International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

ORIGINAL RESEARCH

A TOMOGRAPHIC ASSESSMENT OF ALVEOLAR BONE AFTER EN MASSE RETRACTION- AN IN-VIVO STUDY

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ABSTRACT:

Abstract

Aims & Objective: The objective of the study was to evaluate the alveolar bone morphometric changes and alveolar bone loss and rate of space closure after en masse retraction using CBCT images taken prior to and after treatment using two different methods of retraction, active tiebacks and Nickel Titanium closed coil springs as a split mouth design for the study. **Materials & methods:** MBT 0.022'' slot brackets were bonded, initial leveling, aligning and en masse retraction in twenty patients is initiated. The available extraction space & CBCT images will be recorded before and after retraction. Both the clinically measured values as well as the CBCT values will be compared to conclude the result of the study. **Results:** The time interval taken by the NiTi group showed a substantial difference when compared to active tieback group. The NiTi group showed a reduction in the alveolar bone level on the labial side (P <0.001) and on the palatal side (P of 0.002). The active tieback group also displayed a reduction on the labial side (P < 0.001) whereas no difference was observed on the palatal alveolar bone (0.07). **Conclusion:** Faster space closure was observed with NiTI coil spring group than active tieback group & the alveolar bone was reduced during en masse retraction in both groups, higher being in the NiTi group.

Keywords: Alveolar bone, Active tieback, En masse retraction, Niti coil spring

Received: 8 December, 2019 Revised: 19 December, 2019 Accepted: 26 December, 2019

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This article may be cited as: Shailaja AM, Kumar SP, Suchitra MP, Joy S, Pruthwin R. A tomographic assessment of alveolar bone after en masse retraction: An In-Vitro Study. Int J Res Health Allied Sci 2019; 5(6):81-86.

INTRODUCTION

Facial attractiveness including dental and smile esthetics not only impacts social interactions, but also exerts a significant influence on self-concept, psychological well-being and social behavior. Orthodontic treatment is primarily intended to establish a functioning and esthetic dentition and a gorgeous smile. The tooth-alveolar bone is a complex mechanical unit comprising of both hard mineralized and soft periodontal tissues. The main function of this unique tooth- alveolar housing is to transfer the occlusal force from the tooth to the underlying bone and tissues. The most common sort out reason for orthodontic treatment is bialveolar protrusion. The predictable treatment modality chosen by most orthodontists is the extraction of the first premolars and retraction of the anterior teeth with maximum anchorage[1,2] There are two concepts in orthodontic tooth movement in terms of alveolar bone remodelling. If the alveolar bone is remodelled with coordination of bone resorption and bone apposition, tooth movement and bone remodelling occur in a 1:1 ratio, and the tooth remains in the alveolar housing, known as ''with-the-bone.''[3.] If equilibrium between bone resorption and bone apposition is not maintained during tooth movement, the tooth will move out of the alveolar housing, referred to as ''through-the-bone.''[4]

Therefore, morphometric evaluation of the alveolar bone and roots of the anterior teeth after en masse retraction may be a good model with which to explain the therapeutic limitation of orthodontic tooth movement and to define the ''with-the-bone'' and ''through-the-bone'' concepts. The routinely employed method for radiographic evaluation of the teeth and adjacent structures are the conventionally two- dimensional lateral cephalograms, orthopantomogram and intra oral periapical radiographs. In a study conducted by Fuhrmann expresses the significance of a Three-dimensional (3D) imaging. He stated that 80% of the bony defects which could be visualized on CT scan images were not readily identifiable on the two-dimensional (2D) lateral cephalograms. Conventional two-dimensional (2D) cephalograms have various limitations in certain areas like the anterior alveolar bone and root morphology[5]. Therefore, while a lateral cephalogram can be an invaluable tool for identifying gross craniofacial anomalies, its inherent two-dimensional (2D) perspective hinders the evaluation of periodontal pathologies, especially in the anterior teeth. It poses difficulty in the ability to identify and diagnose dehiscences of individual maxillary and mandibular incisors. The advent of cone-beam computed tomography (CBCT) has made it possible to qualitatively and quantitatively evaluate the height and thickness of the alveolar bone and the length and thickness of the root[6]. Three-dimensional (3D) analysis of definitive regions of interest using cone beam CT (CBCT) is at present the best tool available for identifying these periodontal conditions. Fuhrmann in his study concluded that radiographic imaging free from superimposed structures permits marginal bone evaluation at areas not clearly visualized by conventional radiography. This indicates the usefulness of a tomographic technique for scientific evaluations of marginal bone changes[7]. Cone beam computed tomography (CBCT) provides similar possibilities as CT but with relatively lower dose and better image quality. To overpower the limitations of conventional imaging technique while minimizing radiation exposure for patients, cone-beam computed tomography (CBCT) may be an alternative method for imaging in the field of orthodontics and dentofacial orthopaedics.

MATERIALS & METHODS

Subject design: Prospective study
Study location: Vokkaligara Sangha Dental College
Sample size: 20 subjects

Active tie back group: 20 subjects
Niti coil spring group: 20 subjects

This prospective study was executed under the approval of the ethical committee of Vokkaligara Sangha Dental College and Hospital (VSDCH), Bengaluru. Twenty subjects with bimaxillary protrusion from the Department of Orthodontics and Dentofacial Orthopedics were included in this study according to the inclusion and exclusion criteria. All the subjects were informed about the procedures to be performed and signed informed consent was obtained from the parent/guardian.

Inclusion criteria:

1. Angle's Class I molar relationships
2. Mild anterior crowding.
3. CBCT exposures to be made in the same diagnostic center
4. All subjects with bimaxillary protrusion indicated for first premolar extractions.

Exclusion criteria:

1. Previous history of orthodontic or orthopaedic treatment.
2. Presence of craniofacial anomalies.
3. Presence of any signs and symptoms of gingival and periodontal diseases.
4. Medically compromised patients.
5. Pregnant and lactating women.
6. Subjects with class II and III malocclusions.
7. All subjects with mixed dentition.

Methodology

Fixed mechanotherapy using preadjusted appliance with MBT 0.022'' slot system was bonded in all the patients, both in maxillary and mandibular arches. To evaluate the alveolar bone accurately, CBCT images were taken and the reference planes established. Horizontal reference plane was constructed 7^o from the sella-nasion plane. The long axis of the tooth was designated "A", line joining the cemento-enamel junction on palatal and labial bone designated as "B" and the vertical distance from the cemento-enamel junction from the labial and palatal surface to the alveolar bone designated as "C" and "D" respectively (Fig 1).

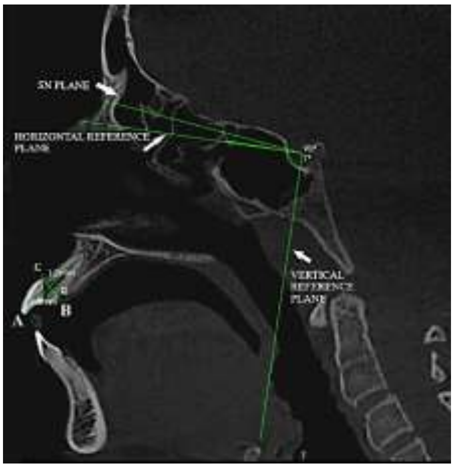

Figure 1: Cone Beam Computed Tomography evaluation reference plane
A – Long axis of the tooth
B – Line joining labial and palatal CEJ
C, D – Vertical distance from the CEJ to the alveolar bone

Pre-treatment intraoral photographs (Fig 2) and CBCT images were recorded (Fig 3). Initial leveling and aligning was carried out with flexible nickel titanium wires. After which 19 x 25 stainless steel wire for retraction by sliding mechanics was initiated in the maxillary arch with 19 x 25 stainless steel wire. The retraction technique used were nickel titanium closed coil springs (Fig 4) and active tieback (Fig 5) used as a spilt mouth design in the maxillary arch. CBCT images were taken after retraction (Fig 6). The CBCT images taken before retraction will be designated as A1 and CBCT images taken after retraction will be designated as A2. The long axis of each tooth will be taken as the reference. The alveolar bone was measured from the CEJ to the marginal bone both on the palatal side and labial side and on the right and left side on all the images of A1 and A2.

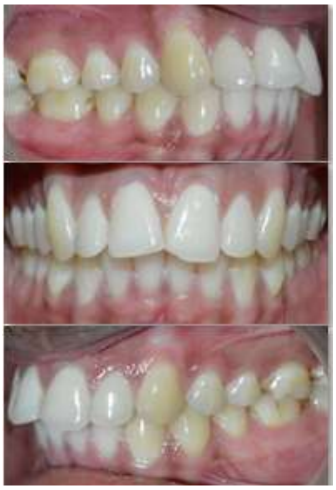

Figure 2: Pre-treatment photographs

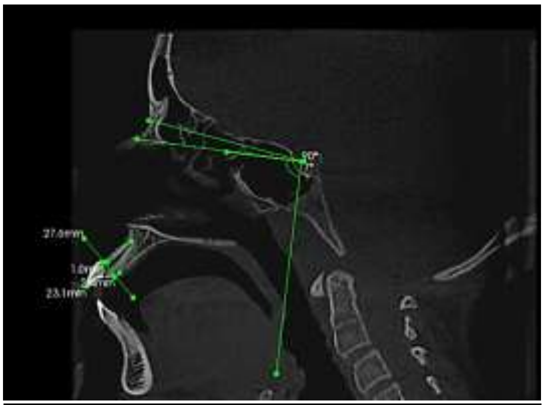

Figure 3: Linear measurements to assess labial & palatal bone level in maxillary central incisor- Pre- treatment

Figure 4: En masse retraction with NiTi coil springs- Post-treatment

Figure 5: En masse retraction with active tiebacks- Post-treatment

Statistical analysis

The data obtained was subjected to statistical analysis. Means, standard, errors, and standard deviations were tabulated, with the paired‘t’ test. The level of significance was set at p ≤ 0.05.

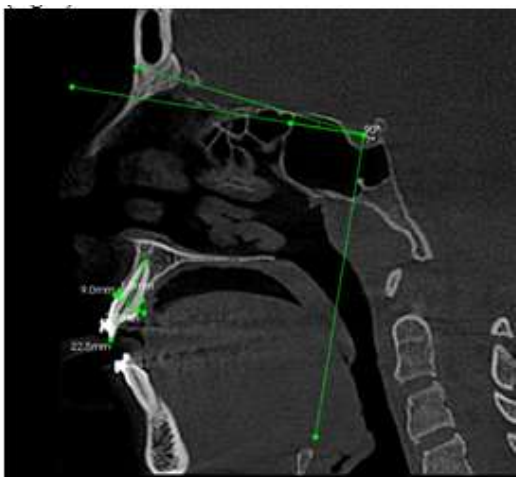

Figure 6: Linear measurements of marginal alveolar bone- Post-treatment

RESULTS

The study was a split mouth design with 20 subjects grouped into two categories, one being the active tie back group and the other being the Nickel Titanium closed coil spring group used for the purpose of retraction. The amount of bone loss was assessed using Cone Beam Computed Tomography images.

Table 1 shows the group comparison of mean for time taken for space closure in NITI group and Active tie back group. Unpaired t test was used for this and was found that the mean space closure in NITI group was 188.10±11.94681 and that in active tie back group was 207.10±12.31131 with a pvalue≤0.05, which was statistically significant. This signified that the mean space closure between NITI group and active tie back group differ significantly. Table 2 compares the alveolar bone level in the pre-treatment and post treatment CBCT images.

TABLE 1: Comparison of time taken by NiTi coil spring and active tie back group for space closure.

Variable	Visit	NITI	Active Tie Back	Mean Difference	t	p
Labial Alveolar Bone	Pre	1.37±0.4	1.30±0.4	0.08	0.53	0.59
	Post	1.58±0.5	1.51±0.4	0.07	0.49	0.81
Palatal Alveolar Bone	Pre	1.21±0.5	1.25±0.4	-0.04	-0.25	0.63
	Post	1.48±0.4	1.42±0.3	0.06	0.43	0.66
Time Taken		188.10±11.9	207.10±12.3	-19.0	-4.95	<0.001

TABLE 2: Comparison of labial alveolar and palatal alveolar bone level in NiTi coil spring and active tie back group.

Group	Variable	Pre	Post	Mean Difference	t	p
NiTi coil springs	Labial Alveolar Bone	1.37±0.4	1.58±0.5	-0.21	-5.96	<0.001
	Palatal Alveolar Bone	1.21±0.5	1.48±0.5	-0.26	-3.64	0.002
Active Tie Back	Labial Alveolar Bone	1.30±0.5	1.51	0.4	-5.92	<0.001
	Palatal Alveolar Bone	1.25±0.4	1.42±0.3	-0.17	-1.90	0.07

Labial alveolar bone: NiTi coil spring group and active tieback group are compared for the alveolar bone level and concludes that the loss of the labial alveolar bone level of post treatment CBCT in both groups showed a highly significant difference from that of the pre-treatment bone levels with a P <0.001and a mean of -0.21 and 0.4 in NiTi coil spring and active tieback group respectively. The NiTI coil spring showed an increase in the labial alveolar bone level reduction compared to active tieback group.

Palatal alveolar bone: NiTi coil spring group and active tieback groups showed that the loss of the palatal alveolar bone level of post treatment CBCT in NiTi group showed a statistically significant difference from that of the pre-treatment bone levels with a P <0.002 with a mean of -0.26. However, the palatal alveolar bone level in the active tieback group did not differ in the bone level when compared with the pre-treatment levels, P 0.07 and a mean of -0.17

DISCUSSION

Patients with bimaxillary protrusion often present with a soft tissue profile which may not be considered as aesthetically pleasing. They have a distinctive dentoalveolar flaring of the maxillary and mandibular anterior segment, with subsequent protrusion of the lips and convexity of the face[1]. The cortical plates of the alveolar bone may be considered as an orthodontic wall.[8] The cortical plates of the palate and the symphysis when observed radiographically, are reproduced in a 2-dimension image which hinders the examiners ability to rule out iatrogenic sequelae during or after tooth movement based on these films.

Cephalometric radiographs are midsagittal projections thus which are superimposed by the overlying structures. The superimposed structures impair the examiner from thorough evaluation of the image of interest.[9] When a must precise image is needed for the understanding of the surrounding structures, one may opt for a 3D radiographic imaging technique. A CBCT scanner was built for angiography at the Mayo Clinic in 1982.[10] CBCT scanners are based on volumetric tomography, using a 2D extended digital array providing an area detector. This is combined with a 3D x-ray beam. The cone-beam technique involves a single 360° scan in which the x-ray source and a reciprocating area detector synchronously move around the patient's head, which is stabilized with a head holder.

Due to the aforementioned reasons, a CBCT imaging technique is preferred over a 2D imaging technique. When weighing the advantages over a CT imaging technique, a multislice spiral CT, multidetector-row helical CT, and spiral CT use more radiation and have higher costs, limiting their use for routine dental radiography.[11-13]

In this study, retraction with sliding mechanics was carried out as a split mouth design using active tieback and NiTi coil springs in the maxillary arch for retraction. CBCT radiographic imaging was exposed before and after retraction and the amount of alveolar bone loss in both quadrants as well as on the palatal and labial aspect of the central incisors were compared and assessed for the amount of bone loss.

Alveolar bone proper: The alveolar bone proper is the thin, lamellated bone which surrounds the root of the tooth and gives attachment to the principal fibers of the periodontal membrane[14]. The alveolar bone proper is remodelled due to various reason such as inflammation due to local infection and mechanical irritation, variation in masticatory apparatus and forces used in orthodontic tooth movement. Reviews of the literature on early tissue response to orthodontic tooth movement have been presented by Oppenhein, Reitan, Halderson and Storey. Most of the work by them were histological and concerned with the early phase of tissue reaction to tooth movement. Tooth movement accomplished by orthodontic movement involved tipping of the tooth. This subsequently affected the alveolar bone proper at its free edges. The initial reaction on the periodontal ligament resulted in the resorption of the alveolar bone in the pressure side and deposition in the tension side.[15]

Referring to the continuous force, Reitan[16] stated "The initial tissue reaction called forth in young patients' incidence to application of continuous forces, consists of a deposition & widening of osteoid tissue at the tension side and bone resorption rapidly increasing with time on the pressure side" when excess force is used, it results in some pathological responses. The amount of these responses depends on the amount of force and length of time the force is applied. Storey indicated that the optimum range of force 162-200 grams would produce maximum rate of retraction.

A study conducted by Baxter[17] on the effect of orthodontic treatment on the alveolar bone adjacent to cemento-enamel junction aimed at assessing the relationship between the alveolar bone and the cemento-enamel junction, the amount of change in height and the difference among extraction and non-extraction group. The author used intra-oral bitewing radiographs for the study from seventy-six subjects who had underwent an orthodontic treatment. The study concluded that there was a decrease in the height of the alveolar bone level of less than 0.5mm. however the author did not observe any difference between extraction and non-extraction group treated by Edgewise or Begg appliance.

In this study, the post retraction CBCT were exposed and compared with the pre-treatment CBCT for the alveolar bone in the palatal and labial alveolar bone in both right and left segment. The labial alveolar bone in the active tieback group and NiTi group both showed a p valve of <0.001, suggesting that the alveolar bone loss in the labial aspect were suggestively reduced when compared to the alveolar bone prior to the start of treatment. The NiTi group and active tieback group showed a reduction in labial alveolar bone loss from 1.37 to 1.58. The amount of reduction of the labial alveolar bone was comparatively more in the NiTI coil spring group than active tieback group.The palatal alveolar bone in the NiTi coil spring group and the active tieback group showed a reduction in the palatal alveolar bone loss from 1.21 to 1.48 and 1.25 to 1.42 respectively. The NiTi group caused more bone resorption than active tieback group.

Sonis AL[18], in his study found that with the same force, nickel titanium closed coil springs and produced nearly twice as rapid a rate of tooth movement as conventional elastics. Samuels RH[16], in his study concluded that rate of space closure to be greater and consistent with the nickel titanium closed coil springs than with the elastic modules. The primary factor responsible for the faster rate of en masse retraction in NiTi springs could be that the low constant force, obtainable by the NiTi springs is more biologically acceptable than the intermittent high force delivery of the elastic module.

Elastic modules lose a larger portion of their force over time. The force decay ranges from 42-63% over a period of one week. Due to this, the force applied by an active tieback is not a constant force and it varies from a high to low from one activation to the other. This type of force is thought to be responsible for the slower rate of en masse retraction seen with the active tie backs.[19] Another aspect responsible for the faster rate of en masse retraction observed with NiTi closed coil spring could be the load deflection rate. The inference from this is that NiTi coil springs deliver optimal forces for orthodontic tooth movement over a longer activation range than other materials. Manhartsberger C et al[20], in his study observed that NiTi coil spring exihibit a superior clinical characteristic compared to elastics modules.

Oral environment also plays a crucial role in the force degradation characteristics. The elastic module shows a more gradual loss of force and as a consequence exhibits an inconstant load on the teeth. In a study conducted by Nattrass C et al[21], demonstrated that NiTi springs were affected only by the environment were as elastomeric chain was affected by all the tests environments (temperature, water & coke).

The study assessed the time duration taken for the space closure between the two groups. Significant difference was noted between NiTi coil spring and active tieback groups. While the active tieback group required 207.1 days for complete retraction of the anteriors, the NiTi coil spring group required only 188.1 days for complete retraction.

CONCLUSION

The study was conducted, and the conclusions drawn were; NiTi coil spring and active tieback were both facilitated easy en masse retraction with sliding mechanics. NiTi coil springs aided in faster space closure than active tieback technique. NiTi coil spring had the advantage of delivering a constant force and there was no need for changing the coil spring on every visit. However, active tieback had to be changed every month. Space closure with NiTi coil spring required minimal chairside time and operator manipulation, however they were more prone to dislodgement from the molar/canine hook due to masticatory forces during the final stage of space closure due to the reduction in the extraction space in turn causing the reduction in the length of the NiTi coil spring. Use on NiTi coil spring resulted in labial and palatal bone loss which was higher than when compared with active tieback technique. Active tieback technique also resulted in labial alveolar bone loss but comparatively less than that with NiTi coil spring and no difference in palatal bone loss was observed compared to NiTI coil spring. Therefore, when treating a case of bimaxillary protrusion, one should bear in mind the entire alveolar housing and not merely the bone in the apical zone. The clinician should consider the therapeutic limitations for orthodontic tooth movement[22]. For an appropriate inference to be drawn, more in-vivo studies need to be carried out to evaluate the better alternative for retraction mechanics.

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