

# New Bone Formation during Horizontal Alveolar Distraction Osteogenesis

## Yatay Alveoler Distraksiyon Osteogenezi Tekniğinde Yeni Kemik Oluşumu

### ABSTRACT

Distraction osteogenesis is a method of generating new bone following an osteotomy and gradual distraction. It presents an alternative procedure for the augmentation of atrophic alveolar bone before inserting dental implants. The present study evaluates the bone formation during horizontal alveolar distraction osteogenesis used to expand the edentulous narrow ridges in the posterior region of the mandible. A total of 7 patients with an edentulous narrow alveolar bone ridge in the posterior mandibular region were included in the present study, horizontal alveolar distraction osteogenesis technique was applied to increase the width of alveolar bone. After 4 months of surgery at the time of implants insertion, 7 biopsies (one from each patient) of the regenerative zone were taken with trephine burr for histological analysis. The histological study showed that the interzone was bounded on either side by areas of bone formation that originated from the host bone margins. The newly formed bone consisted of woven bone reinforced by lamellar bone with the presence of bone marrow spaces in the newly formed bone. The activity of the osteoblast differentiation was good to excellent in 6 samples, and poor with intense vascular congestion and inflammation in one sample. Horizontal alveolar distraction osteogenesis successfully inducing the bone formation, and is a reliable technique to expand the narrow alveolar bone.

**Key Words:** Narrow alveolar ridge, Horizontal alveolar distraction osteogenesis, Bone formation, Histology.


### ÖZET

Distraksiyon osteogenezi, bir osteotomi ve aşamalı traksiyon sonrası yeni kemik üretme yöntemidir. Dental implantları yerleştirmeden önce atrofik alveoler kemiğin büyütülmesi için alternatif bir teknik sunar. Bu çalışmada, mandibulanın posterior bölgesindeki dişsiz dar sırtları genişletmek için kullanılan yatay alveolar, distraksiyon osteogenezi sırasında kemik oluşumunu değerlendirir. Posterior mandibular bölgesinde, dişsiz ve dar alveolar kemik sırtına sahip toplam 7 hasta çalışmaya dahil edildi. Alveolar kemiğin genişliğini arttırmak için yatay alveoler distraksiyon osteogenezi tekniği uygulandı. İmplantların yerleştirildiği ameliyattan 4 ay sonra, Rejeneratif bölgenin biyopsisi (her hastadan bir tane) histolojik analiz için trefin burr ile alındı. Histolojik çalışma, interzonun her iki tarafından kemik oluşumu ile sınırlandırıldığını (kemik oluşumu konak kemik sınırlarından kaynaklanır) göstermiştir. Yeni oluşan kemik, lamel kemiği ile güçlendirilmiş dokuma kemikten oluşuyordu ve yeni oluşan kemikte kemik iliği boşlukları tespit edildi. 6 biyopside osteoblast farklılaşmasının etkinliği iyi ila mükemmel arasındaydı, 1 biyopside ise osteoblast farklılaşmasının etkinliği zayıf ayrıca yoğun vasküler konjesyon ve inflamasyon vardı.

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Yatay alveoler distraksiyon osteogenezi, kemik oluşumunu başarılı bir şekilde indükler ve dar alveolar kemiği genişletmek için güvenilir bir tekniktir.

**Anahtar Sözcükler:** Dar alveoler sırt, Yatay alveoler distraksiyon osteogenezi, Kemik oluşumu, Histoloji.

## INTRODUCTION

The alveolar bone suffers atrophy after tooth extraction, which has been well documented (1-3). The size of the residual ridge is reduced most rapidly in the first 6 months, but bone resorption activity in the residual ridge continues throughout life at a slower rate resulting in the removal of large amounts of jaw structure (4).

Following tooth loss, the adjacent bone resorbs to a greater extent horizontally than vertically in the anterior and posterior regions of the mouth (5, 6). The bone loss in the horizontal dimension occurs mainly on the facial aspect of the ridge. The loss of vertical ridge height has been described to be most pronounced on the buccal aspect (6-8). This resorption process results in a narrower and shorter ridge (9).

Sufficient bone volume is a prerequisite for the long-term success of an implant, as it permits correct three-dimensional placement and ensures stability (10). The 1 mm thickness of bone surrounding the implant must be respected, and in cases of very narrow ridges, a surgery for augmentation still is a necessary intervention (11). Some of the most frequently used methods that make possible vertical or horizontal augmentations are osteotome technique, distraction osteogenesis, block bone graft, guided bone regeneration (GBR), and split crest (12).

Distraction osteogenesis (DO), described by Codivilla, is a biological process that stimulates the formation of new bone following the gradual separation of two bone segments previously joined together (13).

Distraction osteogenesis is of considerable interest to clinicians because of its unique ability to regenerate bone and soft tissues simultaneously, and the possibility of avoiding bone grafts. It does not carry the unnecessary weight of complications of graft and membrane exposure or inadequate tissue coverage, therefore making the distraction procedure an ideal technique for bone augmentation in implantology (14,15).

Alveolar distraction osteogenesis was first reported

by Chin and Toth in 1996 (16) and now is considered an alternative method for reconstructing alveolar atrophy (17). However, most reports on distraction osteogenesis for alveolar processes have dealt with vertical DO (18).

The purpose of this study was to evaluate the bone formation during horizontal alveolar distraction osteogenesis used to expand the edentulous narrow posterior mandibular alveolar ridges

## MATERIAL AND METHODS

A total of 7 patients (1 male, 6 females, with a mean age of 39,5 years) with an edentulous narrow alveolar bone ridge in the posterior mandibular region were included in the present study, distraction osteogenesis technique was applied to all patients to increase the width of alveolar bone before dental implants insertion.

### Inclusion criteria

Horizontal alveolar distraction osteogenesis technique is similar to the alveolar split technique but without the graft. So, inclusion criteria included: a minimum ridge width of 3.0 mm is preferred with a minimum bone height of 10 mm and the absence of any facial bone concavities. In addition to, absence of any systemic diseases including those affect bone healing, no previous radio or chemotherapy, the absence of any disease in soft tissue over the surgical site and the patient should not be smoky or alcoholic with good oral hygiene.

Patients gave informed consent, and approval of the Scientific Research Committee of Damascus University was obtained (registration number 1467).

### Surgical technique

After the clinical and radiographic preoperative assessment, the surgery was done under local anesthesia (2% lidocaine with epinephrine). The partial-thickness flap with minimal mucoperiosteal stripping was used to preserve the blood supply to the buccal plate. A midcrestal osteotomy and two vertical cuts on the proximal and distal ends of the midcrestal osteotomy were performed. The splitting was performed using chisels with a depth between 6-8 mm, and at least 2 mm of bone was maintained over the inferior mandibular canal, then the distractor was fixed. Wound closure was performed using 3-0 silk sutures. Antibiotic and non-

steroidal inflammatory drugs were prescribed. Postoperative instructions included a soft diet and appropriate oral hygiene with a chlorhexidine mouth rinse.

The distractor was made by the author, and it consists of 4 arms, 2 on each side connected with the body which included an activating distraction screw. The arms are inserted inside the space of the splitting, and by rotating the activating screw, the pair of arms move apart.

After 7 days (the latency period), the sutures were removed and the activation of the distraction device started (distraction period). A distraction of 0.75 mm/day (subdivided into activations of 0.25 mm) was performed for 6 days. The distractor was then maintained in position for 6 weeks (consolidation period) then removed.

### Biopsy

After 4 months of surgery (2,5 months after the removal of the distractors) at the time of implants insertion, 7 biopsies (one from each patient) were taken. The alveolar bone crests were exposed and biopsies of the regenerative zone were taken (at the middle of the alveolar bone crest) by trephine bur (outside diameter 2.7, inside diameter 2 mm) (Figure 1-3). The biopsies were immediately embedded in fixative solution (10% formalin) and sent to the department of oral histology and histopathology - Damascus University for histological analysis.



**Figure 1:** The trephine bur.



**Figure 2:** Harvesting the biopsy.



**Figure 3:** The biopsy.

### Histological examination

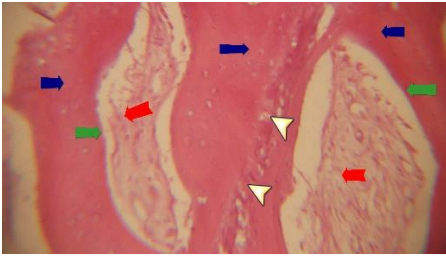
The biopsies were prepared by hematoxylin and eosin staining and examined using light microscopy. The following measurements were studied:

- 1- Degree of osteoblast differentiation which classified into: less than normal, normal, and excessive.
- 2-Vascular congestion: 1) not exist: the blood is not seen in the blood vessels, 2) slight: there is blood collection in the blood vessels, 3) intense: there is oozing from blood vessels.
- 3- Inflammation (exist or not exist) and it is defined by its signs like inflammatory cells and vascular congestion.

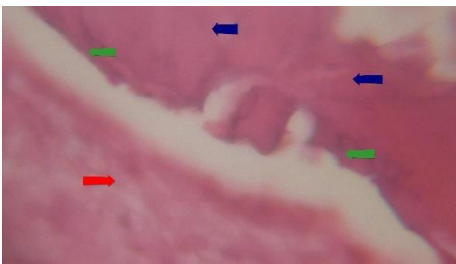
### RESULTS

The histological study showed that the interzone was bounded on either side by areas of bone formation that originated from the host bone margins. The overall orientation of the bone appeared to be in the direction of the distraction force. The new bone in the distraction region consisted of woven bone reinforced by lamellar bone with the presence of bone marrow spaces in the newly formed bone that can be identified. A solid union of new bone has formed across the distraction gap.

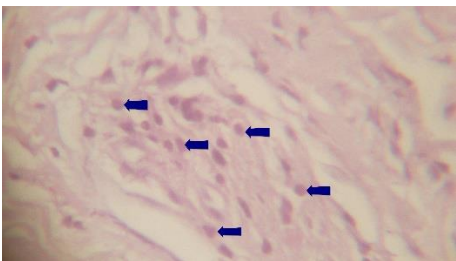
The new bone formation with good (normal) to the excellent activity of the osteoblast differentiation identified in 6 samples (figure 4,5), in two samples of them slight vascular congestion was noticed. In 1 sample the new bone formation and the activity of osteoblast differentiation were poor with intense vascular congestion and inflammation (figure 6) (Table 1-3).



**Figure 4:** Bone formation and osteoblast differentiation: The blue arrows indicate the newly formed waven bone. The green arrows indicate the osteoblast differentiation. The red arrows indicate the fibrous tissue converted to bone marrow spaces. The yellow arrows indicate the central zone.



**Figure 5:** Bone formation and osteoblast differentiation: the blue arrows indicate the lamellar bone. The green arrows indicate the waven bone. The red arrows indicate the fibrous tissue.



**Figure 6:** The inflammation: the arrows indicate the inflammatory cells (lymphatic cells).

**Table 1**

Osteoblast Differentiation		
Less than normal	Normal	Excessive
1	5	1

**Table 2**

Vascular Congestion		
Not exist	Slight	Intense
4	2	1

**Table 3**

Inflammation	
Not exist	Exist
6	1

## DISCUSSION

Distraction Osteogenesis is a biological process of regenerating new formed bone and adjacent soft tissue by gradual and controlled traction of the surgically separated bone segments (19).

Distraction osteogenesis, originally developed for the orthopedic field (13,20) and later applied to the maxillofacial region for the correction of severe craniofacial malformations (21). This technique introduced to correct vertical defects of the alveolar ridge to improve bone volume for dental implant placement by Chin and Toth in 1996 (16). While the use of distraction to gain alveolar width, first reported by Aparicio and Jensen 2002 (22).

Distraction Osteogenesis consists of an osteotomy cut, latency period, distraction period, consolidation period (23). After osteotomy, a blood clot is formed between both bone segments and begins to organize during the following days (latency period), a process that is similar after a fracture. During the distraction phase, tensile forces are applied to the callus with a specific rate and rhythm. As the callus is stretched, a central fibrous zone, called the fibrous interzone forms and characterized by active chondrocyte-like cells, osteoblasts, and fibroblasts. Once the desired bone length is achieved, distraction ceases, marking the beginning of the consolidation phase, where the bone and extensive amounts of osteoid undergo mineralization and eventual remodeling, resulting in the osseous union of the distraction gap (24,25).

In the review of Pérez-Sayáns et al. 20018, they found that most of the studies of alveolar distraction osteogenesis used a latency period of 7 days, with an average of 6.55 (4-10) days. The mean distraction frequency was 0.88mm (0.375-1mm) per day. The mean activation rhythm was 2.14 (1-4) times per day. The average consolidation period of the reviewed studies was 2.87 (1-5) months (26).

In the review of Saulacic et al. 2008, they found that the mean latency period was  $7.26 \pm 2.31$  days (latency period of 7 days was used in 136 cases to permit healing of mucoperiosteum and reduce the risk of wound dehiscence). The distraction rate  $0.71 \pm 0.27$  mm/day, the rhythm of distraction ranged between 1-4 times daily. The mean distraction distance reported was  $6.88 \pm 2.52$  mm and consolidation period  $12.22 \pm 5.58$  weeks (27).

In the present study, the horizontal alveolar distraction osteogenesis was applied to increase the alveolar bone width in the posterior mandibular region to evaluate the new bone formation. In this study, a latency period of 7 days, the distraction rate of 0.75 mm per day, and activation rhythm of 3 times per day for 6 days and the consolidation period of 6 weeks were chosen. The biopsies were taken after 4 months of surgery (2.5 months after the removal of the distractor) at the time of implants insertion.

The results of this study showed that the interzone was bounded on either side by areas of bone formation that originated from the host bone margins, and in 6 samples the new bone formation and the activity of osteoblast differentiation were good (normal) to excellent. It is thought that the new bone formation as a result of distraction is related to the stimulatory effect of tension on angiogenesis and bone-forming cells (12). During the active phase of distraction, a cascade of biological process is demonstrated to occur in the response of mechanical loading which includes cellular differentiation, the formation of new vascular elements, formation, and mineralization of bone matrix and functional bone remodeling (28-31).

In one sample of this study, the bone formation and the activity of osteoblast differentiation were poor with intense vascular congestion and inflammation. It thought that the poor bone formation is may related to the extensive decrease in the initial width of the alveolar bone in this case which was 2.7 mm, and this means a little amount of spongy bone and less vascularization between the cortical plates. The distraction osteogenesis is a process dependent upon the two main factors the adequacy of the local blood supply and stimulating effect, and adequate blood supply to the distraction site is critical to osteogenesis (32). Amir et al. 2006 found in vertical alveolar distraction osteogenesis that in patients with minimal vascularization of the transport bone segment, the new bone was very poorly developed (33). The other possible reason is the inflammation, the recent studies have shown that proinflammatory cytokines not only induce bone resorption but also contribute to bone loss by direct inhibition of osteoblast differentiation (34). The reason for the inflammation may be a low infection during the distraction period or mechanical injury, because clinically there were no obvious signs or symptoms, and did not affect the course of the following stages. The infection rate during alveolar distraction osteogenesis is 3.94%, and it is considered as one of the minor complications,

and the resolution of these minor complications is simple and doesn't hinder the final result of the technique (26).

The results of this study agree with those obtained by Consolo et al. 2000 (35), Zaffe et al. 2002 (36), Chiapasco et al. 2006 (37), Amir et al. 2006 (33) and Türker et al 2007(38).

## CONCLUSION

The results of this study showed that the horizontal alveolar distraction osteogenesis is a reliable technique to expand the narrow alveolar bone. It successfully induced the bone formation and the newly formed bone seems to withstand the functional demands of implant loading.

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