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Changes in alveolar bone thickness during upper incisor retraction

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Abstract

Context: In cases of bimaxillary protrusion or severe crowding, extraction of 4 premolars and orthodontic treatment with retraction of the anterior teeth is a widely used approach. However, there is controversy over whether the changes that occur in the anterior alveolar bone always follow the direction and quantity of tooth movement.

Aims: To evaluate and compare the changes in alveolar bone thickness, type of tooth movement and rate of retraction, before and after retraction of anterior teeth using micro-implants.

Settings and design: A cross-sectional study

Methods and Material: The subjects consisted of 15 ongoing orthodontic patients whose upper incisors were bound for retraction. Changes in alveolar bone thickness in the retracted area were assessed using pre-retraction (T0) and post-retraction (T1) computed tomography images and lateral cephalograms. Labial bone thickness (LBT), palatal bone thickness (PBT), and total bone thickness (TBT) were assessed at the crestal (S1), mid-root (S2), and apical (S3) levels of the retracted incisors.

Statistical analysis used: Paired t-tests were used to compare the difference of bone thickness between T0 and T1. To determine the relation between the changes of alveolar bone thickness, and rate of tooth movement, changes of inclination, initial alveolar bone thickness, the Spearman rank correlation analysis was performed.

Results: As the maxillary anterior teeth were retracted, the LBT at crestal and apical level and TBT at mid-root and apical level were statistically significantly increased ($p < 0.05$).

Conclusion: When tooth movement is limited, forcing the tooth against the cortical bone may cause adverse sequelae. Rate of tooth movement and initial alveolar bone thickness are the significant factors that may influence alveolar bone thickness during upper incisor retraction. These factors must be carefully monitored to avoid the undesirable thickening of alveolar bone.

Key words: Alveolar bone thickness; Incisor inclination; En masse retraction; CT

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Introduction

We know that bone resorption occurs on the pressure area and bone apposition occurs on the tension area. Similarly in orthodontics, during the process of tooth movement such a phenomenon occurs. But there is a controversy that whether all the alterations that occurs during tooth movement in anterior alveolar bone always pursues the path as well as degree of tooth movement.¹ In orthodontics, it is said that “bone traces tooth movement”. According to it, whenever tooth movement takes place, the bone surrounding the alveolar socket remodels to the equal amount.² But on the other hand, sometimes it may not occur with this rule, and a critical bone reaction may occur after incisor retraction. The labial cortical plate leads to increased bone which is larger than the displacement of tooth, leading to discernible bone exostosis, protuberance of labial bone, and an uneven crest of bone.^{3,4} Protuberance of labial bone typically leads to esthetic dilemmas, and usually alveoplasty is advised to abolish surplus alveolar bone. Presently, the mechanisms leading to diverse alveolar bone reactions are indistinct; there is curiosity in finding out the factors associated with alterations in alveolar bone thickness throughout incisor retraction.

In terms of alveolar bone remodeling, there are two perceptions in orthodontic tooth movement. If the bony remodeling is occurring in coordination of resorption and deposition, then the bone remodeling and tooth movement will occur at a 1:1 ratio, and the tooth will stay in the alveolar covering. This type of movement of a tooth is termed as “with-the-bone.”⁵ On the other hand, if there is no equilibrium between resorption and deposition of the alveolar bone throughout the tooth movement, then the tooth will tend to come out of the alveolar covering. This type of movement of a tooth is termed as “through-the-bone.”⁶ Thus, a careful assessment of alveolar bone and roots of the anterior teeth should be done after en masse retraction to determine the therapeutic limitation of orthodontic tooth movement based on the “with-the-bone” and “through-the bone” concepts.

The patients having bimaxillary protrusion may not be well thought-out to have a soft tissue profile which is pleasing esthetically. The anterior teeth of such patients have dentoalveolar flaring, with secondary protrusion of the lips and convex facial profile.⁷ In such patients, the management is extraction of four first premolars in order to decrease the convexity of face and permit retraction of the anterior teeth to a more pleasing and possibly a more stable position.⁷ The retraction of anterior teeth is done with maximum anchorage. Maximum anchorage preservation of posterior teeth permits greater retraction of the anterior teeth.⁷ To overcome the objectives of treatment, anterior teeth are extremely retracted but the alveolar bone remodeling with such a type of tooth movement varies with

each patient. When the area for retraction is very less, then constant application of force to the tooth may lead to incisor roots to touch the cortical plate. This may lead to cortical plate resorption and root exposure.

The thickness of alveolar bone describes the limitations of the orthodontic tooth movement. If one takes a step to challenge the limits then it may lead to unwanted collateral consequences for the periodontal tissues. The most serious orthodontic tooth movement consist of bucco-lingual movement of incisor teeth.⁸ Such mechanics can cause fenestrations and bone dehiscence.⁸

Conventional 2D lateral cephalograms have numerous drawbacks in terms of investigating the changes in the alveolar bone and roots, particularly in the anterior region, as a consequence of the midsagittal projection. CT scanning is the three dimensional imaging technique giving quantitative assessments of the buccal and lingual cortical bone plates and labiolingual width of alveolar bone with elevated accuracy and precision.⁹

In the study done by Adel AlHadlaq¹⁰, he evaluated the thickness of alveolar bone in the anterior region. There are few studies¹¹⁻¹³ which evaluated only the thickness of alveolar bone before and after retraction of anterior teeth. In the above studies they have used friction and frictionless mechanics which may cause variable amount of forces. In the study done by Simten Sarikaya et al.², the loop mechanics (Poul Gjessing spring) has been used for retraction which may cause variable amount of forces in different direction. The amount of force used for retraction will be more than required. In other study done by Nuengrutai Yodthong et al.¹², they have not used uniform mechanics for retraction of incisors which again may have an effect on tooth movement and alveolar bone.

Therefore, the study was taken up to evaluate and compare the changes in thickness of alveolar bone, type of tooth movement and rate of retraction, before and after retraction of anterior teeth using micro-implants.

Subjects and methods

The study design is a cross-sectional study. The sample size included in our study was 15. The inclusion criteria of the study were participants with well aligned maxillary teeth with extracted maxillary first premolars and ready for retraction and age ranging from 17 to 25 yrs. The exclusion criteria of the study were retreatment or relapse cases, mild to moderate crowding with less than 6 mm extraction space for retraction, congenitally missing teeth, extraction of teeth except first premolars and third molars due to any other reason, severe skeletal asymmetry.

The study was approved by the institutional ethics committee. The participants were selected based on the inclusion and exclusion criteria designed for the study. The participants were having maxillary anterior teeth levelled and well aligned with two premolars extracted for orthodontic purpose. These participants were registered for the study after obtaining the written informed consent form. The participants were provided with a participant information sheet. They were subjected to CT scan and lateral cephalogram. The records were collected and analyzed.

Pre-adjusted edgewise appliance (MBT prescription) with 0.022 inch slot was used for full arch. The teeth were well aligned and leveled until complete on 0.016×0.022 inch stainless steel arch wire. A standard protocol of biomechanics for en-masse retraction of anterior teeth with sliding mechanics on 0.017×0.025 inch stainless steel arch wire using micro-implants and NiTi closed coil springs was followed in all the participants.¹³ (Fig.1)

In order to evaluate the changes of alveolar bone and potential influencing factors after upper incisor retraction, CT scan and lateral cephalograms were taken at the beginning of retraction and at the completion of retraction.

Records and data analysis

Parameters measured in this study included the rate of tooth movement, changes of inclination, and type of tooth movement, which were measured using lateral cephalograms, while the alveolar bone thickness was measured by the computed tomography.

Cephalometric analysis

The changes of inclination of anterior teeth were evaluated from lateral cephalometric radiographs. The pre-treatment and post-treatment lateral cephalograms were traced and type of tooth movement was evaluated. The angle between the axis of the maxillary central incisors and the palatal plane (UI-PP) was measured (Fig. 2).

Computed tomography analysis

The thickness of the buccal and palatal alveolar bone of anterior teeth was determined at the position neighbouring to the broadest point of the bucco-palatal root, in 3 slices divided by 3 mm at crestal (S1), midroot (S2), and apical (S3) levels respectively (Fig.3). These levels are specified along the long axis of the tooth and are situated every 3 mm above the cemento-enamel junction (CEJ) level. Buccal, palatal, and total alveolar bone thickness were assessed at the crestal level (S1; L1, P1, and T1), midroot level (S2; L2, P2, and T2) and apical level (S3; L3, P3, and T3) at pre-retraction and post-retraction. The alveolar bone thickness of each side and level of the six teeth was then averaged to represent mean thickness of the particular side and level. Bony defects like fenestration and dehiscence were recorded.

The total time taken for retraction was recorded and rate of tooth movement was calculated. The post-retraction CT scan and lateral cephalogram were taken for analysis. The alveolar bone thickness was evaluated at S1, S2 and S3 levels in CT scan obtained after retraction. The defects in the alveolar bone were also recorded. The thickness of alveolar bone, type of tooth movement and bony defects were compared.

Results

A paired t test was utilized to assess the alveolar bone changes that arise as a result of retraction of incisors with a significance level of 0.05. Spearman rank correlation analysis was used to recognize any associations between the factors and the changes of alveolar bone. The reproducibility of bone thickness and bone level measurements was assessed by calculating method error from the difference between two measurements taken at least one week apart. The measurement error was calculated from the formula of Dahlberg¹⁴. The reliability of the data was evaluated by calculating the intraclass correlation coefficient (ICC)¹⁵. Based on the clinical importance of measurement errors, the significance might be high (ICC >0.95), acceptable (0.80 > ICC > 0.70), or poor (ICC < 0.70).
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