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Morphological Changes In Alveolar Bone Following Orthodontic Space Closure

A Project Submitted to The College of Dentistry, University of Baghdad, Department of Orthodontics in Partial Fulfillment for the Bachelor of Dental Surgery

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Certification Of The Supervisor

I certify that this project entitled "**Morphological Changes In Alveolar Bone Following Orthodontic Space Closure**" was prepared by the fifth- year student "**Abbas Abd Alkareem Kadhim**" under my supervision at the College of Dentistry/ University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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Date: 2/5/2023

Dedication

First of all, I thank “**Allah**” almighty for granting me the will and strength to accomplish this study, and I wish that his blessings upon me may continue throughout my life, without “**Allah**”, I would not have had the patience or the physical ability to do so...

My Mother, who has shared in all my joys and sorrows, my trials, failures and achievements; your strong and gentle soul who taught me to trust Allah, believe in hard work and that so much could be done with little.

My Father, for earning an honest living for us and for supporting and encouraging me to believe in myself

My Brother and Sisters, thank you for standing by my side when times get hard, thank you for making me laugh when I didn't even want to smile.

My Friends, the other half of my mind, who knows the real me and loves me anyway.

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Table Of Content

List Of Figures

List Of Abbreviations

CBCT	**Cone-Beam ComputedTomography**
CEJ	**Cemento-enamel junction**
PDL	**Periodontal ligament**
HERS	**Hertwig epithelial root sheath**
CT	**Computed Tomography**
DBM	**Degree of bone mineralization**

INTRODUCTION

The alveolar bone has always been a factor in the decision-making process for the orthodontists, and there has recently been an increasing interest in the dental profession for evaluating the effects of orthodontic treatment on the alveolar bone **(Kadioglu and currier, 2019).**

The alveolar bone is traditionally and practically considered the anatomical limitation of orthodontic tooth movement **(Henneman *et al.*, 2008)** Controversy exists on whether the changes occurring in anterioralveolar bone during orthodontic tooth movement always follow the direction and extent of tooth movement.

A basic axiom in orthodontics is "bone traces tooth movement" **(Reitan,1964)** which suggests that whenever orthodontic tooth movement occurs, the bone around the alveolar socket will model to the same extent.

The association between vascular blood pressure in the PDL and hyalinization is one of the proposed theories of tooth movement in orthodontics **(Reitan, 1994).**

Later (**Viecilli, 2009)** described the role of P2X7 receptor in the transduction of orthodontic loads into bone adaptation and discussed that until then, the hyalinization theory failed to consider the mechanotransduction events which lead to orthodontic tooth movement.

The adaptation of the alveolar bone is clinically significant on a regular basis when it comes to treatment planning. The amount of correction required for crowding, as well as well as for other orthodontic mechanics that require anterior tooth movement, largely depends on the position of the incisors within the alveolar bone. Multiple studies in the past have evaluated the effects of tooth movement on the alveolar bone using cadavers and patients that have needed procedures involving periodontal flaps **(Fuhrmann, 1995).**

The advent of cone-beam computed tomography (CBCT) has made it possible to evaluate the height and thickness of the alveolar bone and to evaluate the change of position of every single tooth. **(Kalina *et al.*, 2021)** proved, basing on CBCT, that the orthodontic treatment can be carried out without posing a high risk of gingival recession if the periodontal biotype is respected.

AIMS OF THE STUDY

1) Evaluate the alveolar bone changes around maxillary anterior teeth following orthodontic space closure.
2) Provide guidelines for the best morphological changes to be consider with space closure during or post orthodontic treatment.

Chapter one: Review of literature

1.1 - Definition (alveolar bone)

Alveolar process is defined as the parts of the maxilla and mandible that form and support the tooth sockets. Forms with eruption of tooth to provide osseous attachment to forming pdl. Disappears with loss of tooth Because the alveolar processes develop and undergo remodeling with tooth formation and eruption, they are tooth-dependent bony structures.

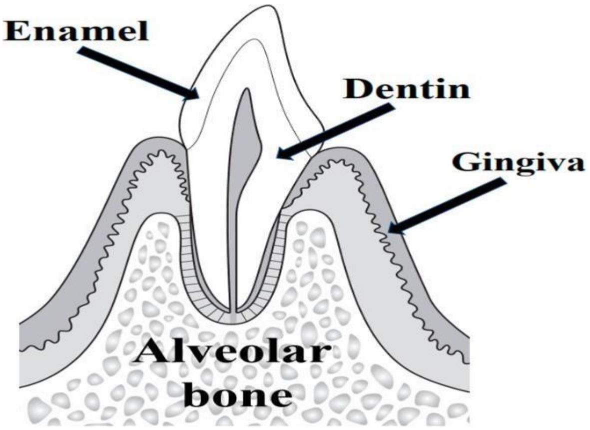

figure1-1The alveolar bone. A diagram of a tooth cut vertically is shown. The alveolar bone is the bone that supports the tooth and is connected to the root of the tooth via the periodontal ligament, which receives the force of the bite. The outer surface is made of hard "dense bone", while the inner surface is made of soft "trabecular bone", and this outer frame and cushioning make it resistant to impact. **(Balta *et al.*, 2021).**

1.2 - Gross histology of alveolar bone

Characteristics of all bone are dense outer sheet of compact bone and central medullary cavity. Medullary cavity filled with red or yellow bone marrow Trabecular/spongy bone present in extremities of long bone.

1.2.1- periosteum

The tissue that covers the outer surface of bone and composed of 2 layers

I. outer (fibrous) layer rich in blood vessels and nerves o composed of collagen fibers and fibroblasts. II. inner layer composed of osteoblasts surrounded by osteoprogenitor cells.

1.2.2- Endosteum

Tissue that lines the internal bone cavities. The endosteum is composed of a single layer of osteoblasts and sometimes a small amount of connective tissue.

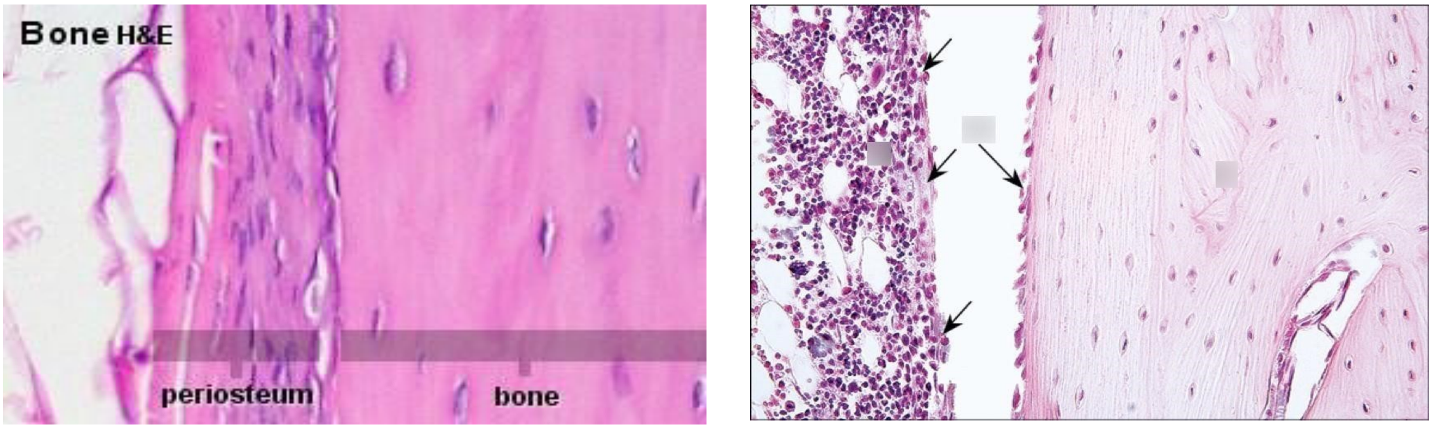

Figure 1-2 a) periosteum b) endosteum

(Fischer et al., 2020)

1.3 - Components of alveolar bone

Cellular components: - Osteoprogenitor (stem cells), osteoblast,osteocyte and osteoclast.

Matrix components: - Inorganic components and Organic components (Collagenous protein non-collagenous protein).

1.4 : Alveolar bone development:

Alveolar bone development closely follows the development of maxilla and mandible through membranous ossification. Although maxillary and mandibular development begins as early as the fourth to sixth weeks of intrauterine life, alveolar bone development does not begin until the formation of teeth (**Jonasson *et al.*, 2018**).

Initially, alveolar bone forms a thin eggshell of support, termed the tooth crypt, around each tooth germ. Gradually, as the roots grow and lengthen, the alveolar bone keeps pace with the elongating and erupting tooth and maintains a relation with each tooth root. Development of the alveolar process begins in the eighth week in utero. At that time, withinthe maxilla and the mandible the forming alveolar bone develops a horseshoe-shaped groove. The bony groove, or canal, is formed by growthof the facial and lingual plates of the body of the maxillae or mandibleand contains the developing tooth germs together with the alveolar blood vessels and nerves. At first, the developing tooth germs lie free in the groove. Gradually, bony septa develop between teeth, so that each tooth iseventually contained in a separate crypt (**Avery and Steele, 2002**).

The earliest sign of development of alveolar bone proper coincides with the developing primary dentition. Each tooth bud undergoes different stages of proliferation, differentiation, and organization to form the crown of a tooth. Once crown formation is complete, root development ensues through interaction between the dental follicularmesenchyme and the Hertwig epithelial root sheath (HERS). HERS is composed only of the outer and inner enamel epithelial layers (**Bhaskar,1991; Som and Naidich, 2014**).

Mesenchymal cells from the dental follicle undergo simultaneous differentiation into cementoblasts, fibroblasts, and osteoblasts. These cells lead to cementum deposition on the developing root surface, formation of periodontal ligament (PDL) fibers, and formation of the bony socket walls, respectively (**Bhaskar, 1991; Som and Naidich, 2014**).

This concomitant development of the triad of periodontal tissues results in embedding of PDL fibers within both the cementum and alveolar bone proper. The PDL progressively increases in length in response to root formation and tooth eruption. Similarly, alveolar bone surrounding the tooth increases in height and continuously remodels during tooth eruption and follows the PDL. Upon tooth eruption, a fully functional dentoalveolar process, comprising the tooth, completed root, alveolar bone, and PDL, is finally created (**Bhaskar, 1991; Philipsen andReichart, 2004; Som and Naidich, 2014**).

Physiologically, alveolar bone is in a constant state of dynamism throughout life. It remodels in response to occlusal wear and tear and masticatory forces placed on the tooth, and transmitted through the PDL (**Bhaskar, 1991; Som and Naidich, 2014**).

Kumar (2015) explained that functions of alveolar bone are:

- Houses the roots of teeth.
- Anchors the roots of teeth to the alveoli, which is achieved by the insertion of sharpey's fibers into the alveolar bone proper.
- Helps to move the teeth for better occlusion.
- Helps to absorb and distribute occlusal force generated during tooth contact.
- Supplies vessels to pdl.
- Houses and protects developing permanent teeth, while supporting primary teeth.
- Organizes eruption of primary and permanent teeth.

1.5 : Normal anatomy of alveolar bone:

Anatomically and clinically, the parts of maxilla and mandible supporting the teeth comprise the alveolar process. Morphologically, alveolar bone is similar to skeletal bones. It has a sandwich construction composed of an outer layer of dense cortical bone on the buccal, labial, lingual, and palatal aspects, and an inner layer of bundle bone abutting theroots of teeth. The middle layer of trabecular bone is filled with marrow spaces. This unique design of alveolar bone provides resilience and rigidity along with a low mass for given volume (**Jonasson *et al.*, 2018**).

The cortical bone is lamellar in nature and contains Haversian systems for vitality of the bone. The cortical bone of alveolar process is thinner in maxilla than in mandible. Similarly, it is thinner in the anterior regions in comparison to the posterior regions. In addition to housing neurovascular bundles supplying the dentoalveolar apparatus, the trabecular bone is rich in bone marrow, which is a source of both osteogenic and hematopoietic precursors. Surrounding the cementoenamel junction (CEJ) of a tooth, alveolar process is termed alveolar crest, wherein the alveolar bone proper and cortical bone merge together, without any trabecular bone. The alveolar crest is significantly more mineralized than apical alveolar bone. Under normal circumstances, alveolar crest lies apical to the CEJ and its three- dimensional shape follows the shape of the root. This results in alveolar crest functioning as an inter-radicular septum between roots of multi-rooted teeth and as an inter-dental septum in between two teeth (**Monje et al., 2015; Tompkins, 2016**).

1.6 : Conditions affecting alveolar bone:

In a healthy periodontium the facial margin of the alveolar crest lies approximately 2 mm apical to the gingival margin, which courses near to the cementoenamel junction. The facial aspect of the alveolar bone covering the root is usually very thin. As revealed by a flap operation oron a skull preparation the coronal portion of the root often is not covered by bone (dehiscence) or there is a fenestration of the facial bony plate (**Wolf *et al.*, 2005**).

Fenestration is the condition, in which the bony coverage of the root surface is lost, and the root surface is only covered by the periosteum and gingiva. In such lesions, marginal bone is intact. When this bone defect spreads toward the marginal bone, it is called dehiscence.

Fenestration and dehiscence bone defects are observed more in the facial than lingual root surfaces and also more in anterior than in posterior teeth (**Kajan *et al.*, 2015**).

Curved and protruding root form, labial tooth protrusion, occlusal trauma, bruxism, and tooth movement along with the thin cortical bone plate are some of the predisposing factors for these bone defects (**Linde et al., 2008**).

Towards the apex, the facial plate of bone becomes thicker and trabecular bone fills the interval between the facial cortical plate and cribriform plate. In these thicker areas, recession generally stops spontaneously (**Wolf *et al.*, 2005**).

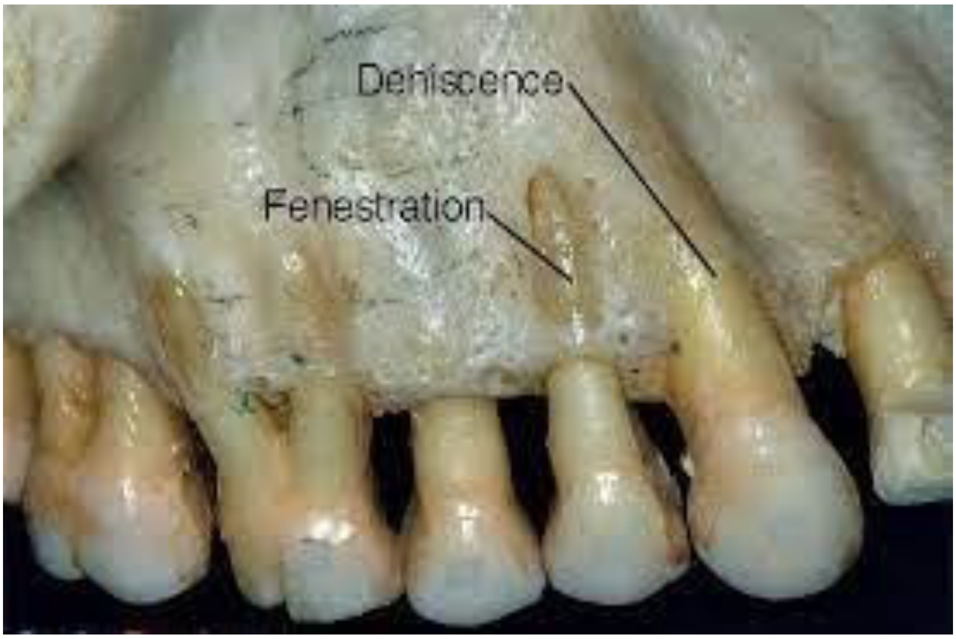

Figure 1-3: Dehiscence and Fenestration **(Rakhewar et al., 2019).**

1.7 : Importance of alveolar bone:

Alveolar bone is a critical component of the tooth-supporting apparatus in the maxillofacial skeleton. A healthy alveolar process, comprising the alveolar bone, PDL, and cementum is required to maintain a healthy dentition (**Jonassone *et al.*, 2018**). Unlike other connective tissues, bone is a specialized connective tissue that is rigid and resilient.

It is primarily responsible for supporting the soft tissue integument and protecting internal organs. The rigidity and resilience of bone are contributed by the mineralization of collagen fibers and non-collagenous proteins within the bone matrix (**Harada and Rodan, 2003**).

1.8 : Tooth movement and alveolar bone:

Alveolar boundary conditions are the depth, height and morphology of alveolar bone relative to tooth root dimensions, angulation and spatial position. Alveolar boundary conditions are determined not only by dentoalveolar anatomy prior to treatment but also by the bone'sadaptability during tooth movement and its morphology following the final positioning of teeth. Thus, in the context of orthodontic tooth movement, alveolar boundary conditions can be considered to be dynamic and dependent on the patient's pretreatment bone and gingival biotype as well as bone physiology. Compromised or inadequate pre-treatment boundary conditions as well as limited ability to adapt to tooth movement may restrict or interfere with the planned or potential tooth movement, as well as the final desired spatial position and angulation of the teeth (**Kapila and Nervina, 2014)**.

Teeth under appropriate forces can readily travel through the alveolar bone of the jaws. Limitations to this movement, and therefore limitations to orthodontic treatment, are mainly due to the size and form of the available bone, and to the presence of adverse forces. As the alveolar bone can, to some extent, be reformed to conform to new tooth positions, the bony limitation to tooth movement is the size and form of the basal bone of jaw (**Foster, 1990**).

Orthodontic treatments that result in pronounced tooth inclinations are considered to be risk factors for dehiscence and fenestration. One possible factor related to these occurrences is the reduced thickness of the alveolar bone around the roots **(Enhos *et al.*, 2012**) Thus, it is important to treat with caution orthodontic patients who already have thin soft-tissue margins before treatment, since the buccal tooth movement may renderthe gingival tissue more vulnerable and less resistant to plaque and tooth brush trauma (**Hu *et al.*, 2009; Enhos *et al.*, 2012**).

Orthodontic tooth movement involves changes in the gingival(**Redlich *et al.*, 1999**), the PDL (**Baumrind, 1969; Rygh, 1973**) and the alveolar bone (**Grimm, 1972; Deguchi *et al.*, 2008**). Many studies have observed changes of alveolar bone density due to active bone remodeling during orthodontic treatment (**King *et al.*, 1991; Redlich *et al.*, 1999; Hsu *et al.*, 2010**).

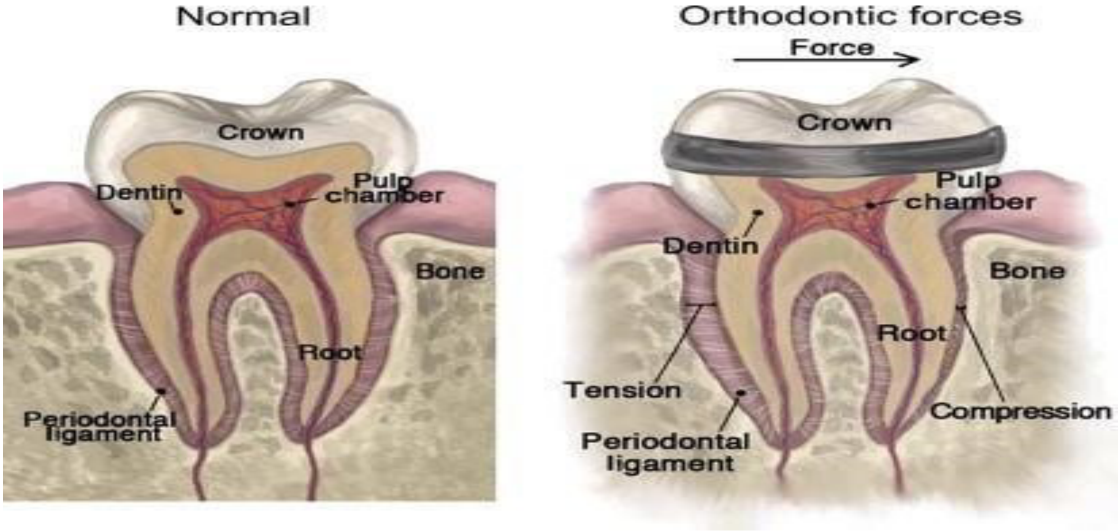

Figure 1-4 **Orthodontic tooth movement.**

Mechanical force on the tooth causes compression of the periodontal ligament on one side and tension on the other side. The compression side is associated with aseptic injury and bone resorption and the tension side with bone formation. **(Tuncay *et al.*, 2006).**

These density alterations of alveolar region result from resorption of pre- existing bone tissue and formation of new bone tissue in the process of bone remodeling. As the new bone tissue has less mineral content than the pre- existing bone tissue, the distribution of the degree of bone mineralization (DBM) inherently changes (**Roschger *et al.*, 1998; Davide *et al.*, 2007**). It was found that the DBM determines the mechanical response of bone tissue to the applied force (**Follet *et al.*, 2004; Kim *et al.*,2011**), and it is well known that mechanical orthodontic force stimulates bone remodeling in the alveolar process (**Grimm, 1972; Kieeling *et al.*, 1993; Verna *et al.*, 1999; Deguchi *et al.*, 2008**). Taken together, it is likely that the DBM distribution reflects bone response to orthodontic force at the initiation and progress of bone remodeling and also provides the status of bone alteration resulting from bone remodeling.

1.9 : Envelope of discrepancy:

Proffit and Ackerman (1982) introduced the concept of the envelope of discrepancy to graphically illustrate how much change can be produced by various types of treatment (Figure 1-1 and Figure 1-2). This diagram helps simplify the relationship of the three basic treatment possibilities for skeletal discrepancies. The inner circle, or envelope, represents the limitations of camouflage treatment involving only orthodontics; the middle envelope illustrates the limits of combined orthodontic treatment and growth modification; and outer envelope shows the limits of surgical correction.

As the figure shows, teeth can be moved farther in some directions than others at any age (the limits for tooth movement change little if any with age), but growth modification is possible only while active growth is occurring. Because growth modification in children enables greater changes than are possible by tooth movement alone in adults, some conditions that could have been treated with orthodontics alone in children (e.g., a centimeter of overjet) become surgical problems in adults. On the other hand, some conditions that initially might look less severe (e.g., 5 mm of reverse overjet) can be seen even at an early age to require surgery if they are ever to be corrected.

Keep in mind that the envelope of discrepancy outlines the limits of hard tissue change toward ideal occlusion, if other limits due to the major goals of treatment do not apply. In fact, soft tissue limitations not reflected in the envelope of discrepancy often are a major factor in the decision for orthodontic or surgical–orthodontic treatment. Measuring millimeter distances to the ideal condylar position for normal function is problematic, and measuring distances to define ideal esthetics is impossible (**Proffit *et al.*, 2019**).

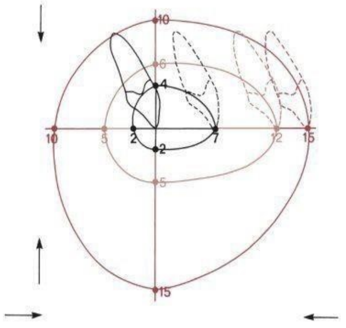

Figure 1-5 With the ideal position of the upper incisors shown by the origin of the x and y axes, the envelope of discrepancy shows the amount of change that could be produced by orthodontic tooth movement alone (the inner envelope of each diagram); orthodontic tooth movement combined with growth modification (the middle envelope) and orthognathic surgery (the outer envelope). Note that the possibilities for each treatment are not symmetric with regard to the planes of space vertical and anteroposterior. There is more potential to retract than procline teeth and more potential for extrusion than intrusion.

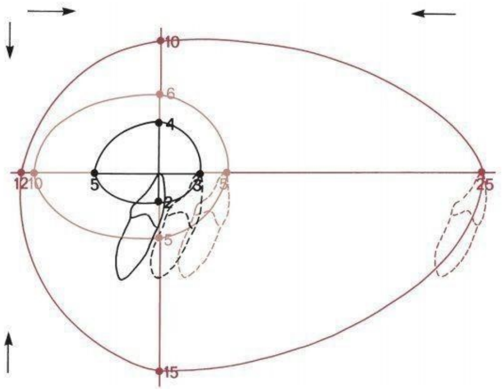

Figure 1-6 With the ideal position of the lower incisors shown by the origin of the x and y axes, the envelope of discrepancy shows the amount of change that could be

produced by orthodontic tooth movement alone (the inner envelope of each diagram); orthodontic tooth movement combined with growth modification (the middle envelope) and orthognathic surgery (the outer envelope). Note that the possibilities for each treatment are not symmetric with regard to the planes of space vertical and anteroposterior. There is more potential to retract than procline teeth and more potential for extrusion than intrusion. Since growth of the maxilla cannot be modified independently of the mandible, the growth modification envelope for the two jaws is the same. Surgery to move the lower jaw back has more potential than surgery to advance it.

2: Morphological change in alveolar bone after space closure:

Tooth movement by orthodontic force application is characterized by modeling and modeling changes in dental and paradental tissue. Orthodontic tooth movement is a process whereby the application of a force induces bone resorption on the pressure side and bone apposition on the tension side.

Combination of PDL modeling, and the localized apposition and resorption of alveolar bone enables the tooth to move (**Krishnan and Davidovitch, 2006**).

Alveolar process modeling in maxillary anterior teeth occurs in response to retraction during space closure, most adversely affected area is a palatal crest which might lead to pdl consequences.

Unfavorable bone response may occur after incisor retraction. For example, the increased bone due to a labial cortical plate is usually greater than the tooth displacement, leading to visible bone exostosis, labial bone protuberance, and an irregular ridge of bone. Labial bone protuberance usually causes esthetic problems, and alveoloplasty can be used to eliminate excess alveolar bone. Currently, the mechanisms leading to different alveolar bone responses are unclear; there is interest in determining the factors related to changes in alveolar bone thickness during incisor retraction. Several studies have indicated a lag in bone modeling in response to tooth movement and reported that as the upper incisors are retracted, labial bone thickness at the crestal level and total alveolar bone thickness at the apical level significantly increase (**Lin *et al*., 2008**).

In a case reported by **(Mimura, 2008),** mini screws were used for treatment of severe bimaxillary protrusion. The upper incisors were retracted 12 mm and intruded 5 mm over 20 months. During treatment an irregular ridge of bone developed labial to the upper incisors, bone was deposited in the incisive fossae and the apices of the upper incisors were resorbed. An alveoloplasty was carried out to recontour the labial bone and the incisive fossae. During extensive retraction, the teeth may contact structures not normally encountered during conventional orthodontic treatment.

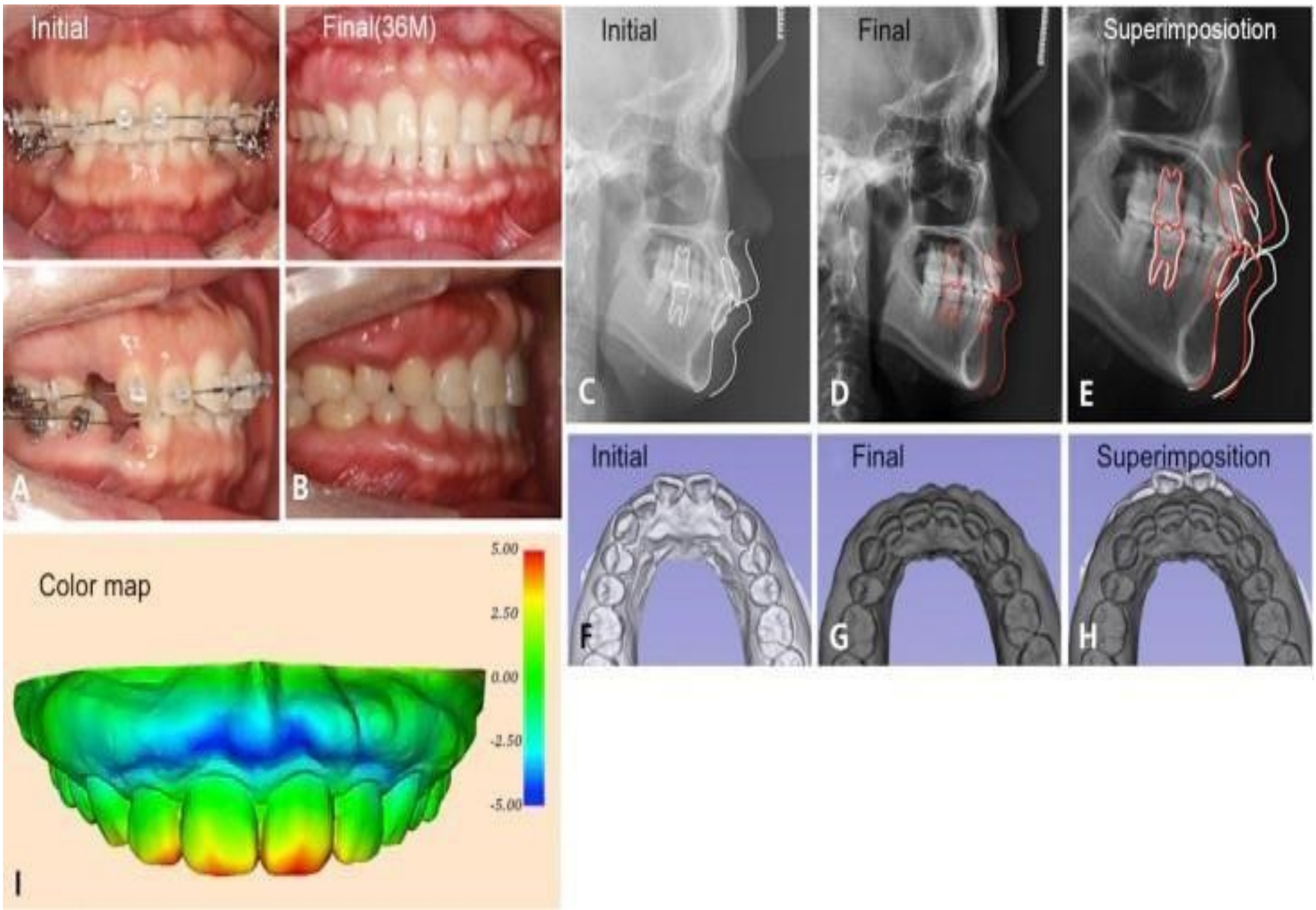

Figure 1-7 Differential alveolar bone modeling after orthodontic retraction **(Cevidanes *et al*., 2010).**

(Baxter, 1965) study the effect of orthodontic treatment on alveolar bone adjacent to the cemento-enamel junction in intraoral bitewing radiographs. His concluded that the relationship of the alveolar bone proper to the cemento-enamel junction at the mesial and distal of the teeth in intraoral bitewing can be measured to the nearest 0.5 mm. He observed a slight general decrease in the height of the alveolar bone proper of less than 0.5 mm following orthodontic treatment. He was not sure whether this change was due to treatment or a normal two-year change in children ten to sixteen year of age. He did not find a significant difference in the change of the height of alveolar bone to the cemento-enamel junction between the non-extraction cases and cases in which first bicuspids had been extracted, or between first bicuspid extraction cases treated by edgewise appliance and Begg appliance. He found that moving teeth toward an extraction area had no specific effect upon the alveolar bone proper. Extrusion of teeth during orthodontic treatment had no specific effect upon the alveolar bone proper, the bone appeared to follow the tooth, and a constant relationship between the height of the alveolar bone proper and the cemento-enamel junction was maintained. He concluded that in children in good health, the alveolar bone proper follows the tooth as it is moved mesiodistally or occlusally in orthodontic treatment, therefore maintaining a constant relationship between the alveolar bone and the cemento-enamel junction. It was also recorded in his study that this constant relationship is maintained both through bodily movement as well as tipping movement of teeth.

Changes in incisor inclination has been reported to affect points A and B. The findings of the study of **(Al-Abdwani *et al.*, 2009)** demonstrated that 10 degrees change in the maxillary incisor inclination resulted in a statistically significant average change in point A of 0.4 mm in the horizontal plane. Each 10 degrees change in the mandibular incisor inclination resulted in a borderline statistically significant average change in point B of 0.3 mm in the horizontal plane. There were no significant changes in the vertical position of points A and B. The effects of incisal inclination changes, due to orthodontic treatment, are of no clinical relevance to the position of point A and B, even though they may be statistically significant. The validity of points A and B as skeletal landmarks generally holds true, and accounting for treatment changes is unnecessary.

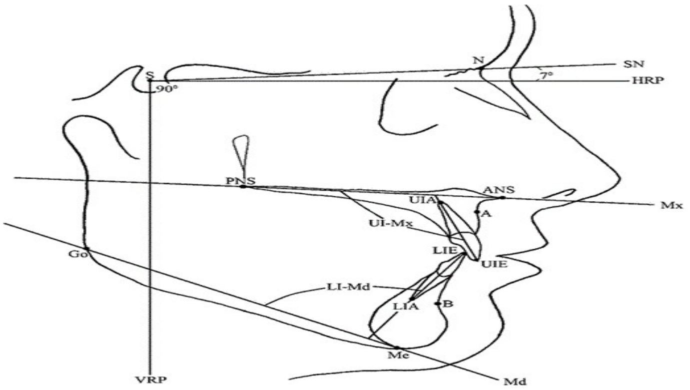

Figure 1-8 Cephalometric landmarks, reference planes, and angular measurements **(David *et al.*, 2009).**

(**Handelman, 1966**) hypothesized that as teeth are repositioned at their anatomic limits, the occurrence and severity of iatrogenic phenomena is enhanced. Thus, it is the occurrence of serious, unfavorable sequelae that may establish the limits of orthodontic treatment and define the borderline case as “orthodontic” or “surgical orthodontic”. He concluded that the width of the anterior alveolus combined with a visualized treatment projection can be used in determining if the borderline patient is best treated via conventional orthodontics or a combined orthodontic-surgical program.

The validity of the postulate “bone traces tooth movement” was examined on 40 Angle Cl II cases. It was hypothesized that a 1:1 cortical bone modeling/tooth movement ratio is preserved during maxillary incisor retraction. The sample was divided into retraction with tip (13 patients), retraction with torque (18 patients), and control (9 patients) groups. Two time point cephalograms were analyzed with two superimposition techniques, SN at S and a newly developed static tooth analysis, with the maxillary left central incisor serving as a reference object. In both retraction with tip and retraction with torque groups, the postulate bone traces tooth movement was not preserved and a bone modeling/tooth movement ratio of 1:2 and 1:2.35 was obtained, respectively. In retraction with tip movement, the apical one third of the root tipped labially reducing the superior area of labial maxillary area by 19%. However, due to the compensating effect of the retraction movement, no apex approximation to the labial cortical plate occurred (eliminating the hazard of root resorption, dehiscence, or fenestration). In retraction with torque movement, the increase in both superior (28%) and inferior (65%) labial maxillary areas was indicative for the hazard of root approximation to the palatal cortical bone. It is recommended to use the 1:2 bone modeling/tooth movement ratio as a guideline to determine the biocompatible range of orthodontic tooth movements. Furthermore, a judicious interplay between the two modes of retraction can prevent major biologic impairment associated with the ratio and can extend the orthodontic range of treatment (**vardimon *et al.*, 1998**).

(Yodthonget *et al.*, 2012) demonstrated that a rapid rate of incisor retraction increased bone thickness at the labial crestal level. The bone-modeling process may not be able to keep up with rapid tooth movement; however, their results indicated that total alveolar bone thickness was maintained. It can be interpreted from this observation that the rate of resorption on the labial aspect is relatively slower than the rate of apposition on the lingual aspect (secondary bone modeling), which may lead to bone prominence.

***** Rapid tooth movement X 1/bone thickness***

Labial bone thickness at the crestal level and total alveolar bone thickness at the apical level significantly increased during upper incisor retraction. The factors related to changes in alveolar bone thickness during incisor retraction were the rate of tooth movement, the degree of inclination change, and the extent of intrusion of the upper incisors.

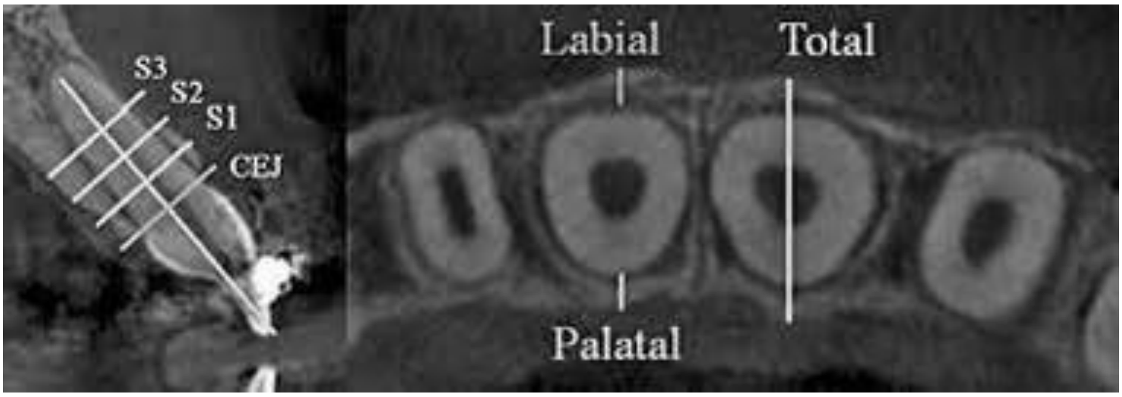

Figure 1-9 Changes in alveolar bone thickness during upper incisor retraction **(Nayak *et al*., 2013).**

It has been suggested that the amount of anterior alveolar bone might increase during orthodontic treatment involving lingual positioning of protrusive teeth (**sarikaya, 2002**).

Other findings regarding the degree of labial alveolar bone change do not support this claim. Apparently, the apposition process in the labial inner cortical plate is somewhat slower than is the resorption process in the labial outer cortical plate. It is clear that either some bone apposition or some plastic deformation of the cortical plates also takes place at the compression site (**Bimstein *et al*., 1990**).

(Guo *et al*., 2021) concluded that alveolar bone height and thickness, especially at the cervical level, decreased during both labial and lingual movement of anterior teeth.

The point of application and the direction of force/a pair of forces determines the tooth movement. In three studies, correlation was found between proclination of incisors and facial bone recession **(Valerio *et al*., 2021) .**

Regarding the dimensions of buccal and lingual bone thickness in anterior region of the mandible, changes in these values after orthodontic treatment may not be detected **(van *et al.*, 2022)**.

CHAPTER TWO

DISCUSSION

In orthodontics, mechanical forces are transferred to the teeth, leading to mechanical loading of the root surrounding periodontal ligament (PDL). Histological evaluations present a tension side associated with bone formation and a compression side coupled with bone resorption. Beside this, modeling of the extracellular matrix is indispensable to generating orthodontic tooth movement (**Landis and Koch, 1977**).

Modeling of the alveolar bone during orthodontic treatment has been considered a useful method for tissue regeneration when there is insufficient alveolar bone (**Ogodscu *et al.*, 1989**).

Two concepts are suggested for orthodontic tooth movement in terms of alveolar bone modeling. The first concept which is called "with the bone" implies that if the alveolar bone is modeled with coordination of resorption and apposition, tooth movement and bone modeling occur at a 1:1 ratio, thus the tooth remains in the alveolar housing. However, if the ratio between tooth movement and bone modeling is not 1:1 and the balance between resorption andapposition of the alveolar bone is not established during tooth movement, the tooth may move out of the alveolar housing, which is referred to as ''through- the-bone'' type of tooth movement (**ahn *et al.*, 2012**).

The concept of bone modeling-to-tooth movement (B/T) has been an issue of investigation in the orthodontics. In cases of non-orthodontic tooth movement, during eruption of the dentition, simultaneous alveolar ridge augmentation occurs as teeth emerge from the alveolar process (**Marks *et al.*, 1983**) It has also been shown that in the presence of inflammatory periodontal disease, tooth movement can actually cause more bone resorption. In this process tooth movement exceeds bony apposition (**Gazit and Lieberman, 1980**) The 1:1 B/T ratio is probably not preserved in pathologic conditions such as over eruption and tooth submergence (**Kurol and Thilander, 1984**) and (**Becker and Karnel-R’em, 1992**) where the ratio is less in the former and greater in the latter.

In regard to changes in the position of point A following maxillary incisor movement, (**Subtelny, 2015**) suggest that labial root torque of the incisors promote development of point A, indicating that point A advancement may bean important adjunct to face mask therapy.

According to (**Meikle, 1980**) producing clinically significant skeletal modelingcan be exercised to avoid destruction of the palatal alveolar cortex during overjet reduction, even where extractions are an essential part of the treatment program. This will be more efficient during growth years when facial skeleton responds to mechanical deformation more readily. For this reason, it may be beneficial to start treatment before all the permanent teeth have erupted.

Excessive retraction of the anterior teeth may result in iatrogenic sequelae such as root resorption, alveolar bone loss, dehiscence, fenestration, and gingival recession (**Wehrbein et al., 1994; Wainwright, 1973**).

CHAPTER THREE

CONCLUSION AND SUGGESTION

Conclusion: -

1) Basal bone does not change following retraction of maxillary incisors.

2) Alveolar bone following incisor tooth movement is greater in labial than lingual side.

3) The change in the angulation of the labial alveolar plate was about 2.5 times more than the palatal alveolar plate.

4) The crestal bone resorption was highly significant in the lingual side and was 5 times greater than that of labial side.

5) Bending of the alveolar process was demonstrated both through increased distance between the labial and lingual crestal reference points and also by significant angular changes of the labial and palatal plates.

Suggestion: -

1) CBCT now allows for a more accurate measurement of the three-dimensional changes that occur to the alveolar bone due to orthodontic tooth movement.

2) A prospective study with a strict criteria and consistent quality of patient records with increased sample size to explore the effect of confounding variables on alveolar bone thickness.

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