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Distraction Osteogenesis of the Ascending Ramus for Mandibular Hypoplasia Using Extraoral or Intraoral Devices: A Report of 8 Cases

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Purpose: This report presents the results of distraction osteogenesis using unidirectional extraoral and intraoral devices in 8 patients with different grades of vertical mandibular ramus hypoplasia.

Patients and Methods: Eight patients with hypoplastic mandibles underwent unilateral lengthening of the ascending ramus using unidirectional extraoral or intraoral devices. Intraoral mandibular distraction was performed on 5 patients with deficiencies of the vertical ramus up to 24 mm. External devices were used in 3 patients with more severe hypoplasias. An intraoral osteotomy was performed, and progressive distraction at rates of 0.5 mm/12 hours was initiated after 5 days. Once the desired length was reached, the device was maintained in place for 8 to 12 weeks. Three-dimensional computed tomography scans were taken in all the patients to plan the procedure and to compare the changes postoperatively.

Results: Successful distraction osteogenesis was achieved in all patients. The amount of mandibular lengthening ranged from 17 to 32 mm. Complications with the external devices such as rotation of the proximal bony fragment (2 cases) and loosening of the external screws at the end of the consolidation period (1 case) were observed.

Conclusions: The results suggest that the intraoral device can be used as the method of choice for distraction osteogenesis of the ascending ramus of the mandible in patients with large deficiencies. Preoperative and postoperative 3-dimensional computed tomographic scans are essential in treatment planning.

Bone regeneration by distraction has become an accepted method of treatment of congenital and acquired mandibular hypoplasia.[1] With this technique, significant skeletal and soft tissue enlargement in the hypoplastic area can be obtained in a short period without the need for bone grafting. Since the first clinical report in 1992 by McCarthy et al,[2] several large series have been published.[3-5] Despite the apparent simplicity of the procedure, complications such as distraction failure[6] or malocclusion[5] can occur. The aim of this report is to describe the results of using internal and external mandibular distraction devices to treat hypoplasia of the ascending ramus of the mandible, with special emphasis on preoperative planning.

Patients and Methods

Eight patients underwent unilateral unidirectional mandibular distraction osteogenesis of the ascending ramus of the mandible. The characteristics of the 8 patients are summarized in Table 1.

An exhaustive preoperative assessment of all cases was performed, including accurate facial and occlusal evaluation, photographs, panoramic radiographs, frontal and lateral cephalograms, articulated dental casts, and 3-dimensional computed tomography (3D CT)

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Table 1. UNIDIRECTIONAL ASCENDING RAMUS DISTRACTION: PATIENT DATA

Case	Age Yr/Sex	Diagnosis	Device	Vector	Distracted Length (mm)	Consolidation Period (Weeks)	Facial Results	Occlusal Changes	Complications
1	9/F	Left hemifacial microsomia grade IIB	EO	Vertical	32	12	Slight transverse asymmetry	Temporary posterolateral open bite Excellent final occlusion	Temporary hypoesthesia of the inferior alveolar nerve Rotation of the proximal segment of the mandible. Loosening of all screws
2	10/F	Hypoplasia of the right ramus and condyle, postrauma	IO	Vertical	18	9	Symmetry	Temporary posterolateral open bite Excellent final occlusion	Pain in the homolateral TMJ during the first days of the distraction
3	9/F	Hypoplasia of the right ramus and condyle, origin unknown	EO	Vertical	22	12	Symmetry	Temporary posterolateral open bite Transverse maxillary deficiency required orthodontic expansion	Rotation of the proximal segment of the mandible Local inflammation during the first days postoperatively
4	10/M	Left hemifacial microsomia grade IIA	IO	Vertical	17	8	Symmetry	Minimal posterolateral open bite Excellent final occlusion	Temporary hypoesthesia of the inferior alveolar nerve
5	16/F	Hypoplasia of the left ramus and condyle, postrauma	IO	Vertical	24	12	Symmetry	Temporary posterolateral open bite Crowding of the teeth required orthodontic treatment	Temporary hypoesthesia of the inferior alveolar nerve Local inflammation during the first days postoperatively
6	13/F	Hypoplasia of the right ramus and condyle, postrauma	IO	Vertical	19	10	Symmetry	Temporary posterolateral open bite Crowding of the teeth required orthodontic treatment	Pain at the homolateral TMJ during the first days of the distraction Temporary hypoesthesia of the inferior alveolar nerve
7	12/M	Hypoplasia of the right ramus and condyle due to previous arthritis	EO	Vertical	28	12	Symmetry	Temporary posterolateral open bite Excellent final occlusion	Temporary hypoesthesia of the inferior alveolar nerve
8	11/F	Hypoplasia of the right ramus, condyle, and the mandibular body, origin unknown	IO	Oblique	17	9	Symmetry	Temporary posterolateral open bite Excellent final occlusion	Temporary hypoesthesia of the inferior alveolar nerve Temporary limitation mouth opening

Abbreviations: F, female; M, male; EO, extraoral; IO, intraoral; TMJ, temporomandibular joint.

images. Deficiency of the length of the mandible was calculated by measuring and comparing both the ramus and mandibular body to the opposite side on 3D CT images (Fig 1). Normal measurements previously presented by Losken et al[7] are used as reference values. If the ramus was the deficient part of the mandible, as is often the case in hemifacial microsomia, unilateral vertical distraction was planned. A horizontal osteotomy of the ascending ramus was performed, always avoiding the gonial angle. The resulting vector must be vertical because the device is placed perpendicular to the osteotomy.

In those cases with a mild vertical deficiency of the ascending mandibular ramus associated with a mild deficiency of the mandibular body unilaterally, the vector of placement of the distraction device was slightly oblique and the osteotomy was performed in the ramus just above the gonial angle. In this manner, ramal elongation occurred without loss of the gonial angle, moving the chin in a more forward position.

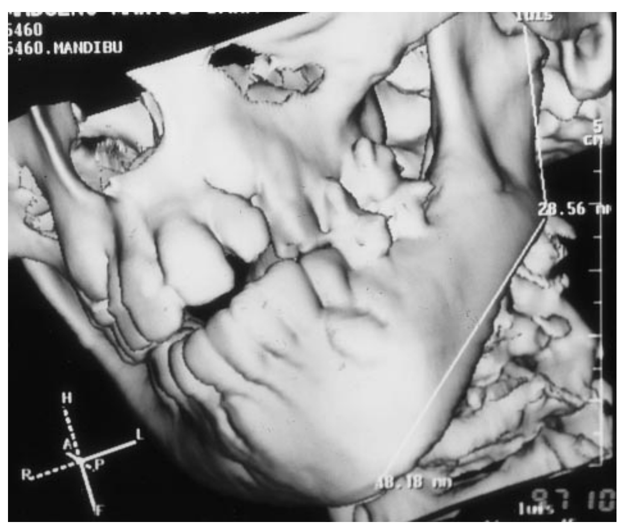

FIGURE 1. Preoperative 3D CT reconstruction with inferior view in patient with an asymmetry due to hypoplasia of the left ramus of the mandible allows accurate measurement of the ramus and body lengths (case 1).

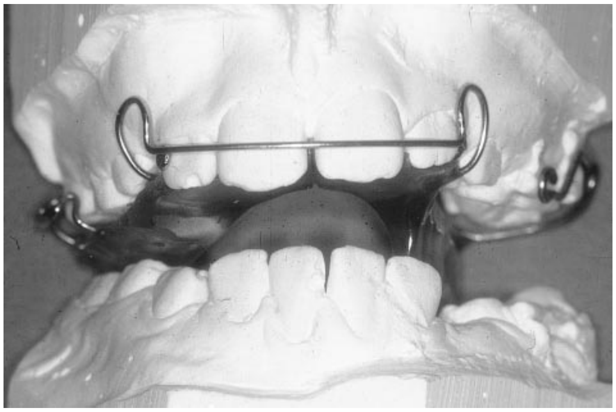

FIGURE 2. Occlusal splint used to help the maxilla increase its vertical dimension (case 1). The splint keeps the tongue out of the space between the occlusal planes.

If there was a moderate to severe deficiency of the ramus, associated with a deficiency of the body of the mandible, independent distraction vectors were produced vertically in the ramus and horizontally in the body. These cases are not included in this report.

The unidirectional extraoral distractor (Leibinger, Freiburg, Germany) was fixed to the bone with minimum of one screw on each side of the osteotomy. The intraoral device (Stratec Medical, Oberdorf, Switzerland) that was used had a miniaturized design and was activated by a transcutaneous rod. The system consists of 2 miniplates fixed to the bone with bicortical screws, available in a unique size for a distraction distance of 40 mm. In spite of this, the external device was preferred in those cases with deficiencies over 25 mm. The surgical technique was very similar with both types of distraction devices.

SURGICAL TECHNIQUE

Exposure of the mandible in a subperiosteal plane was performed through a transoral incision. First, the distraction device was fixed in place. Then, a complete osteotomy was performed in the exact position as planned. In this manner, it was assured that the bony fragments were firmly fixed in a correct position. Whenever possible, 2 screws were placed on each side of the osteotomy to secure the extraoral device. When intraoral devices were used, a minimum of 2 screws on each side of the osteotomy were used to fix the plates.

After a waiting period of 5 days, distraction started at a rate of 0.5 mm twice daily done at home. The parents were given a guide with the instructions and a schedule to record the distraction events during the activation period. Normal temporomandibular joint (TMJ) function was allowed during the entire distraction period.

The mandibles were lengthened until the gonial angles were positioned at the same horizontal level

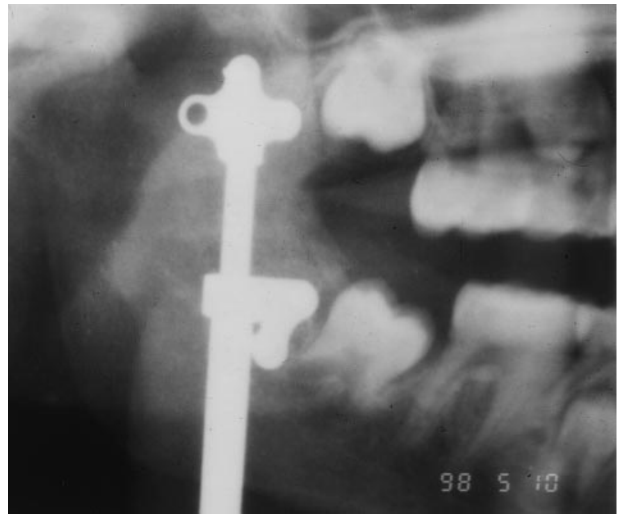

FIGURE 4. Case number 2 (Fig 11). Radiograph of lengthened hemimandible at the end of the consolidation period 9 weeks after elongation. Note the complete radiopacity between the plates of the internal device (case 2).

FIGURE 5. Postoperative 3D CT scan showing the newly generated bone immediately after removal of the distraction device (case 1).

FIGURE 3. Occlusal splint in place.

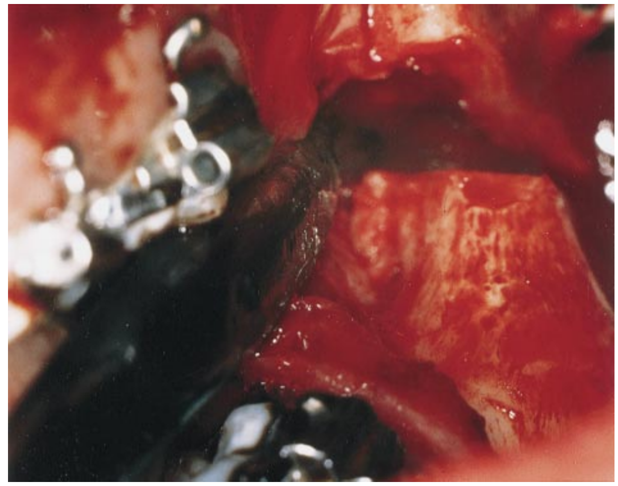

FIGURE 10. Intraoperative view of the case presented in Figure 9 showing rotation of the proximal segment.

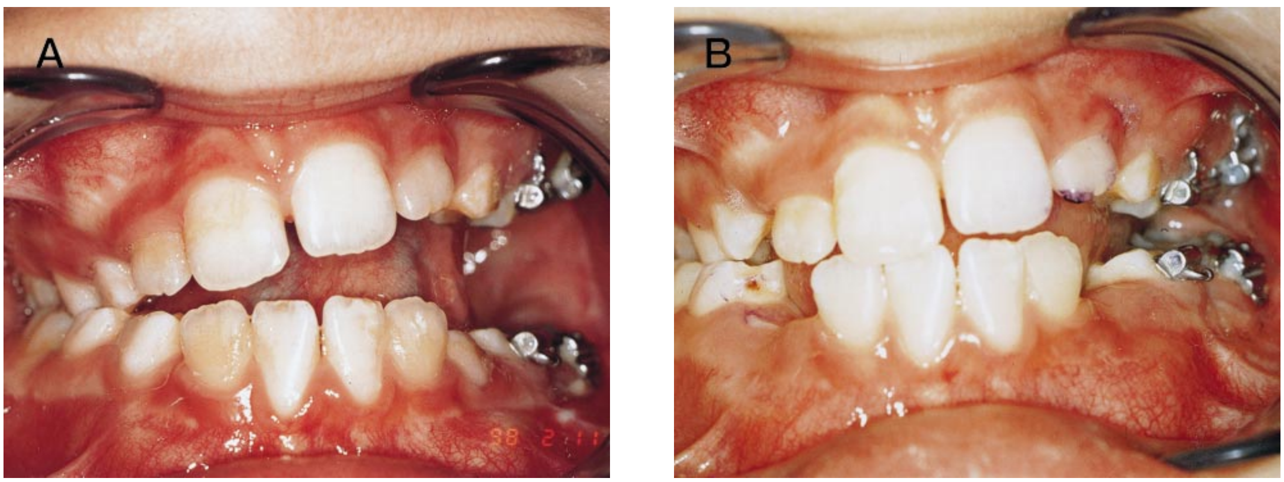

FIGURE 6. Large posterior and lateral open bite at the end of distraction (*A*) and spontaneous closure after 14 weeks (*B*) (case 1).

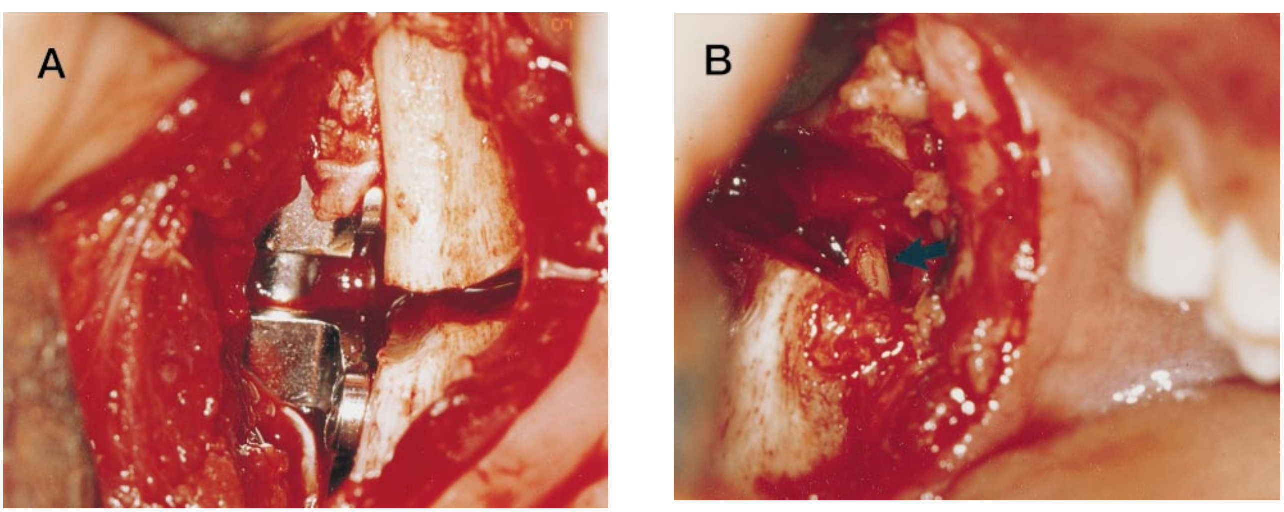

FIGURE 12. *A,* Intraoperative view of the patient in Figure 11 after placement of the intraoral device and completion of the osteotomy. *B,* Activation of the internal distraction device intraoperatively. Note the preservation of the alveolar nerve between the bony fragments (*arrow*).

FIGURE 7. *A*, Preoperative photograph of a 9-year-old patient with grade IIB hemifacial microsomia of the left side (case 1). Mandibular distraction of 32 mm using an external device was done. *B,* Six months after removal of the distraction device showing a great improvement of the facial contour, but some asymmetry still exists.

and there was clinical evidence of slight overcorrection of the mandibular occlusal plane to compensate for the alveolar hypoplasia. An occlusal splint was required in an unique case (case 1, Figs 2, 3) to keep the tongue from delaying maxillary growth during swallowing.

The distraction devices were removed after a variable consolidation period (8 to 12 weeks), when existence of new bone was radiographically confirmed. The intraoral devices were removed under general anesthesia. The resulting size of the neomandible was evaluated and compared with the opposite side using 3D CT scans. All the measurements were made by the same person (P.R-B.). Mean postdistraction follow-up was 12 months from the end of the active distraction period.

Results

The results and complications are summarized in Table 1. These results were based on clinical observation, postoperative radiographs, 3D CT scans, and cephalometric tracings. Both types of distraction device were well tolerated, especially the internal devices. These devices allowed the patients to perform their normal activities without discomfort. Successful distraction was achieved in all patients, showing bone formation radiographically (Fig 4) and in the 3D CT images (Figs 5, 8). This was verified clinically in all cases when the internal devices were removed.

A homolateral posterior and lateral open bite occurred in all patients. As vertical maxillary growth occurred, the posterior and lateral open bite reduced gradually in all cases and finally disappeared (Fig 6). At the end of the procedure, the occlusal stability was excellent in most cases. The aesthetic result was judged as excellent in all but one case. In this case, a slight asymmetry persisted in the transverse plane (Fig 7).

Postoperative 3D CT scan measurements confirmed an effective mandibular lengthening in all patients (Figs 5, 8). The extent of the distraction achieved in 3 cases was greater than the amount planned; during the first days of active distraction, the occlusion remained stable without a posterior open bite in these 3 cases. Pain related to the ipsilateral TMJ during the

FIGURE 8. Postoperative 3D CT scan showing the newly generated bone. Note the holes where the screws were placed and the mark of the internal device on the outer surface of the bone (case 2).

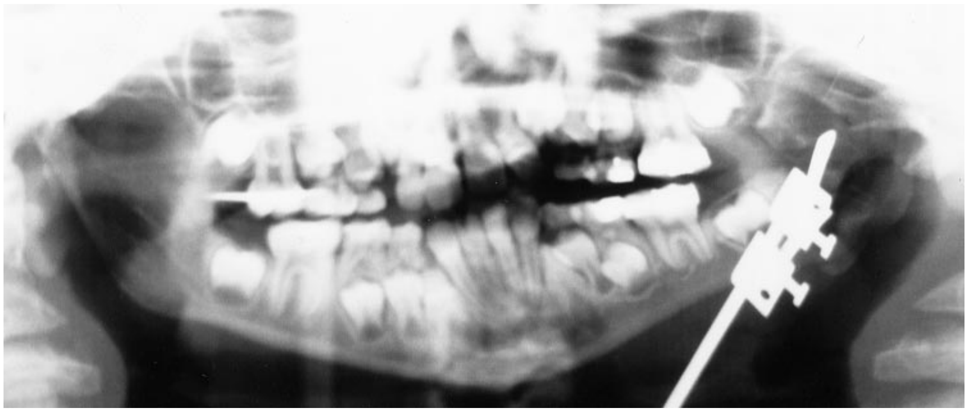

FIGURE 9. One day postoperative radiograph showing rotation of the condylar segment (case 1).

early distraction period appeared in 2 of these cases. After a variable period from 3 to 7 days, a posterior and lateral open bite developed in all patients.

In 2 of the early cases, rotation of the proximal (condylar) segment of the mandible was seen immediately after the operation (Fig 9). In both of these cases, surgical examination showed that the bony segment had rotated around the single external screw, probably because of temporalis muscle pull (Fig 10). An additional screw was added in the proximal segment to fix the bone in its original position and distraction proceeded uneventfully.

Loosening of all the external pins was seen in case 1 at the end of the consolidation period.

Discussion

Distraction osteogenesis has gained popularity as a surgical technique for the treatment of patients with mandibular hypoplasia. Donor site morbidity is eliminated, and the complexity of the procedure is less. However, knowledge in this area is still limited, and more clinical and experimental studies are required.

Even though both the number of cases and follow-up in this series are limited, new information is reported. Three-dimensional CT scans allow accurate measurement of both sides of the mandible. Moreover, if the zygomatic arch is removed in the 3D CT reconstruction, or inferior views are included, accurate measurements of the condyle and the distance to the glenoid fossa can be obtained. This is important in determining the exact amount of lengthening that will be required.

The distracted length of the vertical ramus in 3 of the cases was greater than thought to be necessary by measuring the mandible. This was probably because of anatomic differences in the condyle or glenoid fossa on the hypoplastic side. Size or position of the ipsilateral condyle or glenoid fossa may be altered, increasing the distance between both structures (Fig 1).

During the distraction period, forces tend to push the condyle up into the glenoid fossa. This could explain the pain in the ipsilateral TMJ in 2 cases during the early distraction period.

The aesthetic result was judged as excellent in all but 1 case. In this case, a slight asymmetry persisted in the transverse plane (Fig 7B). In patients with hemifacial microsomia, the lengthening procedure needs to be done in at least 2 planes. In our experience, there is a greater expansion of the soft tissues of the face in the transverse direction with the intraoral devices (Fig 11). The buried device under the soft tissue may contribute to this expansion. However, longer follow-up is needed to conclude that this occurs.

The changes in ramus length resulted in changes in the mandibular occlusal plane. Therefore, a variable posterior and lateral open bite was produced in all patients. This open bite is temporary, because of the considerable growth of the maxilla in young patients. However, it appears that the problem is different in adult patients,[8] because of the absence of compensatory vertical growth of the maxilla.

No permanent sensory nerve complications were seen in any of the patients. Temporary hypoesthesia was seen in 6 cases. The inferior alveolar nerve was carefully isolated during completion of the osteotomy with the chisel (Fig 12). It is helpful to turn the activation screw once or twice to assist in nerve identification before mobility of the mandibular segments is demonstrated.

One complication that occurred has not been reported before. In 2 cases, anterior rotation of the condylar segment was seen immediately after the operation. In both of these cases, surgical examination showed the bony segment to have rotated around the single external screw, probably because of temporalis muscle pull (Figs 9, 10). Stability is essential to keep the 2 mandibular segments in anatomic alignment. Generally, instability of the bony fragments has been related to defective osteogenesis.[9] It is important to use 2 screws on each side of the osteotomy, especially in the proximal segment.

Screw loosening has been reported before.[5,10] It

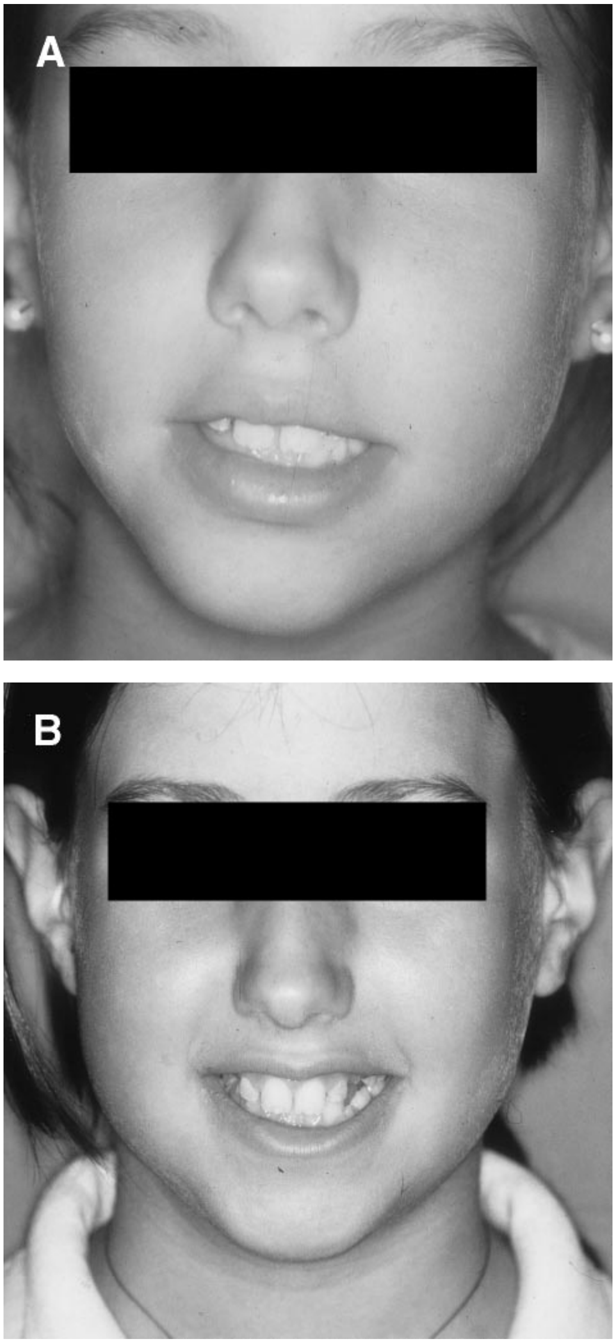

FIGURE 11. *A*, Preoperative view of a 12-year-old girl with moderate hypoplasia of the mandibular ramus postrauma. Mandibular distraction using an internal device was considered the treatment of choice. *B*, Six months after removal of the distraction device. Note the excellent facial symmetry in a transverse direction with this internal distractor device in comparison to case 1 (Fig 7B).

usually occurs at the end of the fixation period, mainly in the youngest children. Fortunately, as described in the literature, it did not affect stable bone formation. So far, there is no way to avoid this problem when using external devices.

Internal distraction devices activated by transcutaneous[6] or transmucosal[11] rods have been successfully used to treat a variety of mandibular deformities. Morbidity is limited to the presence of a tiny, hidden submandibular scar located at the exit of the distraction rod. Stability of the device was excellent, as confirmed by testing during the removal procedure.

The working length of the intraoral device used was 40 mm. To achieve maximal lengthening, it is necessary to fix the device with both plates in contact, which is sometimes difficult to achieve. The device chosen in each particular case depended on the required distraction distance, preferring the extraoral devices in those cases with deficiencies closely matching the length of the intraoral devices.

Our experience suggests that both distraction systems are useful in treating different types of mandibular hypoplasias. However, the intraoral device is our choice for distraction of the ascending ramus of the mandible in deficiencies up to 25 mm, and probably up to 40 mm. Despite the enormous advantages of internal devices, there is 1 disadvantage: the need for another operation to remove the device. There are still many open questions that can only be answered by means of further experiments and clinical applications.

References

1. Tavakoli K, Stewart KJ, Poole MD: Distraction osteogenesis in craniofacial surgery: A review. Ann Plast Surg 40:88, 1998
2. McCarthy JG, Schreiber J, Karp N, et al: Lengthening of the human mandible by gradual distraction. Plast Reconstr Surg 89:1, 1992
3. McCarthy JG: The role of distraction osteogenesis in the reconstruction of the mandible in unilateral craniofacial microsomia. Clin Plast Surg 21:625, 1994
4. Molina F, Ortiz-Monasterio F: Mandibular elongation and remodeling by distraction: A farewell to major osteotomies. Plast Reconstr Surg 96:825, 1995
5. Klein C, Howaldt HP: Mandibular distraction osteogenesis as first step in the early treatment of severe dysgnathia in childhood. J Orofac Orthop 57:46, 1996
6. Chin M, Toth BA: Distraction osteogenesis in maxillofacial surgery using internal devices. J Oral Maxillofac Surg 54:45, 1996
7. Losken W, Patterson GT, Lazarou SA, et al: Planning mandibular distraction: Preliminary report. Cleft Palate Craniofac J 32:71, 1995
8. Ortiz-Monasterio F, Molina F: Simultaneous mandibular and maxillary distraction in hemifacial microsomia in adults: Avoiding occlusal disasters. Plast Reconstr Surg 100:852, 1997
9. Karaharju-Suvanto T, Peltonen J, Kahri A, et al: Distraction osteogenesis of the mandible. J Oral Maxillofac Surg 21:118, 1992
10. Havlik RJ, Bartlett SP: Mandibular distraction lengthening in severe hypoplastic mandible: A problematic case with tongue aplasia. J Craniofac Surg 5:305, 1994
11. Diner PA, Kollar EM, Martinez H, et al: Submerged intraoral device for mandibular lengthening. J Craniomaxillofac Surg 25:116, 1997