

Intraoral Mandibular Distraction: Indications, Technique and Long-term Results

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Abstract

This report describes the experience of the Trousseau Hospital, Paris, France, with distraction osteogenesis of the mandible using an intraoral distraction device. From 1993 to 1998, 26 paediatric patients with mandibular hypoplasia underwent distraction of the mandible using the Leibinger Intraoral Distractor. The majority of the patients had hemifacial microsomia. Distraction was performed at a rate of 1 mm a day following complete osteotomy of the mandible. A mean of 15 mm of distraction was obtained. In conjunction with combined orthodontic management, satisfactory morphologic results were achieved in the majority of patients with good facial symmetry, adequate occlusal relationships and balanced maxillary mandibular relationships. Radiographic evaluation revealed that substantial new bone formation and remodelling was induced by the intraoral distraction along the entire hemimandible on the distracted side and that this contributed significantly to the aesthetically pleasing clinical results.

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Introduction

Distraction osteogenesis is rapidly becoming a mainstream treatment modality for the early management of the patient with mandibular hypoplasia. Following early clinical experience with external distractors, intraoral buried internal distractors have been developed that offer specific advantages over the external device. This report describes the authors' experience with the Leibinger Intraoral Distractor in the treatment of mandibular hypoplasia and addresses the following issues: intraoral versus extraoral distractors; unidirectional versus multidirectional distraction; the timing and indications for distraction; variations in surgical technique; complications; measuring distraction; distraction versus conventional osteotomies; and long-term results.

Patients and Methods

Between 1993 to 1998, 26 paediatric patients underwent intraoral mandibular distraction using the Leibinger Intraoral Distractor. There were 11 males and 15 females. The mean age of the patients was 9 years (range 5 to 15 years). Seventeen of the patients had hemifacial microsomia, 5 had temporomandibular joint (TMJ) ankylosis or had undergone mandibular tumour removal

during infancy, and 1 patient had mandibular hypoplasia on one side and Von Recklinghausen hypertrophy on the the opposite side. The remaining 3 patients had severe Class II dentofacial deformities. The anatomic site of hypoplasia was the ramus in 23 patients and the body in the remaining 3 patients. Three of the patients had distraction of bone grafts previously placed for TMJ reconstruction or in severe cases (Pruzansky Grade III) of hemifacial microsomia. The clinical criteria for distraction in the patients with ramus hypoplasia were essentially morphologic and corresponded to Pruzansky Grades II and above: the high position of the mandibular angle, flattening of the cheek, deviation of the chin point, and displacement of the oral commissure. The distraction was unilateral in 23 patients and bilateral in 3 patients. Two patients underwent simultaneous maxillary and mandibular distraction. All patients had combined and comprehensive orthodontic and/or orthopaedic management.

The distractor used in these patients was first developed experimentally at the Trousseau Hospital, Paris, France, in 1993 and further refined in collaboration with the Leibinger company to produce the first generation of the Leibinger Intraoral Distractor. This device is a unidi-

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rectional, slim design comprising a distractor frame, a distractor rod, and fixation pins. The distractor is able to produce and can withstand a torque of 90 kg.

The surgical procedure began with subperiosteal exposure of the buccal cortex of the mandibular ramus or body via a lower buccal sulcus incision. The subperiosteal dissection was performed widely so that a large enough pocket was created to accommodate the intraoral distractor. Next, an external corticotomy was performed. This was followed by osteotomies of the superior and inferior margins of the body, or the anterior and posterior margins of the ramus. The distal pins were then placed in bicortical fashion, either intraorally or transbuccally. A greenstick fracture of the lingual cortex via the margins' osteotomies was then performed to complete the osteotomy. Finally, the osteotomy site was mobilised and the proximal pins were placed. The wound was then closed in standard fashion, ensuring that there was sufficient mucosa to cover the device. Thus, the entire device was submerged except for part of the distraction rod (Fig. 1).

Distraction was commenced on the fourth postoperative day at a rate of either 0.5 mm twice a day or 1 mm once a day (Figs. 2 and 3). The magnitude of distraction required in each patient was determined according to the severity of the deformity by clinical examination and cephalometric evaluation. Postoperative cephalometric records were taken at the following intervals: after the removal of the device, and one year after.

Upon completion of distraction, the device was left *in situ* until the third or fourth postoperative week, then removed. The patients then underwent orthodontics in order to harmonise the occlusal relationship with the newly achieved morphologic improvements.

Results

A mean of 15 mm of distraction, as measured on the

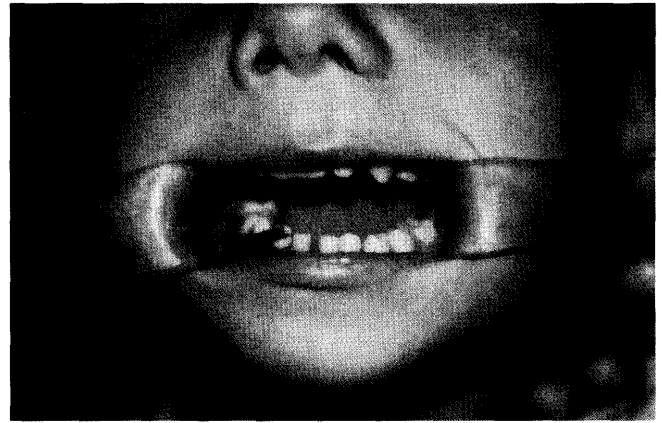


Fig. 1. Submerged intraoral device entirely covered by soft tissue except the labial tip of the distraction rod to allow activation by means of key.

device, was obtained (range 12 to 28 mm). Clinically and radiographically, significant morphologic improvement was achieved in all the patients (Figs. 4 to 14). Radiographically, 3 dimensional new bone production and remodelling without premature consolidation was observed to occur rapidly over the first few weeks. Additionally, these processes occurred not just within the zone of distraction but extended well beyond it to involve nearly the entire ipsilateral half of the mandible (Figs. 5, 15 to 17).

In all patients the degree of mandibular lengthening that was planned for was successfully achieved. However, technical problems occurred in 4 patients that required reoperation to: change a faulty distraction rod ($n = 1$); re-establish an incorrect vector of bilateral distraction ($n = 1$); and repeat osteotomies that had been incomplete ($n = 2$).

Nerve complications occurred in only 1 patient, who had temporary dysaesthesia of the inferior alveolar nerve following distraction of 28 mm. Temporalis muscle pain was commonly observed during active distraction, prob-

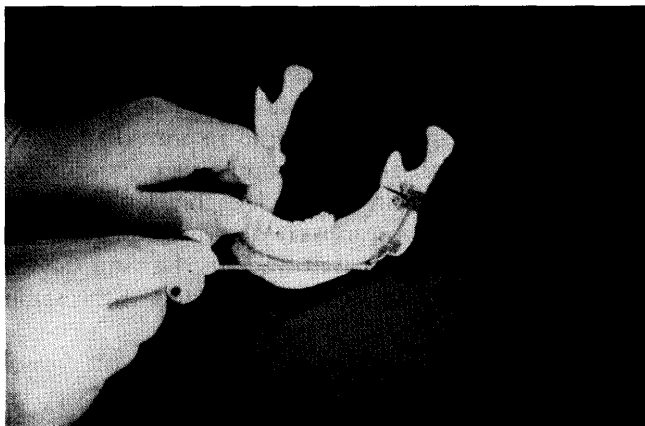


Fig. 2.

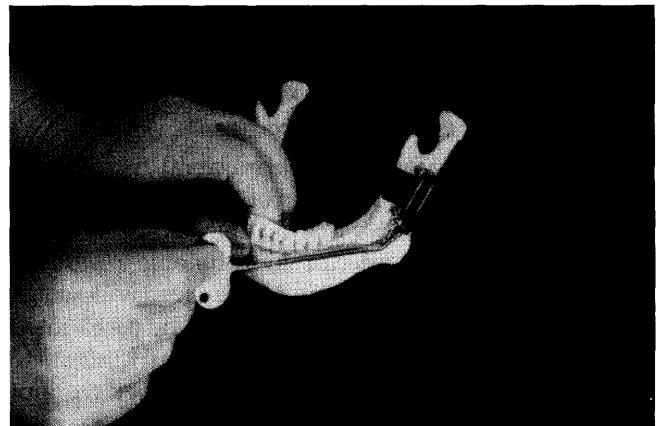


Fig. 3.

Figs. 2 and 3. Device placed on the external side of the mandible. Distraction occurs by turning the rod. One full turn of the key represents 0.5 mm of distraction.



Fig. 4a.

Fig. 4b.

Fig. 4. Left maxillary hypoplasia and left global mandibular hypoplasia explaining the deviation of the chin to the left side. Preoperative (Fig. 4a) and postoperative (Fig. 4b) facial appearance. Note that the results were obtained by a single unidirectional distractor placed on the left mandibular body with a classic orthopaedic maxillary disjunction.

ably due to stretching of that muscle. This discomfort was observed to be less in the patients who underwent distraction of 0.5 mm twice a day compared to those who had distraction of 1 mm once a day. Limited mouth opening due to trismus was frequently observed at the end of the distraction period and immediately after removal of the distractors. However, this was transient in all cases. There were no instances of TMJ dysfunction.

Discussion

Intraoral versus Extraoral Distractors

The current trend in mandibular distraction, especially in Europe, is to favour intraoral devices.⁷ In the overall experience of the Trousseau Hospital, approximately 80% of patients with mandibular hypoplasia have undergone intraoral distraction. Compared to extraoral distraction, the intraoral device has numerous advantages: the lack of an external scar, less soft tissue trauma, near total concealment of the device, and superior psychological tolerance by the patient, particularly in the paediatric group. Older patients are better able to maintain their normal professional and social activities during the distraction period because of the cosmetic advantages of the intraoral distractor.

A major biological advantage of intraoral distraction is the multidimensional formation of greater quantities of bone beyond the zone of distraction. This contributes significantly to the superior morphologic results of intraoral distraction. Furthermore, the speed with which this occurs allows the whole process to be accelerated and the device to be removed relatively early (after 3 to 4 weeks). Thus, the treatment time is shortened without compromising the results. This phenomenon was not observed in our animal experiments of external distraction nor in clinical cases of external distraction.²

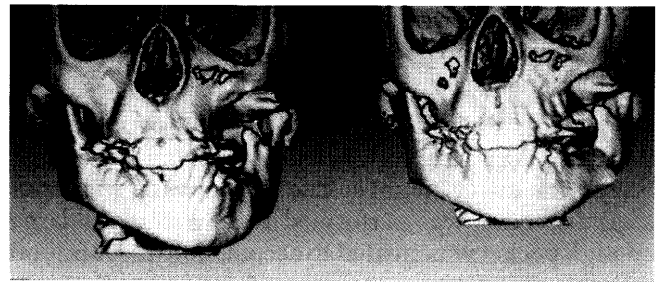


Fig. 5a.

Fig. 5b.

Fig. 5. Preoperative (Fig. 5a) and postoperative (Fig. 5b) 3D CT scans showing bone creation (left mandibular body), bone remodelling and bone movement (pendulum type) which will contribute to the improvement of symmetry.

Figs. 4 and 5. A 9-year-old boy with complex facial asymmetry.

The Leibinger Intraoral Distractor also offers a number of technical advantages. Its low profile design allows relative ease of use. The use of pins rather than screws simplifies the fixation procedure since drilling is not required. Although we have applied the pins bicortically, others have employed a monocortical technique with satisfactory results.⁸ The joint rod system (single joint, 40 degrees range of motion; double joint, 75 degrees range of motion) facilitates ease of placement, easier selection of vector of distraction, unimpeded closure of the mucosa, and minimises trauma to the oral commissure. It was also designed to be used independently of the dentition. This is advantageous in children with deciduous dentition. Unlike toothborne intraoral systems,⁴ its design for use in non-dental areas also avoids the risk of creating an interdental gap.

One theoretical limitation of the intraoral distractor is that it cannot be used on very small mandibles. Nevertheless, we have successfully used this device on a mandibular ramus that was only 25 mm in length, as well as on several small stumps of bone graft in Pruzansky III mandibles. We have found that what is more important than the size of the mandible is the need to ensure adequate mucosal cover for the device.

Although we favour intraoral distraction for the majority of cases, we acknowledge that in certain situations, extroral distraction would be more appropriate. These include very young children who require distraction (less than 4 years of age), global and severe mandibular hypoplasia (such as in severe Treacher Collins Syndrome), and when a transport disk is employed, i.e. when performing a trifocal distraction, the same device allows two distraction sites to be created at the same time.

Unidirectional versus Multidirectional Distraction

Another theoretical limitation of a unidirectional distractor is its inability to provide multidirectional correction of complex deformities. However, we have

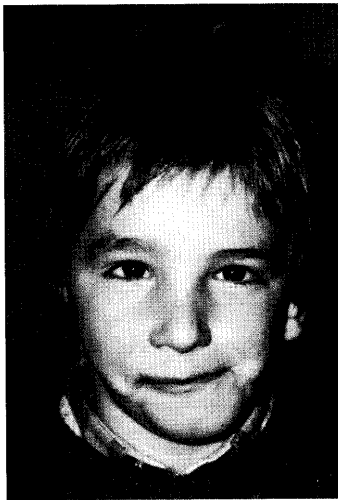


Fig. 6a. Predistraction frontal view.

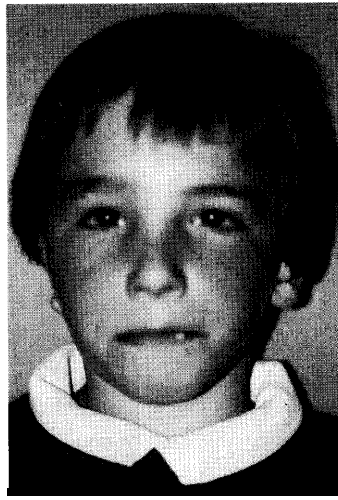


Fig. 6b. Postoperative frontal view. One year after completion of distraction

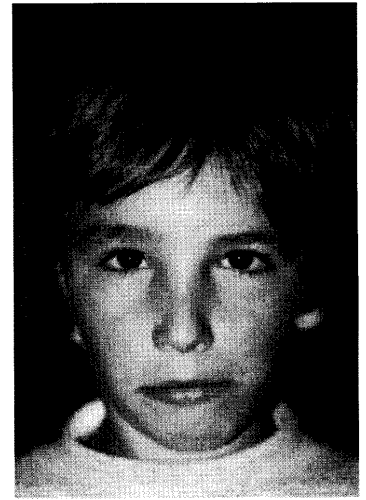


Fig. 6c. Frontal view. Two years after completion of distraction

Fig. 6. An K-year-old boy with left hemifacial microsomia who underwent unilateral distraction of the mandible.



Fig. 7a. Preoperative frontal view.



Fig. 7b. Postoperative frontal view. Five years after completion of distraction.

Fig. 7. A 7 1/2-year-old girl with right hemifacial microsomia who underwent unilateral mandibular distraction.

found, somewhat unexpectedly, that unidirectional distraction with the Leibinger intraoral device does result in 3 dimensional changes in mandibular morphology, particularly when distraction is performed on the ramus in patients with hemifacial microsomia. It appears that a complex process of bone production, bone remodelling and bone movement is induced that is visible radiographically (Figs. 15-17). Furthermore, bone scintigraphy⁵ has confirmed that these changes extend beyond the zone of distraction to involve the entire hemimandible.

We have observed that a pendulum type of mandibular movement occurs that combines an externally visible contralateral shift of mental point with a similar movement of the contralateral ramus. When performing a distraction of the ramus, it was noted that beyond an

amplitude of distraction of about 7 to 8 mm (regardless of the vector of distraction, even if it were vertical) a counter clockwise rotation and advancement of the mandible occurred. This observation suggests that preoperative orthopaedic management of the maxillary arch would be important in order to avoid the creation of a crossbite, and to improve the occlusal stability.

Timing and Indications for Distraction

The issue of timing remains controversial. Our current philosophy is to recommend waiting till the age of 5 or 6 years. The advantages of performing distraction around this age compared to earlier intervention are better cooperation from the child, especially when concurrent orthopaedic management is required, and adequate bone stock in the mandible. Certainly one of the theoretical advantages of performing distraction in childhood rather than later in life is that early correction of the skeletal deformity has the potential to rebalance muscle actions as well as improve proprioceptive function. The main indication for very early intervention would be a child with severe airway problems secondary to mandibular hypoplasia. In this situation, the potential benefits of early distraction may well outweigh the problems associated with a long-term tracheostomy.

Another contentious issue is what severity of mandibular deformity serves as an appropriate indication for distraction. It seems reasonable that patients with severe deformities would be unequivocal candidates for distraction, whereas those with mild deformities should probably be managed orthopaedically with functional appliances.⁶⁻⁸ Patients who fall in between these two ends of the spectrum should probably be evaluated on an individual basis, and the treatment plan formulated according to their specific needs and circumstances.



Fig. 8a. Preoperative frontal view showing deviation of the chin.

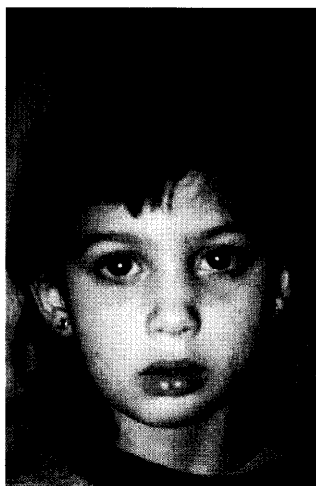


Fig. 8b. Postoperative frontal view, one year after completion of distraction, showing improved chin position.

Figs. 8 and 9. A 6-year-old girl with right hemifacial microsomia.

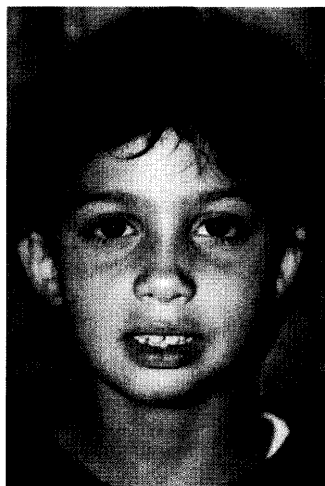


Fig. 9a. Postoperative frontal view. Two years and a half after distraction. Note the stability of the result and the good occlusion.

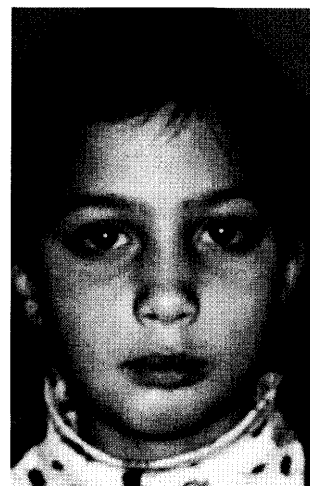


Fig. 9b. Postoperative frontal view. Four years after distraction. Note the pursuit of the growth and maintenance symmetry.



Fig. 10. Comparison between preoperative (left) and postoperative (right) appearance two years after completion of distraction showing good restoration of symmetry.

Figs. 10 and 11. An 8½-year-old girl with no growth of a costochondral graft used to free



Fig. 11. Frontal view. Two years after the completion of distraction (left) and three years after the completion of distraction (right) showing reappearance of an asymmetry but this time less pronounced.

temporomandibular joint ankylosis at age 2.

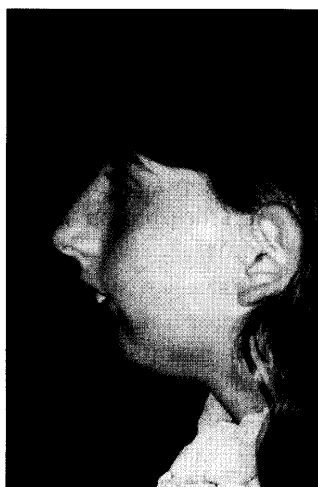


Fig. 12a. Preoperative left profile showing the retrognathia.



Fig. 12b. Postoperative left profile one year after the completion of distraction. Note the increased sagittal thrust of the mandible.

Figs. 12 and 13. A 10-year-old girl with class II syndrome.



Fig. 13a. Predistraction lateral cephalogram.



Fig. 13b. Postdistraction lateral cephalogram. Note the increased mandibular projection and the good occlusion achieved by combined orthodontic treatment.



Fig. 14. A 15-year-old boy with right mandibular hypoplasia and left hemifacial hypertrophy (Recklinghausen); restoration of a better symmetry by mandibular distraction (right vertical ramus lengthening) associated with maxillary corticotomy (right maxillary downward movement using intermaxillary elastics). Note the better positioning of the buccal commissure.



Fig. 16.

Surgical Technique

The surgical technique used in craniomaxillofacial distraction has evolved from and now ignores some of Ilizarov's original principles,⁹ largely because of the superior blood supply of the facial skeleton and the unique properties of the facial musculoskeletal relationships. Consolidation, for example, is rarely a problem, although it has been reported in some cases of external distraction.

The extent of the osteotomy is variable among different authors. Molina¹⁰ performs only an external corticotomy and relies on the strength of the distractor to complete the bony separation before the distraction process begins. McCarthy,¹¹ Wangerin¹² and Hoffmeister¹³ perform a complete osteotomy with a saw and immediately mobilise the bone segments prior to fixation. Our technique lies somewhere in between in that the buccal and marginal corticotomies are performed with osteotomes and the lingual cortex is greenstick fractured. Thus, our osteotomy is essentially complete, but is achieved in a slightly different fashion.



Fig. 15



Fig. 17.

Figs. 15, 16 and 17. Lengthening of a previous cranial bone graft by using an intraoral device (miniplate not removed but cut). Comparative X-rays showing the new bone formation created between the two extremities of the miniplate.

We believe that the completeness of the osteotomy is important, and prefer not to rely on the strength of the distractor for the following reasons: the patient feels less pain during distraction, and the desired vector of distraction is more accurately achieved.

Measuring Distraction

It has also been our observation that the magnitude of distraction as measured by the distractor does not completely correlate with the degree of bone lengthening measured radiographically. We postulate that this discrepancy is due to bone movement associated with the bone lengthening, and recommend that data on the amount of distraction should always be reported with a qualification as to how the measurements were performed.

Complications

Complications due to technical problems that occurred in 4 patients in this series are potentially avoidable and

can be minimised by careful attention to detail. Our learning curve with this device suggests that in order to avoid technical problems, a meticulous surgical technique is essential, especially with regard to the creation of a large enough subperiosteal pocket for placement of the distractor without any soft tissue interference that could obstruct the distraction process. Great care must also be exercised in the direction of placement so that the correct vector of distraction is obtained, while respecting the permissible range of the device. Finally, it is critical that the osteotomy is complete and the mandibular segments completely mobilised so that distraction can proceed uniformly without requiring extra torque from the distractor.

The low incidence of nerve problems in this study concurs with other authors,¹⁴ while the transient nature of problem of trismus is similar to that described in other reports.¹⁵

Distraction versus Conventional Techniques

The proponents of conventional techniques in craniomaxillofacial and orthognathic surgery point to several advantages of these classical techniques over distraction osteogenesis: their planning and treatment is more definitive than distraction, which is a more dynamic process that requires continuous adaptation; costochondral grafts are superior for treating the severely hypoplastic mandibular ramus; the planned result is obtained immediately; and it is easier to harmonize the skeletal and occlusal outcomes with pre and postsurgical orthodontics.

However, distraction clearly has several important advantages over conventional techniques. It is a more physiological process. Severe deformities causing functional problems can be treated by early intervention. When performed in childhood, the early correction of anatomic deformities and its associated functional problems minimises the risk of secondary problems (such as maxillary deformities). It is less invasive, and usually avoids the need for bone grafts, thus eliminating donor site morbidity. Importantly, the soft tissues are concurrently addressed by the same gradual distraction process, reducing the risk of bony relapse. It causes fewer nerve complications and does not adversely affect TMJ function. It can also be more economical than conventional surgical-orthodontic treatment. For example, in a recent report, the overall cost of treating Class II problems by distraction was found to be 50% to 75% less than conventional treatment.³

Orthodontics and Long-term Results

An important issue in evaluating the long-term outcomes of distraction is that of post-distraction growth. The challenge facing the surgeon and the orthodontist is how to harmonise the occlusal and morphologic changes

following successful distraction.^{16,17}

We believe it is important to distinguish between two types of patient. The first is the fully grown patient, in whom a stable long-term result can be expected. The second type is the growing patient, in whom several outcomes are possible. If normal growth occurs on the distracted side, long-term equilibrium and symmetry will be maintained (Figs. 6-9). However, if the rate of growth slackens and fails to match that of the unaffected side, the disequilibrium reappears, although it may not be as severe as before (Figs. 10, 11). Although it is difficult to make predictions regarding growth, our observations suggest that patients with severe ramus deformities and those who have undergone distraction of bone grafts are less likely to develop normal growth rates following distraction.

A controversial issue arising from the quest to maintain long-term stability of outcome is that of overcorrection, which is advocated by some authors.¹⁰ Because the value of overcorrection is difficult to evaluate, our philosophy is to not to attempt overcorrection, but to maximise maxillary and mandibular harmony, from both skeletal and occlusal standpoints, by frequent and careful intervention by the orthodontist so that maxillary skeletal and occlusal changes can be coordinated and matched with the morphologic changes of the mandible induced by distraction osteogenesis. In the case of a Class II problem, the preoperative orthodontics is similar to that for orthognathic surgery, but the post-distraction orthodontics will consist of correcting the anterior open bite by intermaxillary elastics. This treatment commences early, so that the regenerate can be easily manipulated. Our experience since 1993 rejoins the floating callus concept of Hoffmeister.¹⁴ Thus, early removal of the distractor facilitates early orthodontic manipulation of the callus.

The orthodontic management in hemifacial microsomia is more complex. The side effects of vertical distraction of the mandibular ramus are well known: a counter clockwise rotation of the mandible and functional shifting of the mandible to the contralateral side. This is manifested as a shift of the dental midline away from the distracted side and a crossbite on the unaffected side. This laterognathism often masks the vertical lengthening of the ramus and prevents the creation of the desired unilateral open bite on the distracted side. It is important to anticipate these changes so that the maxilla can be treated with preoperative functional dysjunction and thus maintain a good maxillary and mandibular arch relationship. In this regard, a stabilisation appliance is helpful in maintaining the intended vector of vector distraction.¹⁸

Another useful technique is to combine maxillary and mandibular distraction¹⁹ in order to simultaneously correct the obliquity of the occlusal plane and prevent major

occlusal imbalances from developing. This is especially important in the severe occlusal canting in adult patients, who are unlikely to develop sufficient dento-alveolar compensation on their own. A further benefit of simultaneous maxillary and mandibular distraction is that the oral commissure is lowered on the distracted side, restoring facial symmetry (Fig.14).

Conclusions

Intraoral mandibular distraction with the Leibinger Intraoral Distractor is able to address the majority of deformities due to mandibular hypoplasia. The best results are realised through the application of meticulous surgical technique, combined orthodontics, and the judicious use of simultaneous maxillary and mandibular distraction. Recent developments have included a second generation of Leibinger Intraoral distractors with the capability for bidirectional distraction, with encouraging positive results.

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