Intraoral Distraction Osteogenesis of the Mandible in Hemifacial Microsomia

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Purpose: Lengthening of the mandible by distraction osteogenesis is the preferred method for treatment of hemifacial microsomia in children. Use of an intraoral distraction technique and horizontal oblique ramus osteotomy in such patients is presented.

Patients and Methods: Mandibular ramus lengthening was performed in 11 patients aged 6 to 12 years with hemifacial microsomia. During the age of mixed dentition in hemifacial microsomia patients with a hypoplastic mandible, the unerupted molars buds are located high in the retromolar region and are in danger of being damaged by the osteotomy. Therefore, an intraoral approach exposing the mandibular ramus and angle was performed, and a horizontal oblique ramus osteotomy was made, preserving the inferior alveolar nerve. An intraoral device was placed along the ramus, and distraction was started on the third postoperative day at the rate of 1 mm/d and continued for 2 to 3 weeks or as long as necessary. The device was maintained for retention an additional 6 weeks and was then removed.

Results: Clinically, the face became more symmetric. The postdistraction posteroanterior cephalometric radiographs demonstrated elongation of the affected ramus and improvement in facial symmetry.

Conclusions: The advantages of this method are that it allows device placement along the ramus, permitting the ramus elongation necessary in treatment of hemifacial microsomia, that it prevents damage to the tooth buds which, during the age of mixed dentition, are in a higher position in the retromolar area, and that it prevents injury of the inferior alveolar nerve.

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First developed for orthopedic surgery,1,5 distraction osteogenesis using extraoral devices has recently gained increasing popularity in the treatment of deficient mandibles.4,5 The main disadvantages of the extraoral devices are that they are socially inconvenient to the child during the several months of treatment and that they leave a residual cutaneous scar along the insertion tract of the pins.4,6 Recently, smaller intraoral devices have been introduced to replace the extraoral devices.7

The goal of the treatment in hemifacial microsomia is to elongate the hypoplastic mandible (mainly the ramus) and to prevent secondary restriction of maxillary vertical growth and canting of the occlusion.4,5,7,8 The vector of elongation should be mainly vertically downward, with slight anterior protrusion of the hypoplastic mandible.5,8,9 The vertical ramus distractor permits elongation of the ramus, taking in consideration that the vector of elongation depends also on the location of the osteotomy and the position of the fixation screws.

During the age of mixed dentition in hemifacial microsomia patients with a hypoplastic mandible, the unerupted molar buds are located high in the retromolar area and can be damaged by the osteotomy. To prevent damage to the tooth buds and to the inferior alveolar nerve, we describe the use of a horizontal oblique mandibular ramus osteotomy (HORO) for elongation of the mandibular ramus by distraction osteogenesis.
Patients and Methods

Eleven children between 6 and 12 years of age with skeletal type I and Ila Kaban unilateral hemifacial microsomia, were treated using intraoral distraction osteogenesis. The operation was performed under general anesthesia with nasoendotracheal intubation. The incision was made through the buccal mucosa along the external oblique line extending to the first molar. Then, a subperiosteal dissection was performed to expose the entire lateral aspect of the mandibular ramus, gonial angle region, and the proximal part of the mandibular body. A channel retractor was introduced along the lateral side of the ramus across the posterior border. Then, a periosteal elevator was introduced subperiosteally on the medial aspect of the mandible inferior to the entrance of the lingual nerve, and careful subperiosteal tunneling was performed toward the posterior border of the mandible. A channel retractor was then introduced across the posterior border of the mandible to protect the lingual soft tissue and the tissue in the retromandibular region. In this manner, the ramus was encircled to protect the surrounding tissue and the lingual nerve and vessels.

The next step was to place the vertical distraction device (intraoral titanium vertical mandibular distraction device; Medicon, Tuttlingen, Germany) along the ramus and to plan the HORO (Figs 1A, B). Using a reciprocating saw, a horizontal buccal corticotomy was performed obliquely across the ramus in an anterior to posterior direction extending to the posterior border of the ramus (Fig 1A). The medial corticotomy was then performed just below the lingula, in a higher position compared to the lateral corticotomy. Then, using small osteotomes and avoiding the central part of bone where the nerve is located, a nearly complete osteotomy was performed. Next, using a side drill or a transbuccal approach, the distraction device was placed with monocortical screws just before the osteotomy was completed. The monocortical screws were introduced without tightening. Gentle manipulation along the osteotomy completed the fracture, leaving the neurovascular bundle intact.

After the final tightening of the monocortical screws, the incision was sutured in layers, first the periosteum over the device and then the mucosa, leaving the activating rod protruding into the lower vestibule. On the third postoperative day, the distraction was started by turning the rod at a rate of 1 mm/d. The patient and the parents were asked to maintain the device rod as clean as possible by brushing gently. The active, gradual distraction was followed by a retention period of 6 weeks to allow for bony maturation. Then, the device was removed under general anesthesia.

Evaluation of mandibular ramus lengthening and midfacial symmetry was performed using panoramic radiographs and posteroanterior (PA) cephalograms before and after distraction. The orbital rims, crista galli, nasal septum, condylions, mandibular angles, and midsymphysis (protuberance menti [PM]) were traced on each PA cephalogram. Reference lines for each cephalometric tracing included a horizontal line based on the junction of linea innominata and the lateral orbital rim on each side and a vertical line perpendicular to the horizontal line through the crista galli (Fig 2). The horizontal asymmetry of the mandible was assessed by the angle formed between the vertical line (VL) and midsymphysal point. The ver-
tical assessment of the mandibular ramus was based on the gonial height (H-GO) and ramus height (CO-GO). Gonial height was measured between the horizontal supraorbital line and gonial angle, the ramus height (CO-GO) was measured from the most superior aspect of the condyle (CO) to gonion (GO). The ratio of the affected versus the nonaffected ramus and gonial height were calculated before and after the distraction.

Results

All 11 patients tolerated the distraction procedure well and were followed for between 12 and 24 months. A temporary mild postoperative restriction of mouth opening was noted in all patients during the first 2 weeks, mainly because of the postoperative edema. In patients in whom the device was fixed transbuccally, only a minor scar was noted adjacent to the mandibular angle region.

Elongation of the ramus and a slight anterior protrusion of the mandible occurred in all 11 patients. The face and the midchin point were more symmetric (Figs 3, 4). New bone formation was seen above the unerupted molar. When comparing the PA cephalometric radiographs taken before treatment with those at the end of the retention period and after a 1 year follow-up, a decrease in the PM angle was evident (Table 1). The vertical ramus elongation was shown by improvement of the ramus height ratio (CO-GO) and the decrease in the gonial height difference (H-GO). The patients continued to grow, with the distracted side growing at a rate similar to the contralateral, unaffected side.

Intraorally, a lateral open bite of 9 to 12 mm was created on the affected side and maintained by an occlusal appliance, which was slowly adjusted to allow downward maxillary growth to meet the newly

FIGURE 3. Eleven-year-old boy with left hemifacial microsomia. A, Pretreatment appearance. B, View after intraoral lengthening of the left ramus and before removal of the vertical distraction device. The face is more symmetric. The slight left side enlargement is caused by the device. C, Symmetric appearance of the face 1 year later.
positioned mandible. The open bite was closed after 6 to 12 months. However, in 2 patients, an undesired contralateral open bite appeared. This was treated by removal of the device after 3 weeks of lengthening (without any retention period), followed by placement of an interocclusal wafer on the affected hypoplastic side. Maxillomandibular elastics were then used for traction before advanced mineralization of the regenerate occurred.

In 2 of the 11 patients, a transient postoperative hypoesthesia of the lower lip occurred, which recovered after 3 weeks. No other sensory disturbances were noted, and there were no signs of facial palsy of mandibular branch of the facial nerve. Neither postoperative infection nor pseudoarthrosis occurred.

Discussion

The main advantage of the intraoral distraction osteogenesis method is that it is socially convenient to the patient, without the discomfort associated with the extraoral distraction osteogenesis method.4,5,6 Another advantage of the intraoral device is that there are no extraoral skin scars, just a small scar in the place of the transbuccal screw placement. This minor scar can be avoided by using a side drill intraorally.

According to Ilizarov et al3,10 and other studies,11-13 bone formation is markedly increased during distraction osteogenesis. The increased activity has been attributed to the tension-produced stimulatory effect on blood flow and the bone forming cells.14-17 Bone formation activity during distraction osteogenesis is significantly increased compared with the normal fracture healing process, generating a significant enhancement in the range of 200 to 400 μm/d18,19 compared with the normal mineral apposition rate in the human of 1 μm/d20 and even the linear growth rate of the distal femur (50 μm/d.)19,21

Although it has not yet been proved, there are clinical reports that distraction of the mandible leads to an increase in the soft tissue, mainly the muscles of mastication on the affected side.4,5 In long endochondral bones, Ilizarov et al1,2 found that there was an associated lengthening of the affected muscle and nerves after gradual distraction. The explanation according to Moss and Salentijn22 is that the functional matrix for development of the craniofacial skeleton is influenced by the function of the attached neuromuscular tissue and the associated spaces. Enlow23 also demonstrated that mandibular growth is dependent on the development of the mastication muscles and eruption of the teeth.

Ilizarov2,3 reported that the rhythm of distraction has a significant influence on the regenerate. The rate of distraction in our patients was 1 mm/d. It has been observed in animal studies that a rate of distraction of 2 mm/d resulted in delayed union or nonunion in the distracted area.5,24,25 On the contrary, a slow distraction rate of 0.3 to 0.5 mm/d produced premature consolidation.25,26 Another study on the lower limbs of the rabbit25 showed that a distraction rate of 0.7 mm/d appeared optimal for cell proliferation and bone formation. A rate of distraction more than 1.3 mm/d is biologically unfavourable for bone formation.

The mineralization of the newly regenerated bone

FIGURE 4. A, The postoperative anteroposterior (AP) cephalometric radiograph before commencement of lengthening. Note the oblique osteotomy, (arrow), which avoids damage to the unerupted molar. B, The postdistraction AP cephalometric radiograph. The new bone formed is above the unerupted molar (wide arrow). C, The AP cephalometric radiograph 1 year later.

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is low (24.3%) immediately after lengthening and increases mainly during the 6-week retention period (77.8%). One year later, it is nearly equal (95%) to the nondistracted bone. Total new bone volume and bone formation indices are significantly increased in the distraction and osteotomy callous regions.

During the age of mixed dentition in patients with hemifacial microsomia and a hypoplastic mandible, the unerupted molar buds are located high in the retromolar region and can be damaged by an osteotomy in this region. To place the osteotomy below the inferior alveolar nerve and above the teeth buds and also to permit the placement of a vertical distraction device along the ramus, we placed the osteotomy more inferior along the ramus from the buccal side and upward, transverse, and oblique to the lingual side. In this manner, the osteotomy can be in the inferior part of the ramus below the entrance of the inferior alveolar nerve and above the tooth buds. The advantage of this osteotomy is that it also permits vertical elongation of the ramus necessary in the treatment of hemifacial microsoma.

The ramus is wider in the retromolar region than superiorly. Therefore, performing an oblique osteotomy results in more bony surface on both sides of the osteotomy for bony regeneration. A recent experimental study in tibial bone has demonstrated that when the osteotomies were created at a 30° angle to the bony axis there were changes in distribution of gap strain, which caused increased shear on the osteoblasts, resulting in deposition of more osteoid and mineralized bone. In treatment of hemifacial microsoma, elongation of the affected side of the mandible, especially the hypoplastic ramus, is one of the key elements. During distraction, the vector of elongation in the mandibular ramus should be in a downward and forward direction. One of the important phases in distraction osteogenesis, and especially in the intraoral method, is determination of the distraction vector. For inferior and forward elongation of the mandible, the force should be applied along the posterior part of the ramus. The distraction vector determines the direction of the ramal osteotomy (oblique or transverse), placement of the screws or pins, and the orientation of the device. An anterior position of the device can cause an undesirable anterior open bite. Posterior placement of the device can achieve the desired result of vertical elongation of the ramus with a slight anterior movement needed to treat hemifacial microsoma. By placing the device more obliquely, there is a vertical elongation with forward advancement of the mandible. This vector should be determined preoperatively because, with intraoral distraction osteogenesis, there is no possibility to change the vector of elongation during lengthening as can be done with the extraoral method. In the mandible, it is better to perform an osteotomy rather than corticotomy to allow better movement of the segments and increased control of the planned vector of elongation. The intraoral devices are not rigid enough to move the segment in the planned direction without an osteotomy. The osteotomy should be completed at the posterior border of the ramus to allow downward distraction and to prevent an open bite.

An acrylic wafer should preserve the interocclusal space created on the affected side after ramus elongation. Then, progressively the wafer should be reduced, permitting optimal vertical maxillary and midface growth.

In treatment of hemifacial microsoma before the distraction osteogenesis method was introduced, an additional compensatory osteotomy on the contralateral side was often necessary. Using the distraction osteogenesis method, there is no need for a contralateral osteotomy.

### References


| TABLE 1. POSTDISTRACTION CHANGES IN PM ANGLE, RAMUS HEIGHT RATIO, AND GONIAL HEIGHT |
|---------------------------------|----------------|----------------|
| Predistraction (mean±SD) | Postdistraction (mean±SD) | 1 year follow-up |
| PM angle (°) | 3.87 ± 1.60 | 0.19 ± 0.85 | 0.32 ± 0.70 |
| Ramus height (CO-GO) ratio (%) | 83.24 ± 4.86 | 98.0 ± 5.72 | 97.15 ± 4.50 |
| Gonial height (H-GO) difference (mm) | 11.87 ± 4.65 | 2.12 ± 1.40 | 1.95 ± 1.30 |
| (affected gonial height vs nonaffected side) | | | |

Abbreviation: PM, protuberance menti.