Distraction Osteogenesis of the Human Craniofacial Skeleton: Initial Experience with a New Distraction System

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Application of distraction osteogenesis to the human craniofacial skeleton in properly selected cases represents a major advance in the treatment of craniofacial deformities. We report our initial clinical experience with a system of miniature distraction devices that permitted maxillary, orbital, and mandibular distraction in a 4-month-old boy with unilateral craniofacial microsomia and anophthalmia. At 6 months of age, after maxillary repositioning and orbital expansion, a costochondral rib graft was used to construct the missing left mandibular ramus and condyle.

Key Words: Distraction osteogenesis, maxillary distraction, orbital expansion, temporomandibular joint reconstruction

The concept of distraction osteogenesis was championed by Ilizarov, beginning as early as 1954, for the treatment of a variety of congenital and acquired deformities of enchondral bone [1]. In 1973, Snyder and associates reported on gradual distraction of the mandible using an extraoral device in canines [2]. After successfully lengthening the canine mandible [3], McCarthy and his group reported the first clinical application of distraction osteogenesis of the mandible in four patients with a variety of congenital craniofacial anomalies [4]. Because the technique of gradual, osseous distraction of the membranous bones of the human craniofacial skeleton promises major advances in the early reconstruction of severe craniofacial anomalies, numerous reports of clinical mandibular distraction as well as experimental distraction in other areas of the craniofacial skeleton have ensued. Osseous expansion of the cranial vault was reported by Persing and colleagues [5], and distraction of the frontal bone outside of the cranial plane was demonstrated by Barone and coworkers [6]. Successful expansion of the cranial vault using a craniotactic device in rabbits was presented by Remmler and his coworkers [7]. More recently, midfacial advancement was shown to be feasible in adult sheep using lengthening "bolts" mounted on transversely placed pins [8]. Using a modified Hoffman bone-lengthening device, Staffenberg and associates [9] reported successful midface distraction and advancement in the immature canine without osteotomies.

The application of distraction osteogenesis to the human craniofacial skeleton potentially represents a major advance in the treatment of craniofacial deformities. The technique is less invasive than conventional surgery and possibly more stable. In addition, once developed, it is likely that even more complex manipulation of the craniofacial skeleton will be achievable. Herein, we report our initial clinical experience with a system of miniaturized distraction devices that permit three-dimensional movements of the human craniofacial skeleton.

Method

A 4-month-old boy presented with left craniofacial microsomia (Fig 1). At birth the child had upper airway obstruction and was transferred to Scottish Rite Children's Medical Center, where he underwent tracheostomy. Because of extremely poor feeding, a gastrostomy tube was also placed during the same admission. Once the parents were trained in how to care for the tracheostomy and the gastrostomy tube, the patient was discharged home.

At 3½ months of age, the child returned to the operating room, where orbital impressions and a facial moulage were obtained. Preoperatively, a three-dimensional computed tomographic (CT) scan was also procured (Fig 2). In the operating room anteroposterior (AP) and lateral cephalograms were taken with an intraoperative cephalostat (see Fig 2). For the mandibular device, microplates and screws were chosen, whereas for the craniomaxillary device, micro-plus/panfacial-size plates were

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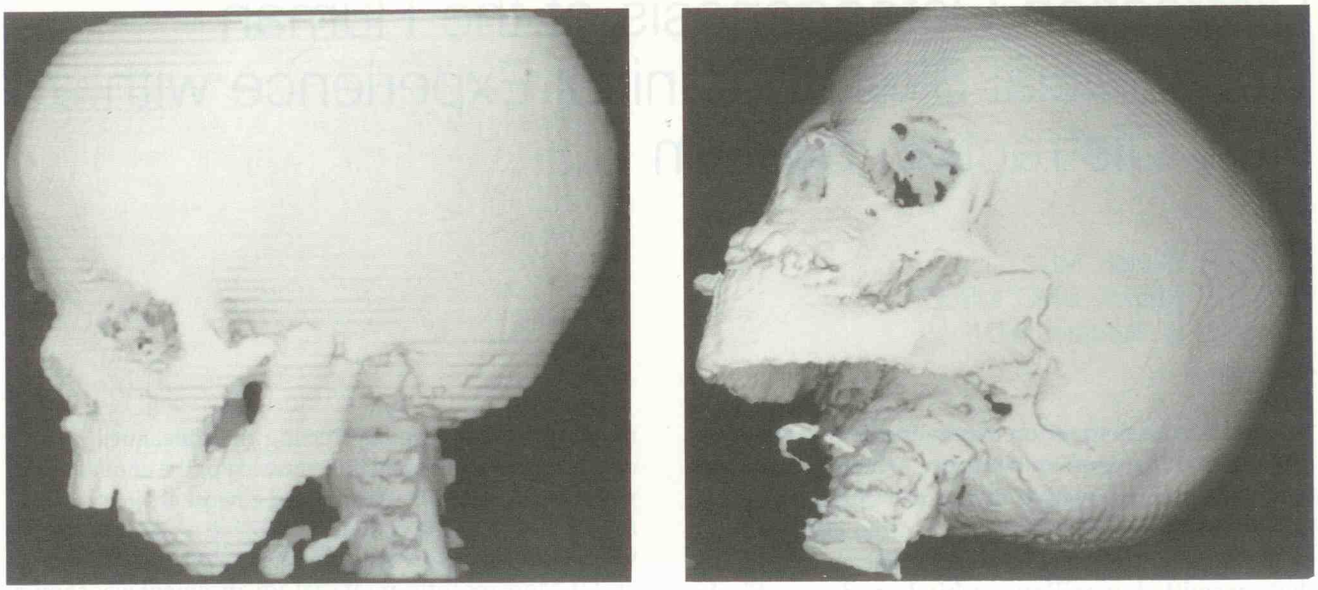

A B

Fig 4 (A) The left temporomandibular joint of the same patient is also flat and malformed. (B) Postexpansion, the condyle has uprighted with an increase in volume. No displacement of the glenoid fossa was noted.

cartilaginous portion of the condylar head [5]. Excessive compression of the proximal segment is also implicated in temporomandibular joint resorption and relapse after orthognathic surgical procedures [6]. Chronic compressive forces have also been implicated as a contributing factor in the development of temporomandibular joint disorders, including internal derangements [7, 8].

In this clinical study, bone distraction, however, appeared to have a beneficial effect on the temporomandibular joint. Patients with craniofacial deformities manifest abnormalities of the facial skeleton often including the temporomandibular joint. Depending on the degree of disease, the temporomandibular joint may be malformed or absent. The condyle is often malopposed as well as misshaped. Osteodistraction appeared to stimulate the pathological condyle to reorient to a more normally oriented vertical axis as well as to increase in size and volume. In bilaterally expanded cases, such stimulation was expressed on both sides, causing the two condyles to become more closely symmetrical. In unilaterally expanded cases, the affected condyle came more closely to resemble the unaffected side. The unaffected condyle did not appear to be influenced by the contralateral expansion because no gross changes were noted.

Although the condyle is important in growth and development of the mandible, the condyle is only a growth site responding to the soft-tissue forces to which it is subjected [9]. These forces appear to distract the mandible in a downward and forward direction, leading to deposition along the posterior aspect of the mandible with resorption along the anterior ramus region [10]. One can envision that the expansion device may mimic and enhance this soft-tissue developmental effect [1]. Instead of causing deleterious compressive forces on the temporomandibular joint, the bone expansion device appears to stimulate the affected condyle to assume a more upright position and to increase in size and volume.

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