

The use of distraction osteogenesis in oral and maxillofacial surgery



INTRODUCTION

Distraction osteogenesis (DO) is a method of generating new bone following a corticotomy or an osteotomy and gradual distraction. The method is based on the tension-stress principle proposed by Ilizarov.^[1,2] The gradual bone distraction creates mechanical stimulation which induces biological responses and consequently bone regeneration. This is accomplished by a cascade of biological processes which may include differentiation of pluripotential cells, angiogenesis, osteogenesis, and bone mineralization.^[3-5] In facial bones, the method was proved to be predictable in animal studies with the generation of new bone^[4,5] and was later used in clinical practice.

The use of DO in oral and maxillofacial surgery (OMS) has increased enormously in the last two decades especially for severe bone deficiency such as: (1) Deficient maxilla or midface, (2) deficient hypoplastic mandible, and (3) deficient alveolar bone prior to implants placement.

Distraction osteogenesis includes four steps:

- Corticotomy or osteotomy and placement of the distraction devices
- Latency period of several days for callous organization
- Gradual distraction at a rate of 0.5–1 mm per day
- Retention/consolidation period of several months for callus maturation and mineralization.

We describe here, the current applications of DO in OMS upon the authors' experience and based on the literature.

DEFICIENT MAXILLA OR MIDFACE

Correction of the hypoplastic maxilla secondary to cleft patients is a great challenge due to a significant vertical and horizontal deficiency and difficulty in mobilizing the hypoplastic maxilla due to scarring from previous operations in the soft and hard palate or after lip closure. In addition, there is a great tendency for relapse following the major movements which are required.

In the maxilla and midface, the main uses of DO are for the treatment of a hypoplastic maxilla in cleft patients by Le Fort I^[6] and midface hypoplasia, as in Crouzon syndrome, by Le Fort III distraction using external or internal devices.^[7]

The RED system (Rigid External Distraction, KLS Martin, Tuttlingen, Germany) uses a halo anchored to the skull. An adjustable distraction system is attached to the halo. The RED system offers greater distraction length, permits to perform the osteotomy in a hypoplastic deficient bone, has the possibility to change the distraction vector during the lengthening period, offers a control on the vector of lengthening, and is easily removed by unscrewing the pins. However, it is uncomfortable for the patient to wear the device for several months, the device is exposed to external trauma forces during that period and there is a risk of parietal bone penetration.

Internal distraction devices (IDD) are fixated directly to the bone. They are safer to wear for a period of several months, do not create social discomfort and, therefore, permit longer retention periods which may contribute to better stability than external devices. However, their major disadvantage is that they require a second operation under general anesthesia for device removal.

DEFICIENT HYPOPLASTIC MANDIBLE

Mandibular distraction may be used for unilateral or bilateral mandibular deficiencies. Unilateral mandibular distraction is used for unilateral deficiency as in hemifacial microsomia (HFM). Bilateral mandibular deficiency may be a manifestation of congenital craniofacial malformations such as Pierre-Robin sequence or Treacher Collins syndrome, resulting among others in obstructive sleep apnea (OSA) due to decreased pharyngeal airway, which in severe cases leads to tracheostomy dependency.^[8,9] Mandibular DO for children with micrognathia is a promising technique that may eliminate the need for a tracheostomy or allow early decannulation in infants who have a tracheostomy.

Internal distraction devices offer a more predictable and precise rate of lengthening due to a direct contact of the device to the bony segments. External devices are less comfortable to young

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10.4103/2231-0746.175777

patients compared to internal devices. External devices are vulnerable to trauma during daytime and while sleeping. Internal devices are invisible to the patients and to others around them; they are not vulnerable to external trauma and allow for nearly complete jaw function. Usage of external devices results in two visible buccal scars.

In recent years, intra-oral curvilinear distraction devices were introduced.^[10] These devices allow for a better control of the vector of lengthening, mainly in OSA treatment and for gonial angle preservation in HFM.

DEFICIENT ALVEOLAR BONE PRIOR TO IMPLANTS PLACEMENT

Alveolar ridge reconstruction may be indicated for the deficient alveolar process resulting from maxillofacial trauma, periodontal disease, and postresection of aggressive large jaw cysts or tumors. Alveolar ridge deficiency may interfere with safe and correct positioning of implants, therefore, bone augmentation is essential to guarantee adequate bone volume, which provides patients with proper inter-arch relations and allows for satisfactory esthetic, prosthetic, and occlusal results. Alveolar DO (ADO) can be unidirectional, bidirectional, multidirectional, or horizontal. ADO can be performed using intraosseous distraction devices, intraosseous distraction implants, or by extraosseous devices which are the most prevalent today.

The main advantages of ADO as compared to augmentation using autogenous bone grafts are the use of small distraction devices that gradually lengthen the bone and generate new bone at the distraction gap with no need for a bone graft with the associated donor site morbidity. ADO also includes simultaneous expansion of both bone and soft tissue, greater bone lengthening, and minimal resorption and relapse of the newly formed bone. A major challenge in DO is maintaining the proper vector of bone elongation. ADO as a treatment modality in implant dentistry is a very useful technique which allows for adequate bone formation suitable for implant insertion in moderate and severe cases of alveolar deficiency.

SUMMARY

Distraction osteogenesis is a useful and well-established technique for bone and soft tissue formation in moderate to severe bone deficiency cases, both in the mandible, maxilla, and midface. DO demonstrates good results with long-term stability. The IDD are more comfortable to the patients and permit greater retention periods which contribute to long-term stability. In the future, better understanding of the biomolecular

mechanisms that mediate DO may allow for the improvement of bone regeneration using different molecular mediators, growth factors, or stem cells. Further research might allow for shorter consolidation periods using different methods like shock wave therapy. Development of biodegradable devices may spare the need for a second surgery to remove the distraction devices. Development of new methods and devices for better control over the vector of elongation will improve clinical and functional results significantly. Three-dimensional imaging and custom devices designed specifically for each patient will allow for better prediction of bone and soft tissue formation.

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Cite this article as: Rachmiel A, Shilo D. The use of distraction osteogenesis in oral and maxillofacial surgery. *Ann Maxillofac Surg* 2015;5:146-7.

Source of Support: Nil, **Conflict of Interest:** None declared.