Review

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Evaluation of the efficacy of horizontal distraction osteogenesis using expansion screws in the repair of the acquired jaw bone defects

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Background: Restoration of the segmental defects of the maxilla presents a reconstructive dare to obtain a perfect osseous form and height. A variety of prosthetic and surgical bone grafts exists, that produces less than optimal results. Bone transport distraction is a dependable procedure in several maxillofacial bone defects reconstruction techniques. This study aimed to evaluate the effectiveness of horizontal distraction osteogenesis (DO) using expansion screws for the treatment of atrophic and deficient bone, which is caused by acquired malformations.

Material and methods: A total of eight patients (age 17–36 years) who came with atrophy of the maxilla were treated by horizontal DO. The used device consisted of two parts: one was an orthodontic expander and the other was a screw-ring. The expansion screws were set on the transport bone, which was osteotomized and fixed to the segments using microscrews. Radiographical documentation of the patients was obtained with cone beam computed tomography prior to the surgery and after 4 months of the distraction phase.

Results: The average of the actual bone gain at the end of the consolidation period was 7 mm (range 5–9 mm). Intraoral DO failed in one patient. The average bone density in the distraction gap after 4 months of the DO was 460.40. The average bone density of the bone defect region after 4 months of the DO was 487.90

Conclusion: Our results confirm that horizontal DO using expansion screws is a predictable and effective regenerative procedure for patients with acquired bone defects in the jaw.

Keywords: Acquired, distraction osteogenesis, expansion screws, transport segment

Introduction

Background and objectives

Restoration of the segmental defects of the maxilla presents a reconstructive dare to obtain a perfect osseous form and height with good soft tissue investing. However, a variety of prosthetic and surgical bone grafts exists, that produces less than optimal results. Graft failure sometimes occurs due to inadequate covering with the surrounding soft tissue, inappropriate patient age, or the size of the defect[1].

Distraction osteogenesis (DO) is a tissue engineering way to restore a new bone. The use of DO in the turf of oral and maxillofacial surgery has provided a favorable alternative as it can be combined with conventional surgical techniques for bone lengthening. This method has the benefits of providing a higher amount of bone lengthening, thus reducing the need of autogenous grafts and donor site morbidity. This can be useful in young patients and allows simultaneous increase of the surrounding soft tissues[2].

The process of bone renewal involves a compound system of biotic changes whereby mechanical stress is changed into a chute of signals that stimulate cellular conduct resulting in the creation of the bone[3].

Gradual traction on living tissues makes stresses that can motivate regeneration and active growth of the tissues involved[4,5].

In the maxillofacial area, the first clinical application of DO was started by McCarthy in 1992 for mandibular lengthening. The success of this application has paved the way for many other maxillofacial DO indications involving other areas such as the alveolar ridge, maxilla, and midface[2].

DO includes three serial phases; latency, distraction, and the consolidation phase[6].

HIGHLIGHTS

- This technique provides a new and effective intervention for repair alveolar bone defects by alveolar tansport distraction osteogenesis on the adjacent side.
- We used expansion screws for that.
- This technique is a predictable and effective regenerative procedure for patients with acquired alveolar bone defects to obtain a new bone with a good density in a good time with a relatively low economic cost.

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Latency period

The latency phase is a period between the osteotomy and the distraction. It signifies the time allowed for callus formation. Ilizarov recommended 5–7 days.

Distraction period

The distraction phase is a period after the end of the latency when the distractor is activated by the gradual traction on the callus tissue which is formed between the osteotomized bone segments. Ilizarov suggested that the rate of distraction of 1 mm per day as the optimal rate for bone regeneration during DO[6].

Consolidation period

The Consolidation phase is a period after the end of the distraction when the distractor is left in position to provide physical support to the osseous gap; this phase represents the period required for the maturation of the bone formed in the gap that will attach the two bone segments[6].

Clinical uses of distraction osteogenesis

This procedure may be used for: lengthening, widening, deformity correction, bone transport, and alveolar ridge augmentation of the mandible and maxillary bone, in both congenital and acquired conditions[7].

Material and methods

Study design, and participants

This study is a prospective single-arm, open-label clinical trial that was conducted during the past 2 years (from 2021 to 2022) in the department of oral and maxillofacial surgery at Tishreen University Hospital. Patient exclusion standards : smokers (more than 20 cigarettes daily); uncontrolled diabetes; reduced oral hygiene; and noncompliant patients. Radiographical documentation of the patients was obtained with cone beam computed tomography (CBCT) prior to the surgery and after 4 months of the distraction phase.

Research sample

A total of eight patients (six men and two women; age 17–36 years) who came to the department of oral and maxillofacial surgery at Tishreen University Hospital, with atrophy of the maxilla were treated by alveolar transport DO. The patients submitted written consent and filled out the appropriate research forms for participating in this study.

The device used for distraction osteogenesis in the research

The device consisted of two parts: one was an orthodontic expander and the other was a screw-ring. In this alveolar transport method, bone was distracted in the defect direction by osteotomy of bone adjacent to the bone defect (Fig.1).

Surgical technique

The procedure was performed under general or local anesthesia depending on the patient's condition. A horizontal incision on the top of the alveolar bone was made followed by a vertical incision on the mesial or distal margins. The labial surface of the bone was exposed. A vertical osteotomy was done using a reciprocating saw, used carefully not to hurt the roots of the adjacent teeth. A horizontal osteotomy above the root apices to the depth of the buccal plate was performed using a reciprocating bone saw (Fig. 2). Once the horizontal osteotomy through the labial plate was taken, we made punch holes at a depth through the palatal surface and completed the cut using the surgical hammer and scalpel, cautious not to hurt the palatal mucoperiosteum and then we closed the wound using silk sutures. The expansion screw device was set on the transport bone and fixed to the segments using titanium microscrews. The distractor was fixed in the desired position by one or two screws on both sides of the vertical osteotomy line on the bone (Fig. 3).

Figure 1. The device used for distraction osteogenesis.

Postoperative protocol

All patients were given 1 g of ceftriaxone sodium intravenously preoperatively and then 1000 mg of amoxicillin/clavulanate orally for 5 days. The postsurgical orders comprised a soft diet

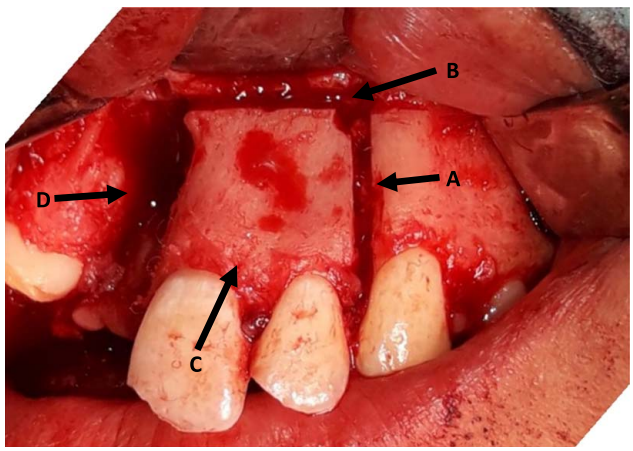

Figure 2. (A) Vertical osteotomy. (B) Horizontal osteotomy. (C) Transport segment. (D) Bone defect region.

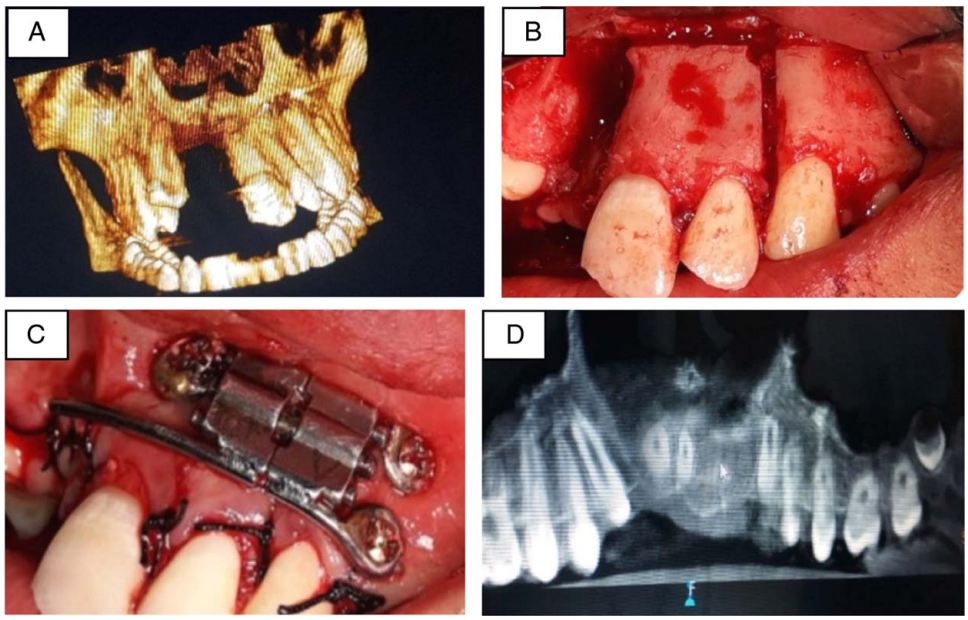

Figure 3. (A) preoperative 3D CT showing the bony defect. (B) Intra operative picture showing the transport segment. (C) The expansion screw device was set on the transport bone and fixed to the segment using titanium microscrews. (D) Post distraction CT showing consolidating distraction regenerate.

and 0.12% chlorhexidine mouth solutions for oral hygiene. The latency period was 3–7 days, the expansion screw was activated 0.5 mm twice daily. The motivation of the expansion screw was continual until the target quantity was achieved. The average of the distraction period was 12 days (range 10—14 days). The consolidation stage was 4 months then the devices were removed. CBCT of patients was taken after removing the devices for measuring the bone gain and the quality of the new bone (Fig. 4). The average bone density and bone gain was measured by CS 3D imaging software. The horizontal bone gain was calculated by measuring the length of the acquired bone in the predefined loss area through a CBCT image. The vertical bone gain was calculated by measuring the distance between the top of the alveolar ridge and unchangeable anatomical points on the CBCT images, which were (the floor of the maxillary sinus in the posterior region and the floor of the nasal cavity in the anterior region) before and after 4 months of surgery.

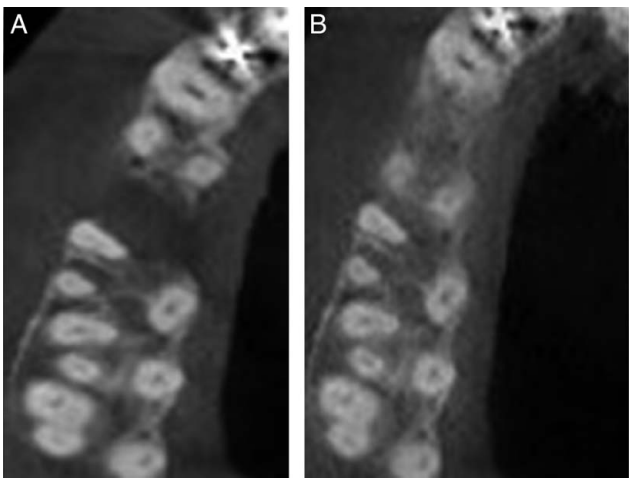

Figure 4. (A) preoperative cone beam computed tomography showing the bony defect. (B) Post distraction cone beam computed tomography showing consolidating distraction regenerate.

To measure bone density in CBCT, we followed these steps:

1. We started the CBCT scan in the imaging software.
2. We chose a specific region of interest (ROI) within the bone that we wanted to measure.
3. We used the software's measurement tool to draw a line in the ROI.
4. The software displayed the housfield units value associated with the ROI. This value represented the bone density within the ROI.
5. We repeated the steps on different ROIs within the same bone to get the average of the bone density.

Results

The average of the actual horizontal bone gain at the end of the consolidation period was 7 mm (range 5–9 mm). The average of the actual vertical bone gain at the end of the consolidation period was 8 mm (range 5–11 mm).

In seven of eight patients the procedure was successful without any complications. In one case, dehiscence of the transport segment happened and the appliance was removed. The dehiscent bone was removed carefully by a round-bur and the area was enclosed with the mucosa. The patients were trained to wash their mouth daily by chlorhexidine chloride solution.

We noted simple gingival recession of the teeth inside segmental transport (0.2–0.5) mm in two patients.

The average bone density of the bone defect region before the DO was 0. The average bone density of the bone defect region after 4 months of the DO was 487.90, and this value represents the average bone density of the transport segment to the bone defect region after 4 months of the DO. The average bone density

Table 1

Averages of the bone density

	N	Minimum	Maximum	Average	SD
Bone density of the transport segment before DO.	8	396.33	600.00	522.08	94.69
Bone density of the transport segment after DO.	8	373.30	595.00	487.90	90.86
Bone density of the bone defect region before DO.	8	00	00	0.0000	0.0000
Bone density of the bone defect region after DO.	8	373.30	595.00	487.90	90.86
Bone density of the distraction gap after DO (4 months).	8	345.30	540.00	460.40	82.107
Bone density of the adjacent nonmanipulated bone.	8	390	597	509.62	
Valid N(listwise).	8				

of the transport segment before the DO was 522.08. The average bone density of the distraction gap (which was formed between the osteotomized bone segments) after 4 months of the DO was 460.40. The average bone density of the adjacent nonmanipulated bone was 509.62 (Table 1).

Discussion

Alveolar bone defects resulting from trauma, large cyst resection, and facial deformities produce great esthetic functional problems and have remained a serious challenge for surgical restoration. The surgical management of alveolar bone defects is important to restore functional occlusion, esthetic improvement, and improvement of the oral environment. A traditional method with autogenous nonvascularized bone grafts and microvascular grafts causes donor position morbidity, a form and a height less than what is required for sufficient dental restoration. Also, fibrosis surrounding the graft can cause a poor vascular source resulting in greater chances of wound dehiscence and bone resorption[8].

DO is an inventive technique used to avoid donor site morbidity and complications with soft tissue coverage and narrow augmentation[9]. We tried to repair alveolar bone defects by alveolar transport DO on the adjacent side.

There are conventional devices for DO in the maxillofacial region. We did not use those appliances because of their exorbitant price and they need another surgical intervention for flaps lifting and removing screws, so we used expansion screws for that. The device consisted of two parts: one was an orthodontic expander and the other was a screw-ring. The assessment of the special effects of expansion devices with the aid of CBCT aids researchers to classify the effects of expansion screws[10].

Ipsit Trivedi[10] found an important increase in the opening of the mid palatal suture using bone anchored expansion devices without any injury on teeth compared to conventional expansions. In our method, the expansion screws achieved elongation of the bone and soft tissues without hurting the teeth.

With DO using this device, the elongation of the soft tissues involved the keratinized tissue. This is likely because a crestal incision was made within the keratinized tissue in our method, which avoids the need for surgery to acquire keratinized tissue for cosmetic purposes. Kensuke Yamauchi *et al.*[11] reported that the elongation of the soft tissues involves mainly the movable mucous membrane in conventional bone grafts.

In our method, we noted simple gingival recession of the teeth inside segmental transport (0.2–0.5) mm in two patients that is may be caused by application expansion screws over soft tissues and the tension of screws.

In an experimental study of horizontal DO, mature lamellar bone was observed at 24 weeks. In addition, most of the transport segment was absorbed[12]. This resorption of the transport segment probably occurred because the periosteum was completely reflected from the transport segment. In our study, we observed mature bone at 16 weeks and the transport segment was not absorbed because the transport segment was preserved and connected to the lingual or palatal mucoperiosteum.

The average of the actual horizontal bone gain at the end of the consolidation period was 7 mm (range 5–9 mm). The average of the actual vertical bone gain at the end of the consolidation period was 8 mm (range 5–11 mm). The quantity of distraction activation tends to be more than the estimated quantity and the actual gain of bone. The quantity of new bone gain should be based on the size of the transport segments.

In one case, dehiscence of the transport segment happened because of poor oral hygiene, so the appliance was removed. Thus, postoperative oral care is important.

The average bone density of the alveolar bone defect region after 4 months of the DO was 487.90. The average bone density of the distraction gap after 4 months of the DO was 460.40. According to the Hounsfield Scale, bone quality is considered good (D3) and suitable for implantation.

We did not observe an important difference between the average bone densities we got and the average bone density of the adjacent nonmanipulated bone. Also, we did not observe an important difference between the average bone density of the transport segment before and after the DO because the transport segments preserved the palatal or lingual mucoperiosteum. In addition, the degree and frequency of the distraction was suitable. The reason of this simple difference between the average of bone density of the transport segment seems to be the surgical trauma, including flap elevation and osteotomy.

Conclusion

Our results confirm that horizontal DO using expansion screws is a predictable and effective regenerative procedure for patients with acquired alveolar bony defects to obtain new bone with a good density in a good time with a relatively low economic cost.

Ethical approval

The approval of the ethics committee for research was obtained. The protocol of the study had been approved by the ethics committee of the collage of Dentistry Research Center at the university under approval (538) during session (6).

Consent

Informed consent was obtained from patients and it is available from the corresponding author upon reasonable request.

Sources of funding

No funding was obtained for this study.

Author contribution

All authors have approved the final draft of the manuscript.

Conflicts of interest disclosure

All authors declare no conflict of interest.

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Data availability statement

All data and material collected during this study are available from the corresponding author upon reasonable request.

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