephalometry radiographs was performed before and after upper incisor retraction. The result for mean labial bone thickness of maxilla and mandibular alveolar bone, as measured from lateral cephalometric radiographs at T1 to T2, is shown in Table 1 and Table 2, Graph 1.

Variable	N	Alveolar bone thickness (Mean ± SD) (mm)			*p*-value
		T1	T2	Differences	
Mx1	22	0.932±0.07	1.002±0.102	0.069±0.494	0.515
Mx2		1.244±0.075	1.304±0.1	0.059±0.517	0.593
Mx3		1.992±0.166	2.271±0.162	0.278±0.643	0.055

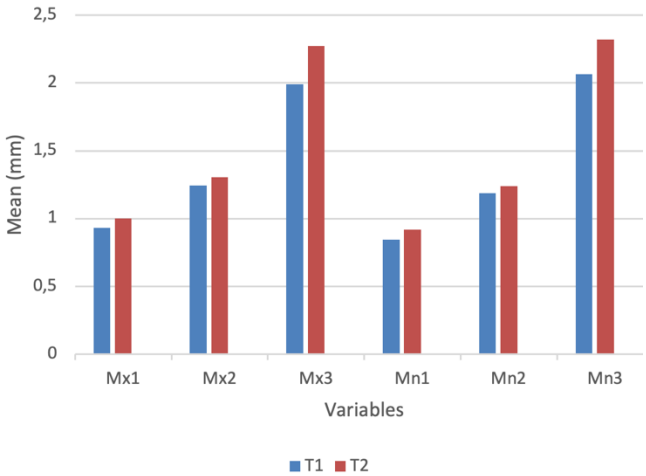
Table 1. Comparison of maxilla alveolar bone thickness at T1 and T2 measurements with Paired t-test.

Variable	N	Alveolar bone thickness (Mean ± SD) (mm)			*p*-value
		T1	T2	Differences	
Mn1	22	0.844±0.099	0.917±0.12	0.073±0.409	0.506
Mn2		1.187±0.11	1.239±0.156	0.051±0.628	0.661
Mn3		2.063±0.167	2.322±0.189	0.259±0.557	0.112

Table 2. Comparison of mandibular alveolar bone thickness at T1 and T2 measurements with Wilcoxon test.

The tests for normality of variables were performed using Shapiro-Wilk test. The data of Alveolar bone thickness in maxilla was normally distributed. Paired t-tests were used to compare the difference in mean maxilla alveolar bone thickness pre-retraction (T_1) and post-retraction (T_2). The data of Alveolar bone thickness in mandibular was not normally distributed. The differences of alveolar mandibular bone thickness pre-retraction (T_1) and post-retraction (T_2) were calculated using the Wilcoxon test with significance set at $p < .05$.

Labial alveolar bone thickness in maxilla increased at Mx1, Mx2, Mx3. These findings were consistent to the results from the analysis of the difference in alveolar bone thickness in mandibular Mn1, Mn2 and Mn3 respectively (graph 1). Table 1 and Table 2 summarizes that there were no significant differences in thickness of labial maxilla and mandibular alveolar bone before and after retraction of anterior teeth. ($p > 0.05$)



Graph 1. Means of maxillary and mandibular alveolar bone thickness before and after retraction of anterior teeth.

Discussion

Orthodontic tooth movement can eliminate dental malocclusion.[14] Correction of anteroposterior discrepancy requires proper alveolar bone thickness to move the incisors to the desired place and harmonious facial profile is achieved.[15,16] The question arises what is the average incisor tooth movement that can be accepted by the bone tissue without passing through these anatomical limitations so as to prevent bone perforation, bone loss and root resorption.

Retraction is the most frequently used technique in space closure.[17] The strategy used in retraction mechanics must be based on a careful diagnosis and treatment plan made according to the specific needs of the individual.[17] Under normal/healthy conditions, such movement is carried out by highly coordinated and efficient bone remodelling,

which requires coupling of bone formation following bone resorption.[18]

The purpose of this study was to evaluate and compare the changes in thickness of labial maxilla and mandibular alveolar bone before and after retraction of anterior teeth. The present study demonstrated that labial alveolar bone thickness at Mx1, Mx2, Mx3, Mn1, Mn2, Mn3 levels was increased when the retraction of anterior teeth was carried out. However, this difference was not statistically significant (Fig.4). this result is similar to the reports of sun[6] and zhang[19]

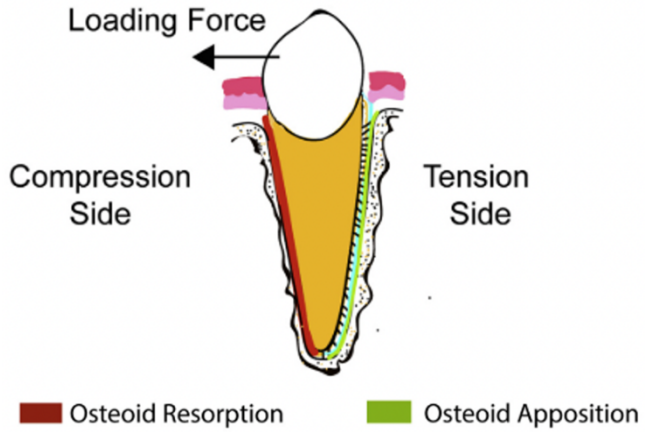


Figure 3. Bone response in compression and tension.[18]

The results of this study are in accordance with Yodthong's research, which reported that an increase in the amount of buccal alveolar bone may occur as a result of retraction.[20] In addition, Hong's study found that the changes in labial alveolar bone thickness at three levels tend to increase.[21] This finding agrees with the classic pressure-tension theory. According to this theory, the tooth adjusts its location within the PDL space within seconds of force loading, resulting in PDL compression in certain areas and PDL stretch or tension in the other side (Fig.2).

On the compression side, blood flow is reduced, whereas on the tension side, it is maintained or enhanced. If the loading force is sustained, the alteration in blood flow quickly (in minutes) changes the oxygen tension (O2: CO2 level) and the chemical environment by releasing biologically active agents such as prostaglandins and cytokines (e.g., Interleukin (IL)-1b).[9] These chemical mediators activate cellular activity differently in the compression and tension sections of the PDL, resulting in bone resorption on the compression side and bone growth on the tension side.[9,18]

This study showed that changes in bone thickness were increased equally between the maxillary and mandibular labial alveolar bones. This result was different to the study done by Krishna et al[22], who reported that the bone labial to the anterior teeth decreased in thickness at the coronal level of the left lateral and left central incisors after lingual movement of the incisors In the mandibular arch. Anshu et al[23], studied peoples with class II malocclusion and bimaxillary protusion. They reported that The maxillary labial alveolar bone thickness reduced at crestal level and increased at mid root and apical level The mandibular labial, lingual as well as total alveolar bone thickness was found to be reduced at all the three levels.[23] Different mechanics including anchorage position and traction vectors might influence the different values.

There are a few limitations and areas of improvements for this study. Measurements were taken with lateral cephalometric radiographs, further quantitative research based on three-dimensional computed tomography will greatly improve the higher resolution of images and finer measurements. A longitudinal observation in addition to the starting and ending points might provide more detail on how continuous modelling occurs.

Conclusions

The following conclusions are drawn from the study:

1. As the upper incisors are retracted, labial bone thickness at crestal (Mx1), middle (Mx2) and apical (Mx3) level increased, however, this difference was not statistically significant
2. As the lower incisors are retracted, labial bone thickness at crestal (Mn1), middle (Mn2) and apical (Mn3) level increased, however, this difference was not statistically significant

Acknowledgements

The authors of the present study would like to thank all the participants who enrolled in this study.

Declaration of Interest

The authors declare no conflict of interest, financial or otherwise.

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