Craniofacial Distraction Osteogenesis

Ryan Winters, MD, Sherard A. Tatum, MD*

KEYWORDS

• Distraction osteogenesis • Distraction osseogenesis • Craniofacial surgery • Orthognathic surgery • Maxillofacial surgery • Pediatric craniomaxillofacial surgery

KEY POINTS

- Distraction osteogenesis has a wide variety of applications in the craniofacial skeleton.
- Greater degrees of skeletal movement can be achieved with distraction osteogenesis compared with conventional techniques.
- The decision to use distraction osteogenesis, conventional osteotomy, or a combination of techniques should be based on individual patient situations.

OVERVIEW

Distraction osteogenesis (DO) is a method of inducing new bone formation within a gap between 2 bony surfaces of an osteotomy via gradual application of an external separating force. Orthopedic surgeons have used this technique for nearly a century to lengthen long bones, and much of the current understanding of the biomechanics involved and progression of the osteoneogenesis has been extrapolated from this literature.[1–3] Initial interest in application of DO to surgical osteotomies in the craniofacial skeleton centered on lengthening the mandible or on repairing segmental mandibular defects. In the early 20th century, European surgeons pioneered mandibular DO in animal models. From the 1970s through the 1990s, various canine models were used to develop techniques to lengthen the mandible via distraction at a surgically created osteotomy.[4] Rosenthal reported the first clinical results of DO of the human mandible in 1927, and since then DO has been applied to an ever-expanding list of locations and clinical scenarios throughout the craniofacial skeleton.[5,6]

The underlying goal of DO, regardless of specific anatomic location, is to lengthen the chosen bone, thereby establishing more normal anatomic size and position relative to surrounding structures. The surgical osteotomy is created (or the distractor can be placed across an existing suture), the distractor device is applied, and a latency period is allowed to elapse before beginning distraction. This latency phase allows initial bone healing to begin at the osteotomy gap via bony callus formation. The bony segments are gradually separated by activating the distractor device over a period of several days. This is the distraction phase, gradually stretching the callus, inducing osteoneogenesis. Once the desired length is achieved, distraction stops, and the soft immature bone now present in the distraction gap mineralizes, eventually resembling mature bone. This newly formed bone is likely never as strong as native bone. The cross-section of the regenerate can only be as big as the cross-section of the bone at the osteotomy and is frequently smaller. This should factor into the planning of the osteotomy location. During this consolidation phase, the distractor device is left in situ to provide rigid fixation

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Division of Facial Plastic & Reconstructive Surgery, Department of Otolaryngology & Communication Sciences, SUNY Upstate Medical University, 750 East Adams Street, Syracuse, NY 13202, USA
* Corresponding author.
E-mail address: tatums@upstate.edu

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to the bony segments, facilitating maturation of the bony regenerate and preventing skeletal relapse and pseudoarthrosis.

PREOPERATIVE PLANNING

When considering DO of the craniofacial skeleton, planning begins with a thorough history and physical examination. Particular attention should be given to occlusion, cranial vault shape, and position of the orbits (and globes within them), as well as the overall shape and symmetry of the maxillofacial region. Photographs are taken and placed in the medical record. Cephalograms, both lateral and frontal, are useful in nearly all patients. Pantomograms of the tooth-bearing areas are helpful as well. High-resolution 3D computed tomograms are most useful for analysis and planning although the radiation particularly of children should be considered and minimized. Computer-aided design/computer-aided manufacturing systems are widely available to construct life-size acrylic models or perform virtual surgery for planning purposes. Detailed anatomy, including defect or malposition magnitude and precise location of brain, eye, tooth, and other important structures, are well visualized. An additional advantage is the ability to clearly evaluate surrounding bone stock to ensure adequate amounts are available to generate bone and secure the selected distractor devices. This technology allows planning osteotomy sites, device placement, and final desired position of the distracted bones. Plastic jigs or guides can be constructive for intraoperative guiding of these steps. The distractors in some cases can be custom made or shaped for a specific situation.

Surgical Technique

A detailed discussion of the individual procedures performed for craniomaxillofacial distraction osteogenesis is not the purpose here. Certain important points bear mention. With regard to positioning and prepping, there are 2 points. Regardless of the approach chosen, there is a reasonable chance the aerodigestive tract will be traversed at some point. Therefore, we prefer complete irrigation of the nasal, oral, and pharyngeal cavities with 3% hydrogen peroxide solution, including brushing teeth if present. A second irrigation of the same areas is done with 10% povidone-iodine solution (Betadine, Purdue Pharma, LP, Stamford, CT), and the teeth if present are brushed again. For scalp incisions the hair is washed with Betadine scrub. Then the external field is prepped with the same povidone-iodine solution.

PATIENT POSITIONING

For the majority of craniofacial DO surgeries, the patient is placed supine, with the head of the operating table rotated about 120° away from the anesthesiologist to allow the surgical team maximum access to all sides of the head. For bilateral mandibular distraction, the table usually is not turned. The head of the operating table is extended, and the whole table is placed in reverse Trendelenburg position.

Although we have found this positioning to be amenable to nearly all DO surgeries (including some posterior cranial vault distractions), some authors prefer either the standard prone position or the "sphinx" position, wherein the patient is placed prone with the neck maximally extended and head elevated with the arms placed anteriorly. These positions allow better access to the entire skull and posterior cranium, but special care must be taken to pad the multiple pressure points created along the chin and mandible and especially to secure the endotracheal tube, which can be disastrous if dislodged in this position.[7–9] Air embolism might be more likely with the sphinx position as well, owing to the open circulation of the medullary space and the skull osteotomies being elevated significantly above the heart. In the senior author's practice, the prone position is reserved for cases where successful posterior distraction requires osteotomy to the level of the foramen magnum.

DISTRACTOR SELECTION

The first choice is (semi)internal versus external devices. The prefix "semi-" refers to intraoral devices where all or part of the body of the device is not buried under the tissues but remains contained in the mouth. Otherwise the internal devices are buried, but there is always a partially exposed activator mechanism. The external devices are outside the patient connected to the bone percutaneously.

External Distractors

In the current practice of the senior author (S.A.T.), the majority of DO performed utilizes internal devices; however, some situations exist wherein external devices may be superior. Arguments for internal or external devices exist throughout the literature.[6,10] Internal devices may increase long-term patient compliance because they are less conspicuous and less likely to be dislodged by patient activity. Some authors feel the distraction forces are better transmitted via the direct fixation of the device to bone with screws rather than the