Review

ALVEOLAR DISTRACTION OSTEOGENESIS FOR ALVEOLAR RIDGE DEFICIENCY: AN UPDATE AND NEW PERSPECTIVES

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ABSTRACT

Alveolar osteogenic distraction is a bone regeneration technique used in implantology to prepare implant sites, which, through the slow and constant distraction of a bone segment, allows the simultaneous regeneration of hard and soft tissues. The purpose of this review is to analyze the most recent articles in the literature and evaluate the role of modern piezoelectric surgery techniques, guided surgery, and invisible orthodontics. A search was conducted on the Pubmed platform. The initial selection was based on the title and abstract. Subsequently, the articles included in the study were chosen by reading the full text. The mean latency period was 7.26±2.31 days. The mean distraction rate was 0.71±0.27 mm, with one, two, or four daily activations. The mean distraction distance reported was 6.88±2.52 mm. The mean consolidation period was 12.22±5.58 weeks. The average period of osseointegration was 4.59±1.34 months. The overall survival rate of the implants was 97%. Alveolar osteogenic distraction represents a predictable technique for bone regeneration. With the support of guided surgery, piezoelectric instruments, and new invisible bone traction devices, this technique can become even more predictable, minimally invasive, and increasingly aesthetic.

KEYWORDS: *distraction osteogenesis, alveolar ridge augmentation, piezoelectric surgery, guided surgery, aligners*

INTRODUCTION

In recent years, dental implants have significantly rehabilitated edentulous people, partially or totally. However, they require adequate bone volume for the correct positioning of the implants. Today, in the case of insufficient bone volume, the possible solutions are the use of short implants or bone regeneration. In regards to bone regeneration, various methodologies are available: GBR, autologous or heterologous bone grafts, ridge splitting, and alveolar osteogenic distraction (ADO).

ADO is a technique by which it is possible to regenerate bone through the distraction of two bone fragments following an osteotomy. The method is based on the tension-stress principle described for the first time by Dr Ilizarov (1,

Received: 19 April 2024
Accepted: 10 May 2024

2), who conducted a series of experiments on the canine tibia to evaluate the optimal conditions for osteogenesis during limb lengthening, changes in the soft tissues subjected to lengthening and assess the influence of both speed and frequency of distraction. Ilizarov established two principles: the tension-stress principle, according to which when two bone segments are moved apart, there is pressure acting on one side and tension on the other, stimulating the action of osteoblasts, resulting in the generation of new bone; the influence of mechanical load and blood supply.

Following Ilizarov's principles, osteogenic distraction was applied in the human mandible and maxilla. The method was first clinically performed in 1992 by McCarthy and colleagues on hypoplastic mandibles of syndromic children (3).

The gradual distraction of the bone segment is followed simultaneously by osteogenesis (hard tissue formation) and histogenesis (soft tissue formation), as it determines stem cell differentiation, angiogenesis, and mineralization (4-6). This leads to a reduction in the treatment time and a more rapid placement of the implants, which show success rates similar to those inserted in native bone (7, 8).

ADO devices are divided into extraosseous, intraosseous, and distraction by implants. Extraosseous devices are the most used devices. Intraosseous distraction and distraction by implants require abundant basal bone for support (9).

MATERIALS AND METHODS

A search was conducted on the Pubmed platform. The search strategy was as follows: (“osteogenesis distraction” OR “distraction osteogenesis” OR “alveolar distraction osteogenesis” OR “alveolar distraction” AND “alveolar bone loss” OR “jaw atrophy” OR “atrophic jaw” OR “alveolar ridge deficiency”). An initial selection was based on the title and abstract. Subsequently, the articles included in the study were chosen by reading the full text.

RESULTS

After selecting studies by title and abstract, all articles were read in their entirety, and only 25 studies were considered for the current study.

The mean latency period is 7.26±2.31 days (range 4-21 days). The mean distraction rate is 0.71±0.27 mm (range 0.25-1 mm). The distraction rate varies between one, two, and four daily activations. The mean distraction distance reported was 6.88±2.52 mm (range 3-15 mm). The mean consolidation period was 12.22±5.58 weeks (range 4-24 weeks). The mean osseointegration period was 4.59±1.34 months (range 3-8 months). The overall survival rate of the implants was 97% (10).

DISCUSSION

Alveolar osteogenic distraction consists of the following steps:

1. *Osteotomy and distractor placement*: surgical separation of the bone into two segments following the preparation of a flap (Fig. 1-3). It occurs by making two vertical incisions and one horizontal, creating a trapezoidal bone segment capable of moving. In the past, it was made with an oscillating saw, rotary instruments, or osteotomes. Today, the piezoelectric device is preferred, which uses ultrasonic vibrations to perform precision osteotomies (11-16). This results in a discontinuity in the integrity of the bone, which will trigger a healing process for the fracture, leading to a new bone callus. After the osteotomy, the bone distraction device is positioned, and the flap is closed and sutured.

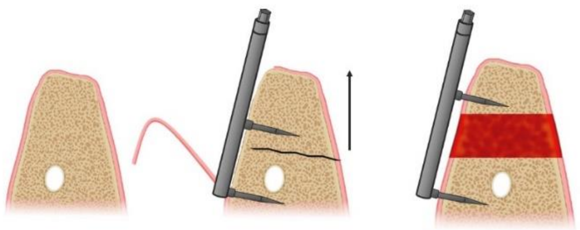

Fig. 1. *Example of a distraction device used.*

Fig. 2. *The alveolar distraction procedure in the anterior mandible.*

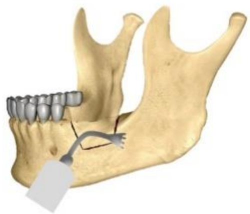

Fig. 3. *The alveolar distraction procedure in the posterior mandible.*

2. *Latency period*: the period between the osteotomy and the activation of the distractor. It represents the time required for the repair callus to form. Ilizarov's experiments showed that the latency period must be at least 5 days. The average latency period is 7 days to allow healing of the mucoperiosteum and reduce the risk of dehiscence. Prolonged latency periods exceeding 15 days have been applied to ensure complete revascularization of the transport segment in cases where the mucoperiosteal pedicle is small or endangered (10).
3. *Distraction*: the process of separating the two bone segments using a mechanical device that applies a pulling force. The normal healing process of the fracture is interrupted, and the biological processes of angiogenesis, fibroblast proliferation, and intensification of biosynthetic activity are stimulated (17). The quantity of bone to be distracted depends on the amount of bone necessary for implant rehabilitation (18). In addition to the amount of bone to be distracted, two fundamental parameters are:
    a. *Distraction rate*: the amount of bone distracted per day. The mean distraction rate is 0.71 mm (10). A distraction rate of 0.5 mm per day results in faster osteogenesis than a distraction rate of 1 mm in elderly patients (19).
    b. *Distraction rhythm:* the number of distractor activations per day. This parameter has tended to be chosen empirically, partly due to the lack of data in the literature. The rate of distraction varies between one, two, and four activations per day (10).

    Distraction continues until the desired bone volume is achieved, and the total amount of distraction varies from 10 to 15 mm (17).
4. *Consolidation period*: the period following the distraction in which the complete mineralization of the new bone callus occurs. The mean consolidation period is 12 weeks (10). At least 10 weeks are required for the new bone to fill a 10 mm distraction gap (20).
5. *Distractor removal and implant placement*: Implants are placed 4 weeks after the distraction device is removed, with a 12-week osseointegration period (10).

It should be added that there is a phase of callus remodeling that begins upon completion of distraction, continues during the consolidation phase, and may extend up to 1 year after completion of distraction. In this phase, the initially formed bone scaffold is reinforced by parallel fibers of lamellar bone (18).

The main advantages of ADO are predictability, simultaneous regeneration of hard and soft tissues, and reduction of treatment times. On the other hand, the disadvantages are the need for greater collaboration with the patient, a greater number of visits, and higher costs (21). Furthermore, it is not a technique free from possible complications, the most frequent of which are malposition of the distracted segment, resorption of the distracted segment, fracture of the distractor or basal bone, local infection, and loss of the vestibule (22-25). However, this method could be too invasive for the patient, leading him to opt for different alternatives for aesthetic reasons, mainly due to the discomfort caused by unaesthetic obsolete devices.

Today, the new technologies at our disposal can represent a new frontier for alveolar osteogenic distraction, making it less invasive, shortening intervention times, and making the dentist's work easier. To carry out corticotomy, the piezoelectric device is preferred, thus reducing the aggressiveness of the operation, improving the visibility of the operating field, and reducing the risks of damage to the anatomical structures. Furthermore, the piezoelectric device reduces complications such as incomplete lingual osteotomy, laceration of the lingual periosteum, and injury to the inferior alveolar nerve (12).

A new frontier is also represented by guided surgery. In fact, after carrying out a CBCT, it is possible to design the case digitally. This will lead to the creation of surgical guides that can be used to carry out guided corticotomies and insertion according to the correct axis of the distraction device (26, 27). Morever, using a surgical guide and corticotomies allows one to perform a flap-less operation, further improving patient compliance. Furthermore, this makes the latency period no longer necessary since waiting for the soft tissues to heal is unnecessary.

Concerning distraction devices, to meet the aesthetic requests of patients, it is imaginable to create a customized mini-device to obtain vertical growth on the model of palate expanders, with palatal or lingual anchoring for aesthetic needs. Since the device is entirely external, it significantly reduces the invasiveness of the operation.

Furthermore, possible support could be represented by invisible masks on the model of transparent removable aligners, which could guide the direction of the bone segment's distraction with precision and allow distraction with well-defined timing. Alternatively, invisible aligners could be used once distraction has ended during consolidation to stabilize the bone callus during the mineralization and remodeling processes.

CONCLUSIONS

Alveolar osteogenic distraction represents a predictable technique for bone regeneration. ADO results in a more stable outcome than GBR and block graft, but relapse is observed in 3% to 20% of cases. Therefore, an overcorrection of a few millimeters should be considered. This overcorrection can be easily reduced when removing the device and positioning the implant (9). With the support of guided surgery, piezoelectric instruments, and new invisible bone traction devices, this technique can become even more predictable, minimally invasive, and increasingly less aesthetic. The next step of this study will be patient testing to validate a new operating protocol that is effective and aesthetically accepted by the patient.

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