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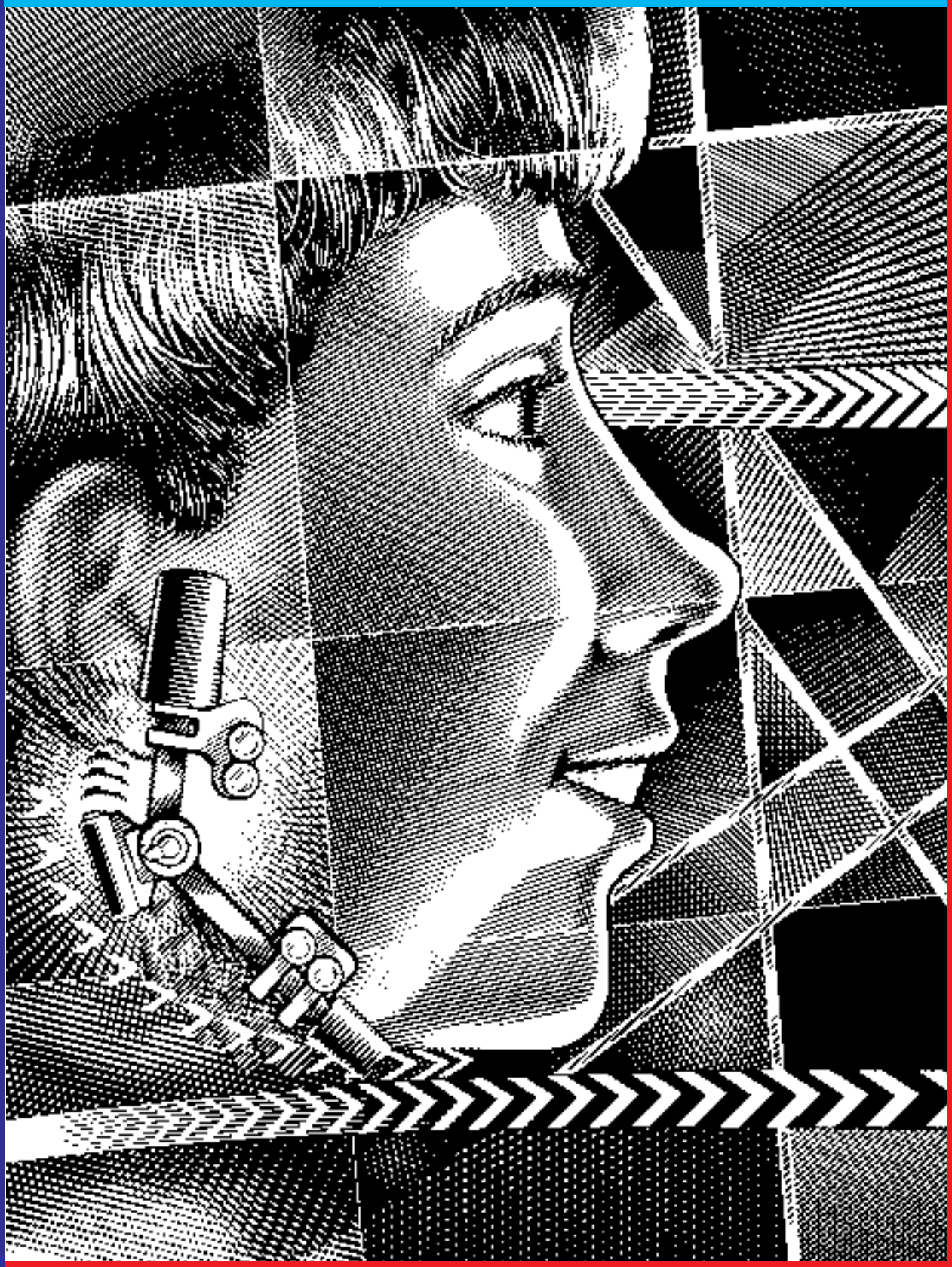


DISTRACTION OSTEOGENESIS: A NEW FRONTIER IN CORRECTING DENTOFACIAL DEFORMITIES

ORTHODONTIC DIALOGUE

DISTRACTION OSTEOGENESIS: A NEW FRONTIER IN CORRECTING DENTOFACIAL DEFORMITIES

"Them that have, get" is an aphorism that orthodontists have spoken and heard over and over again. However, the days of this Old World truth regarding facial growth may well be numbered in the new millennium. An exciting new treatment paradigm has been introduced in the last decade that is capable of significantly increasing facial bony tissue. Distraction osteogenesis is a process of new bone formation between vascularized margins of bone segments gradually separated by incremental traction.[1] In simpler terms, it is the growing of new bone by stretching the callus, as in a fracture. This technique was originally applied for the correction of long-bone length deformities and was subsequently introduced to treat severely deficient mandibular growth in the early nineties. In recent years, distraction osteogenesis has gained popularity as an alternative treatment for severe craniofacial skeletal dysplasias.[2]

FACIAL INDICATIONS AND AGE GROUPS

Distraction osteogenesis is being applied to treat patients with complex unilateral and bilateral facial deformities. At the present stage of development, indications for cranial and/or midfacial distraction include syndromic craniosynostosis, severe midfacial deficiencies associated with palatal clefts,[3] and severe obstructive sleep apnea. Mandibular distraction is indicated in children with many of the severe mandibular hypoplastic anomalies (Fig. 1), craniofacial microsomias, post-traumatic growth disturbances, TMJ ankylosis, for condylar regeneration, and in children who are dependent on tracheostomies due to an airway impairment related to their severe mandibular underdevelopment. The technique can also be used for mandibular expansion and for the treatment of adults with severe Class II mandibular deficiency.[4] Applications for distraction osteogenesis cover a wide age range — from infants to adults. At the present time, for many patients with syndromic craniosynostosis and severe midfacial retrusions, monobloc osteotomies and distraction procedures can be applied as early as the first year of life. For cleft patients and those who have other midfacial retrusions with severe Class III relations, midfacial distraction is usually performed in the primary dentition or older age groups. Mandibular distraction and orthognathic surgical procedures are commonly delayed until teenage years unless the deformity is very severe and warrants early intervention. When attempted early, overcorrection of the condition is often done, and a second phase of distraction may also be required if the structures do not keep up with the growth of the remaining normal face.

FIG. 1

Pre-treatment (A) and post-distraction (B) profile changes (with a bidirectional vector distractor still in place) in a boy who presented with gross underdevelopment of the mandible.
(Pictures courtesy of Dr. Hanson and Dr. Melugin)

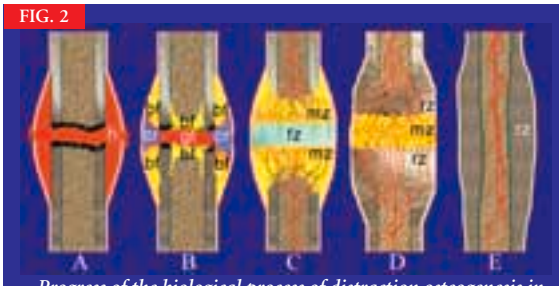
PROCEDURES AND BIOLOGIC FOUNDATIONS

An osteotomy or corticotomy separates the bone undergoing distraction. Care is taken to preserve the local blood supply. The direction of the osteotomy is based largely on the bony pathology, the position of tooth follicles or roots, and the planned vector (direction) of distraction. The segments are stabilized by internal or external fixation. The distraction device, which usually employs an expansion screw mechanism, is secured in proper position by plates, bicortical pins, or bands around the teeth, depending upon the regional anatomy and the type of device used. Following the surgery and placement of the distractor, a latent period (usually 5 to 7 days) is allowed for initial fracture healing to bridge the cut bone surfaces. Thereafter, active distraction is initiated at home, by opening the screw at a usual rate of 1mm per day in single or divided increments. Once distraction is begun, the traditional reparative response of normal fracture healing transforms to a regenerative response with well-organized longitudinal intramembranous ossification. The blood supply in the region of distraction increases manifold. Newly formed bone and trabecular columns originate from the residual bony walls and progress to the center of the regenerating callus, which eventually remodels to mature bone (Fig. 2). Simultaneously, tensional stresses produced by gradual distraction stimulate expansive growth in different tissues, including skin, fascia, muscle, ligament, cartilage, periosteum, and neurovascular elements, by a process called distraction histogenesis. Following active distraction, a stabilization period (usually 8 to 10 weeks) is allowed for consolidation. Distraction devices are normally removed after radiological demonstration of bone formation.

TEAM APPROACH TO PLANNING

As with combined surgical-orthodontic techniques, successful distraction osteogenesis involves a team approach between the operating surgeons and orthodontists. A thorough clinical examination of the face and oral structures is done with the presenting deformity in focus. Diagnostic records include study models, clinical photographs, lateral and postero-anterior cephalograms, panoramic radiographs and 3-D CT scans (Fig. 3). In addition to aiding in treatment planning, these records serve as a baseline to study changes. The team jointly determines the desired distraction vectors and devices to be used based on a thorough appraisal. Oblique distraction vectors in mandibular lengthening are useful if both ramus and body lengthening are required while vertical elongation alone is best realized with a vector perpendicular to the occlusal plane. Most of the devices currently in use are of the extraoral type providing unidirectional or bidirectional distraction vectors.

FIG. 2



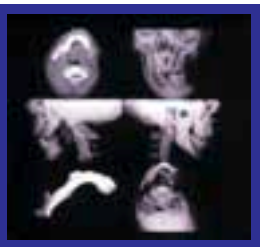
Legend:
h=*hematoma*
bf=*new bone formation*
cr=*cartilage*
gt=*granulation tissue*
fz=*longitudinally arranged collagen fibers*
mz=*mineralization*
rz=*remodeling*

Progress of the biological process of distraction osteogenesis in a long bone illustrated through different sequential stages: Inflammation (A), Soft Callus (B), Early Distraction (C), Stabilization (D), After Stabilization (E).
(Drawings courtesy of Dr. Samchukov, Dr. Cherkashin and Dr. Cope)

ORTHODONTIC MANAGEMENT

Orthodontic support with removable and fixed appliances is required during all phases of treatment — prior to, during, and after active distraction and consolidation. Pre-distraction orthodontics focuses on removing dental compensations, coordinating arch widths, correcting occlusal plane disharmonies and relieving crowding that would interfere with the distraction process. For mandibular widening, incisor root divergence is required in the osteotomy site to provide sufficient alveolar bone on both sides for periodontal health.[4] During active distraction, the goal is to direct the tooth bearing segments to their planned post-distraction positions. The increased metabolic response during the healing and manipulation of the regenerating bone allows large skeletal and dental changes with orthodontic therapy.

FIG. 3



CT and three-dimensional reconstructions help to visualize and analyze the deformity in detail from every perspective as illustrated in this patient with hemifacial microsomia.

Custom-made fixed orthodontic appliances and splints are used to provide a rigid attachment site for maxillary and midface distraction.[3] In one such rigid external distraction system, traction hooks from the splint are connected to distraction screws from the anchorage component of the distractor (Fig. 4). The clinician controls the direction and magnitude of force to achieve the desired distraction vector during the active phase. In mandibular procedures, interarch elastics during and after distraction influence the vector and are used to remodel the regenerate bone and close open bites created due to the lengthening.[5] Unilateral mandibular distraction often leads to the creation of a posterior open bite on the distraction side and a crossbite on the normal side (Fig. 5). Maxillary expansion appliances, along with intermaxillary elastics, can be used to correct these transverse and vertical malrelationships. A major part of post-consolidation phase orthodontics includes management of the canted maxillary occlusal plane. Occlusal acrylic wafers or buildups with serial reduction are used to super-erupt the maxillary posterior dentition to correct the cant in the maxillary occlusal plane (Fig. 6), and functional appliances with lingual shields can be used to guide the mandible into the desired intermaxillary relation. Tooth movement through the regenerate bone is generally undertaken following the consolidation period.

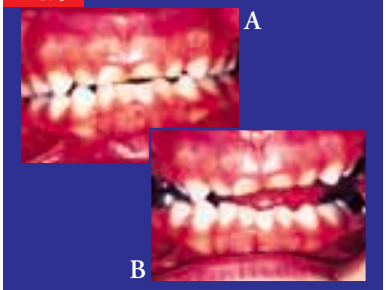
ADVANTAGES

The main advantage of distraction osteogenesis is the remarkably large amount of bony correction that can be achieved. Successful distractions of 25 to 30 mm are possible. The surgical procedures for distraction are claimed to be less invasive, of short duration, and have minimal associated blood loss and low chances of infection. No bone grafting is required, thus eliminating donor site morbidity. The new bone is more native to the region and allows orthodontic tooth movement through it. It is thought that gradual distraction, as opposed to one-step large surgical movements, leads to simultaneous incremental muscular and cutaneous tissue expansion, and therefore, only minimal relapse should be expected. The gradual expansion and adaptation of the surrounding tissues would be helpful in cases of severe tissue deficiency and may help to enhance long-term stability. However, being a relatively recent concept, long-term data on large series of patients are awaited to validate this.

FIG. 4

A Rigid External Distraction System is being used for efficient vector control during maxillary distraction in a boy with a repaired cleft lip and palate.
(Pictures courtesy of Dr. Figueroa and Dr. Polley)

FIG. 5



Pre-treatment (A), and post-distraction (B) occlusion following unilateral mandibular distraction of the left side. An ipsilateral open bite and a mandibular midline shift to the contralateral side are seen. A cemented distraction stabilizing appliance with hooks for interarch elastics is being used to control these side effects.
(Pictures courtesy of Dr. Hanson and Dr. Melugin)

FIG. 6

Posterior occlusal acrylic buildup on the distracted side supports the corrected mandibular occlusal plane. Selective acrylic reduction and interarch elastics are being used to serially super-erupt maxillary teeth.
(Picture courtesy of Dr. Hanson and Dr. Melugin)

LIMITATIONS AND PRECAUTIONS

Some of the limitations and disadvantages of distraction osteogenesis are linked to the present level of refinement in the procedures and technology. Most distraction devices currently available are extraoral and leave a cutaneous pin track scar as distraction progresses. With careful placement of the incision along the lines of minimal tension, the scar can be made less obvious. Intraoral osteotomies and devices best circumvent these problems. The surgeries should be performed cautiously to avoid damage to the nerves and the tooth buds in the area. Uncontrolled growth or poorly managed distraction vectors can lead to TMJ alterations and malocclusion leading to functional problems. The clinically observed vector may vary from the planned vector due to the biomechanical characteristics of the distractor device, its anatomic orientation, neuromuscular influences and external forces such as those of occlusion. Close control by the surgeon and the orthodontist is essential to avoid bad results and worsened occlusal relationships.

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The American Association of Orthodontists is a national dental specialty organization that was founded in 1900. The AAO is comprised of more than 13,500 members. Among its primary goals are the advancement of the art and the science of orthodontics; the encouragement and sponsorship of research; and the achievement of high standards of excellence in orthodontic instruction, practice and continuing education.

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Correspondence is welcome and should be sent to: American Association of Orthodontists, Council on Communications, 401 N. Lindbergh Blvd., St. Louis, MO 63141-7816.

The AAO recommends that every child should have an orthodontic screening no later than age 7.

FUTURE GOALS AND INTERIM CONCLUSIONS

Distraction osteogenesis has an enormous role in the future as an alternative method of skeletal correction in patients with severe and syndromic dentofacial deformities. It is not a replacement for established therapies involving growth modification and orthognathic surgery in cases best indicated for those approaches. Current investigatory and research efforts are directed towards better manipulation at the cellular and pharmacologic levels, refining the surgical and distraction protocols, improving the devices, and developing newer techniques to monitor and regulate distraction vectors. Clinicians are looking forward to the development of technologically superior intraoral devices with multidirectional capabilities that can alter the distraction vectors during treatment. With proper treatment planning, sequencing and execution, and with a good control of the distraction vectors, the technique can be applied with success in all three planes — vertical, horizontal and transverse.

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