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Craniofacial/Pediatric

Treatment of Facial Asymmetry Using Distraction Osteogenesis in a Mandible First Approach

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Background: Facial asymmetry includes several etiologies, among them trauma to the condylar area during early childhood and congenital malformations such as hemifacial microsomia. This article describes the management of facial asymmetry in adolescents and young adults using a mandible first approach by distraction osteogenesis, followed by maxillary Le-Fort I as a second stage.

Methods: Eighteen patients 14–25 years of age presented with unilateral hypoplasia of the jaws which manifested clinically by deviation of the chin and canting of the occlusal plane. Etiology included hemifacial microsomia and trauma injuries at early childhood.

All patients underwent orthodontic treatment and two phases of surgical treatment. Surgical treatment included unilateral mandibular distraction followed by Le-Fort I osteotomy for alignment of the maxilla. Additional bone graft in the affected side and sliding genioplasty were done as required.

Results: Marked ramal elongation of 18.94 mm concomitant with mandibular forward traction of 12.5 mm was noted while achieving symmetry. In all cases, the maxilla was centered to the midline in proper occlusion. Post distraction, posteroanterior cephalometric radiographs demonstrated elongation of the affected ramus, improvement in facial symmetry, and correction of the occlusal canting. Relapse was minimal based on long-term follow-ups of 47.4 months.

Conclusions: The two-stage surgical approach that includes elongation of the mandible as a first stage followed by adaptation of the maxilla is useful in correcting facial asymmetry. Using this protocol at the correct age (14–18) is very stable, as demonstrated by our results, yet one should always remember the transverse deficiency in the gonial angle requires additional bone grafting or patient specific implants.
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INTRODUCTION

Facial asymmetry includes several etiologies such as trauma to the condylar area during birth or early childhood and congenital malformations, of which the most abundant is hemifacial microsomia (HFM).[1]

HFM is a progressive deformity[2,3] manifested by unilateral hypoplasia of the mandible and shortening of the ramus. When left untreated until adolescence or young adulthood, it is usually associated with secondary restriction of vertical maxillary growth, and results in canting of the maxilla and the occlusal plane.[4,5]

Although some authors[4–6] consider the disease a progressive one, requiring early surgical treatment, others claim HFM is nonprogressive, as the ratio between the affected and nonaffected sides is constant during growth.[7–9] HFM can be graded based on the classification system of Pruzansky.[10] Grade I describes a hypoplastic condyle compared to the normal side. Grade II describes a grossly distorted condyle, ramus, and sigmoid notch. Grade III describes a grossly distorted ramus with loss of landmarks and agenesis.

Another etiology of facial asymmetry includes condylar fractures during birth and early childhood which can

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cause restriction of mandibular growth on the affected side, resulting in secondary restriction of vertical maxillary growth, exhibiting canting of the occlusal plane and facial asymmetry.[11]

The difference between the two etiologies include soft-tissue agenesis in HFM which is not present in patients with asymmetry secondary to trauma.

The aim of the treatment in facial asymmetries is to correct the defect three-dimensionally. The treatment plan is aimed at elongating the hypoplastic ramus, moving the affected side of the jaw downward and forward, and the chin toward the midline of the face, followed by maxillary canting correction. It is also important to correct the gonial angle region transversely, especially in HFM.[12] The affected hypoplastic side of the mandible requires marked elongation at the gonial region in vertical and anterior directions. This is nearly impossible to achieve by conventional orthognathic methods, because in these modalities, a large gap is created, which is difficult to fixate and may result in significant relapse. Due to these drawbacks, we use the distraction osteogenesis (DO) method. DO was developed by Ilizarov to elongate long bones.[13,14] It is a proven, efficient method for large elongation of hypoplastic mandibles.[12,15–17]

In this article, we present our treatment experience for moderate and severe hypoplastic facial asymmetry in adolescents and young adults by elongation and centralization of the mandible as a first stage using DO, followed by a second stage of maxillary Le-Fort I adjustment and decanting to the corrected mandible (Table 1). This treatment modality is appropriate for HFM type I and II, and also in type III previously treated by costochondral graft which resulted in undergrowth compared to the unaffected side.[18,19]

Takeaways

Question: How to treat facial asymmetry—treating cases with severe facial asymmetry is one of the most difficult tasks in maxillofacial surgery.

Findings: We describe a mandibular first approach using distraction osteogenesis for correcting severe mandibular canting, followed by Le-Fort I maxillary osteotomy for final adjustment and maxillary decanting.

Meaning: The mandibular first distraction osteogenesis approach significantly contributes to the field and adds a very effective method for treating asymmetry cases.

MATERIAL AND METHODS

This is a retrospective study performed on 18 patients 14–25 years of age, with unilateral hypoplasia of the jaws which manifested clinically by deviation of the chin and canting of the occlusal plane. Etiology included 15 patients with HFM or Goldenhar syndrome and three patients presenting following trauma injuries to the temporomandibular joint (TMJ) at early childhood. Posteroanterior (PA) cephalometric radiographs were performed prior to and following treatment, utilizing vertical and horizontal measurements for evaluation. Vertical measurements included ramus height in relation to the nonaffected side (condylion–gonion) and gonial height (to the horizontal line through the sphenozygomatic suture) (Fig. 1). Facial asymmetry was measured using protuberance menti (PM) angle and occlusal canting angle (OC) (Fig. 1). PM angle is measured between the vertical line and the line to the PM point. OC angle is measured between the horizontal line and the occlusal line (Fig. 1).

Horizontal changes were measured using the anterior edge of the atlas to A point (AA-A) and condylion to pogonion (Con-Pog) (Fig. 1).

Airway analysis was measured using posterior airway space (PAS) and mandibular plane to the hyoid bone (MP-H) (Fig. 1).

Treatment included three phases; orthodontic treatment followed by two surgical phases.

Orthodontic treatment included leveling and alignment of the maxillary and mandibular arches. One should emphasize the importance of the orthodontic phase as this allows for a stable result.

The first surgical phase included unilateral mandibular DO at the gonial angle region of the affected side to elongate the mandible downward and forward. Under general anesthesia, a circumferential osteotomy was performed at the gonial area, and a distractor was connected to the bone across both sides of the gonial osteotomy (Fig. 2). In seven cases, external distraction devices were used by an intraoral approach, and in 11 cases, internal distraction devices were used by an external submandibular approach. Intraoral mucosa and subcutaneous tissue were sutured using 3/0 Vicryl, and the skin was sutured using nylon 5/0 sutures. We used external devices in earlier cases, and with the development of internal devices, we began using them as they are more comfortable to the patients. Following a latency period of 4 days, unilateral elongation at a rate of 1 mm/d was performed, and the mandible was elongated downward and forward (Fig. 2).

A unilateral surgical open bite on the affected side was gradually created and maintained by periodic incremental creation of an acrylic wafer. Intermaxillary elastics were used to guide the mandible to the correct midline. At the end of the mandibular distraction phase, the nonaffected side presented with dental cross bite due to the elongation

Table 1. Sequence of Treatment

First Surgery: Mandibular Distraction Osteogenesis				Second Surgery: Le Fort I Osteotomy for Decanting, Removal of Mandibular Distraction Device, Bone Grafting at the Mandibular Angle and Genioplasty as Required	Optional Operations: Fat Injection or Patient-specific Implants in the Affected Side
	Latency Period	Rate of Bone Elongation	Consolidation Period		
	4 d	1 mm/d as necessary	3 mo		

Protocol for two stage mandibular first treatment of facial asymmetry using distraction osteogenesis.

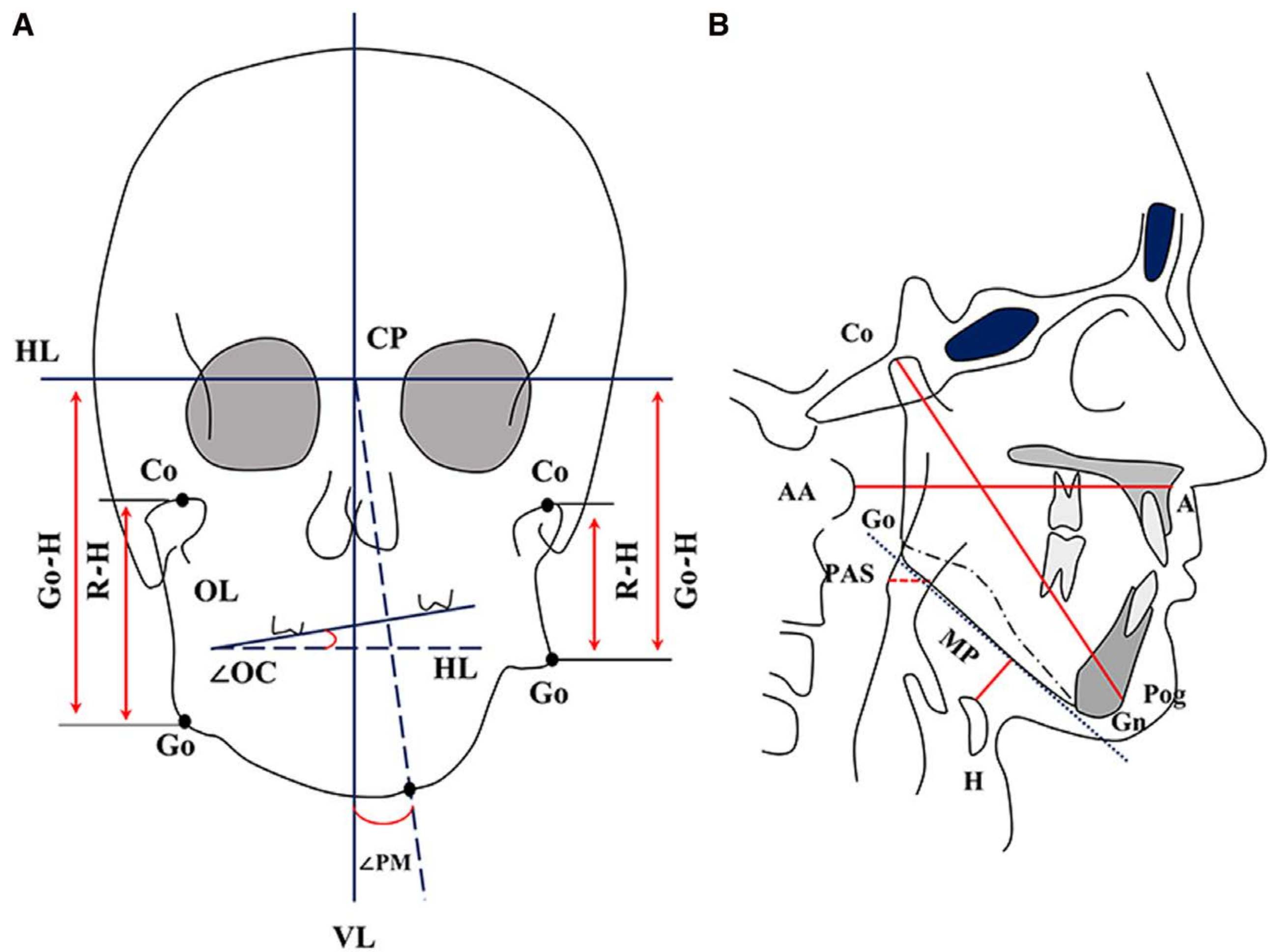

Fig. 1. Posteroanterior and lateral cephalometric analysis were performed prior and following treatment, utilizing vertical and horizontal measurements for evaluation of asymmetry. CO, condylion; CP, crista galli point; Gn, gnathion; GO, gonion; GO-H, gonial height; H, hyoid; HL, horizontal line; MP, mandibular plane; OL, occlusal line; R-H, ramus height; VL, vertical line. A, Frontal view. B, Lateral view.

of the affected side (Fig. 2). Consolidation period was 3 months. Panoramic and PA cephalometric X-rays were performed during the lengthening and later during the consolidation period, to observe the vector of elongation and the gradual ossification. The total amount of time between the first and second procedures was ~4 months, which includes the distraction phase and the consolidation period.

In the second surgical stage, under general anesthesia and using a circumvestibular approach, a Le-Fort I osteotomy was performed 5 mm above the apex of the teeth and the maxilla was decanted by downgrafting the affected side, centralized and adapted to the mandible using intermaxillary fixation. The bone gap created in the affected side of the maxilla was filled with autogenous corticocancellous bone graft originated from the anterior iliac crest, and the maxilla was fixated using plates and screws (Fig. 2). During the same procedure, the mandibular distraction device was removed, and in 17 of the 18 patients, a bone graft was placed in the gonial angle area for additional transverse correction. At this phase, six of the patients underwent additional sliding genioplasty for achieving superior symmetry. Suturing of the circumvestibular mucosa was performed using 3/0 Vicryl sutures, and the patients received 5 days of antibiotic treatment (Augmentin 500 mg, 3 times per day). Intermaxillary relations were maintained using interocclusal elastics for 2 weeks.

RESULTS

Eighteen patients were included in the study. Gender distribution included 11 male and seven female patients. Eleven exhibited left mandibular hypoplasia and seven, right mandibular hypoplasia. Age distribution included patients 14–25 years of age with a mean of 16.9 years. Eleven patients were treated using an internal device system and seven using an external system (Table 2). Figures 3–5 present a case of unilateral mandibular deficiency treated with external distraction device using our protocol. Pre- and posttreatment can be observed and photographs during elongation and following mandibular elongation but pre

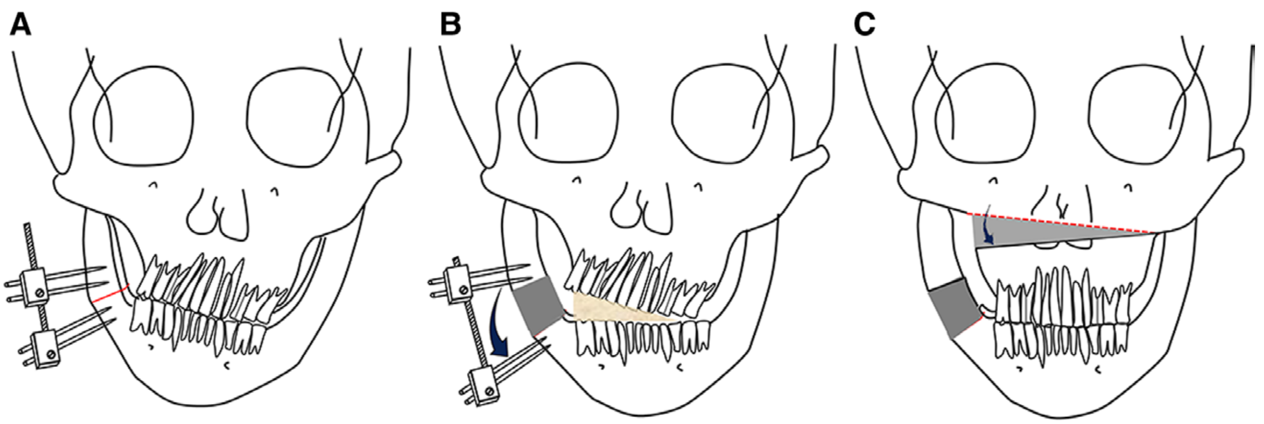

Fig. 2. Surgical treatment included two stages. A-B, We demonstrate a mandibular unilateral distraction osteogenesis with concomitant incremental creation of an acrylic wafer for maintaining the surgically created open bite and thus receiving mandibular symmetry. C, We demonstrate device removal and maxillary repositioning by maxillary down grafting of the affected side and bone graft insertion in the created gap.

Table 2. Demographic and Surgical Details of the Patient Group

Patient No.	Gender	Side	Diagnosis	Age (y)	Device	Genioplasty	Follow-up (mo)
1	M	Left	HFM	22	Internal	V	24
2	M	Left	HFM	17	Internal	V	25
3	F	Left	HFM	14	Internal	X	39
4	F	Left	Goldenhar syndrome	14	Internal	X	32
5	M	Left	HFM	23	External	X	50
6	F	Left	HFM	14	External	X	36
7	F	Left	Goldenhar syndrome	14	Internal	X	104
8	F	Left	HFM	17	External	V	36
9	M	Left	Goldenhar syndrome	16	Internal	X	71
10	M	Left	Trauma	17	External	X	24
11	F	Left	HFM	15	Internal	V	72
12	M	Right	HFM	14	Internal	X	24
13	M	Right	HFM	25	Internal	X	53
14	M	Right	Trauma	17	External	X	36
15	M	Right	Goldenhar syndrome	22	Internal	V	24
16	M	Right	HFM	16	External	V	72
17	M	Right	HFM	14	External	X	96
18	F	Right	Trauma	14	Internal	X	36

maxillary treatment. Intraoral photographs present the surgically created and maintained open bite. The second surgical stage included treatment of the maxilla and correction of the occlusion canting (Figs. 3 and 4). Pre- and posttreatment PA cephalometric radiographs can be observed (Fig. 5). Figures 6 and 7 present a second case treated using an internal distraction device.

Measurements included vertical and horizontal changes as well as canting and airway evaluation. Ramus height increased by an average of 39.5% (18.94 mm). All results were stable in the follow-ups (minimum of 2 years), showing between 0.7% and 3.6% relapse. (**See figure, Supplemental Digital Content 1**, which demonstrates ramus height of the affected side compared to the healthy side at three time points, **http://links.lww.com/GOX/A20**.) Another vertical measurement included is the gonial height which increased by 13% with 0.3% relapse in the follow-ups. (**See figure, Supplemental Digital Content 2**, which demonstrates gonial height of the affected side compared to the healthy side at three time points, **http://links.lww.com/GOX/A21**).

Facial vertical asymmetry was measured using the PM angle. Results showed a marked decrease from an average of 8.22 degrees to 1.11 with a relapse to 1.36 degrees in the follow-ups. (**See figure, Supplemental Digital Content 3**, which demonstrates occlusal canting and PM angle at three time points, **http://links.lww.com/GOX/A22.**)

Canting was measured using the OC angle. Similarly, a marked decrease was observed from 9.6 degrees to 0.86 with a relapse to 1.28 in the follow-ups. (**See figure, Supplemental Digital Content 3**, **http://links.lww.com/GOX/A22**.)

Horizontal changes were measured using AA-A and Con-Pog. Both showed a significant increase with AA-A increasing from 74 to 82 mm with a 1.2% relapse and Con-Pog increasing from 100 to 112.5 mm with a 0.7% relapse. (**See figure, Supplemental Digital Content 4**, which demonstrates maxillary length and mandibular length at three time points, **http://links.lww.com/GOX/A23**).

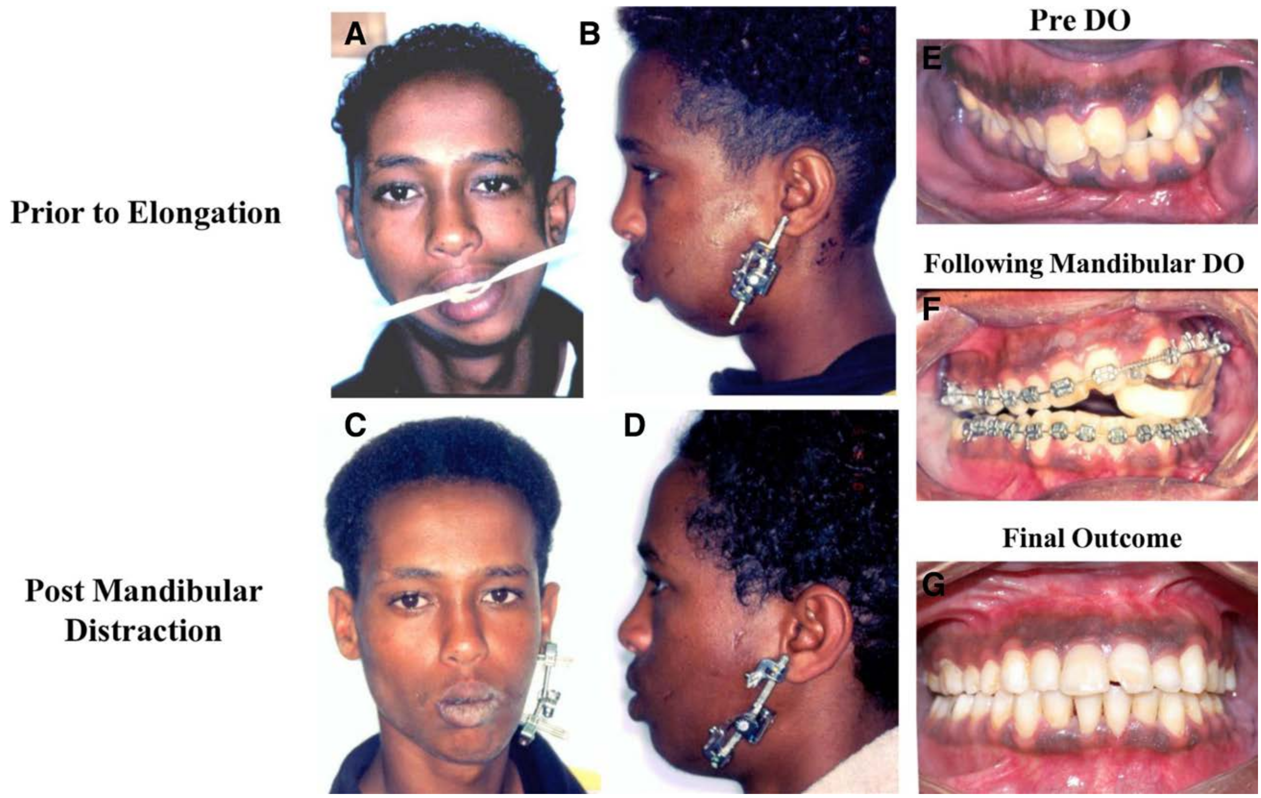

Fig. 3. Patient treated using an external distraction device. Photographs before treatment; a severe canting is observed (A, E). Postfixation of distraction devices and before mandibular elongation (B). Post mandibular distraction and before maxillary treatment (C, D, F). Occlusion following mandibular and maxillary treatment (G).

Airway analysis included PAS and MP-H. PAS increased from 11 to 15 mm with no relapse, whereas MP-H decreased from 19.47 to 13.1 mm with 2% relapse. (**See figure, Supplemental Digital Content 5**, which demonstrates airway analysis at three time points, **http://links.lww.com/GOX/A24**).

During the mandibular distraction, successful marked curvilinear elongation of the gonial angle was carried out and resulted in mandibular ramus and body elongation while achieving symmetry and correction of the mandibular occlusal canting. In the second operation following a consolidation period of 3 months, the distraction device was removed, and the maxilla was centered to the midline in proper class I relations while eliminating the maxillary canting. Placing a bone graft at the gonial area contributed to the transverse correction of the mandible. Comparing panoramic radiographs, lateral and PA cephalometric X-rays taken prior to and following the procedure revealed significant vertical ramus elongation compared to the opposite side as well as anterior movement of the mandible. The Le-fort I osteotomy allowed for resolution of the maxillary canting, eliminating the skeletal asymmetry of the jaws. None of the cases exhibited long-term dysesthesia in the chin and lower lip, indicating the inferior alveolar nerve was preserved. Four patients exhibited temporary hypesthesia which resolved in several weeks spontaneously.

Analysis was performed prior, immediate postoperatively and 2 years postoperatively. The class I molar occlusion relationship was achieved in all cases, following postoperative orthodontic treatment.

In six of the cases, an additional genioplasty correction was performed during the second operation to improve mandibular symmetry. All patients exhibited skeletal stability of the facial skeleton and the dental occlusion which were maintained during the follow-up periods.

DISCUSSION

The surgical treatment plan of patients with facial asymmetry is challenging. The aim of the treatment is to correct the unilateral mandibular deficiency three-dimensionally by elongation of the mandibular ramus downward and forward toward the midline followed by maxillary correction using a Le-Fort I osteotomy for correction of the maxillary canting. In contrast to other deformities, such as skeletal class II or skeletal class III deformities, which are treated based on their potentially created occlusion which guides the surgery, in facial asymmetry, the occlusion will not guide the surgery, and the treatment requires a three-dimensional two-stage correction of the maxillofacial complex in which the mandibular canting is treated in the first stage, creating an open bite in the deficient side. In the second stage, the maxilla is repositioned based on the new occlusion. It is important to understand that the mandibular elongation at the affected side requires marked elongation at the gonial area of 20–30 mm in the vertical and

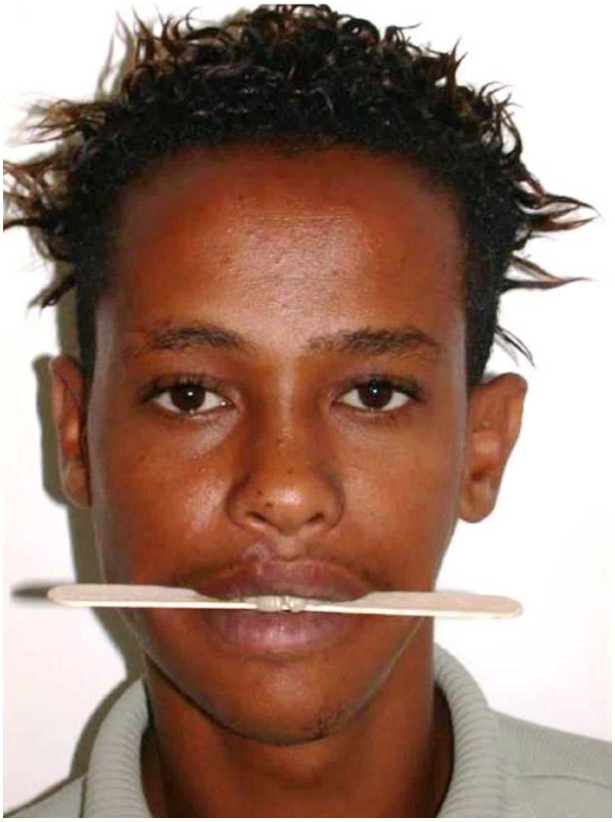

Fig. 4. Post maxillary decanting and orthodontic treatment.

anterior planes, which is difficult to perform by conventional orthognathic surgery due to the large gap created, which is also difficult to fixate and may result in significant relapse. This marked elongation should be performed by DO, which generates new bone by gradual traction.[12,15,16,20]

We performed mandibular elongation using unilateral DO of the affected side followed by maxillary adjustment at a second stage on 18 patients 14–25 years of age. Most cases were HFM type I or II according to the Pruzansky classification. In cases of graded class III, the treatment of choice should be costochondral graft, and only if this graft is underdeveloped, DO should be applied. We achieved marked elongation using this method with a mean of 18.94mm in ramus height. We achieved horizontal increase of over 12.5% in mandibular length (Con-Pog). The same relative increase was observed in the maxilla, and this can be explained by the skeletal changes in the maxilla secondary to the mandible. Facial asymmetry in the vertical plane (PM angle) and the horizontal one (OC angle) decreased as we planned from 9.6degrees and 8.22, respectively, to ~1degree aspiring to 0degrees and showing good correction of the asymmetry. Finally, airway analysis showed a significant increase. Airway increased by 36% and 48% based on the PAS and MP-H measurements, respectively. Using DO allows for a stable result as observed by our long-term follow-up of 47.4 months in average. During this period, a relapse of 3.6% was observed in ramus height and 0.7% in mandibular length. This is in contrast to conventional orthognathic movements that show higher rates of relapse in significantly smaller movements.[21] Disadvantages of the distraction method includes two operations, one for the mandible and the other for the

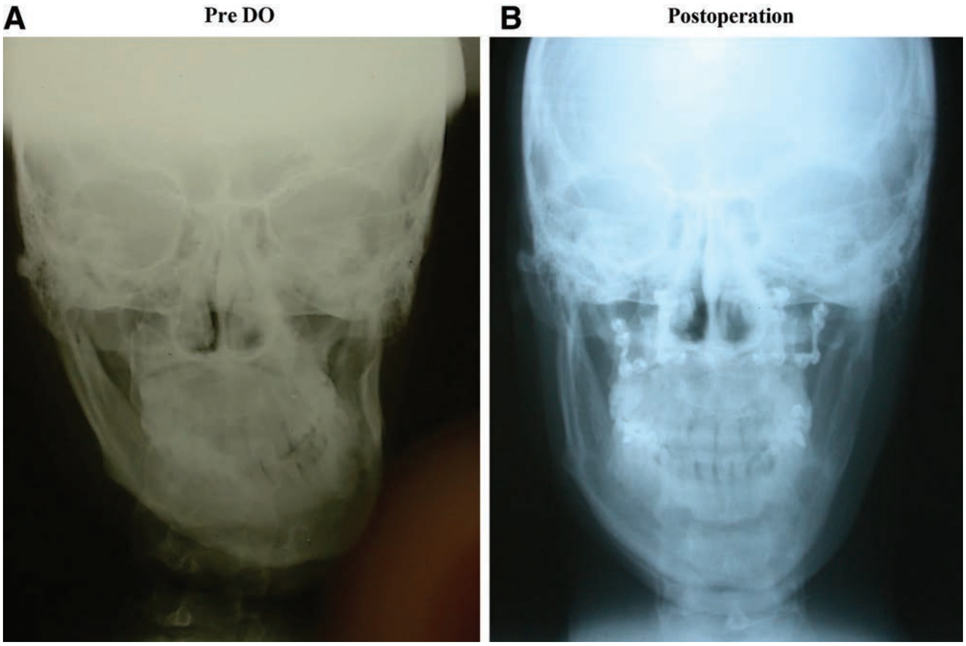

Fig. 5. Radiographic surveillance. Pre (A) and post (B) surgical treatment posteroanterior cephalometric radiographs of the patient described in Figure 3 are presented.

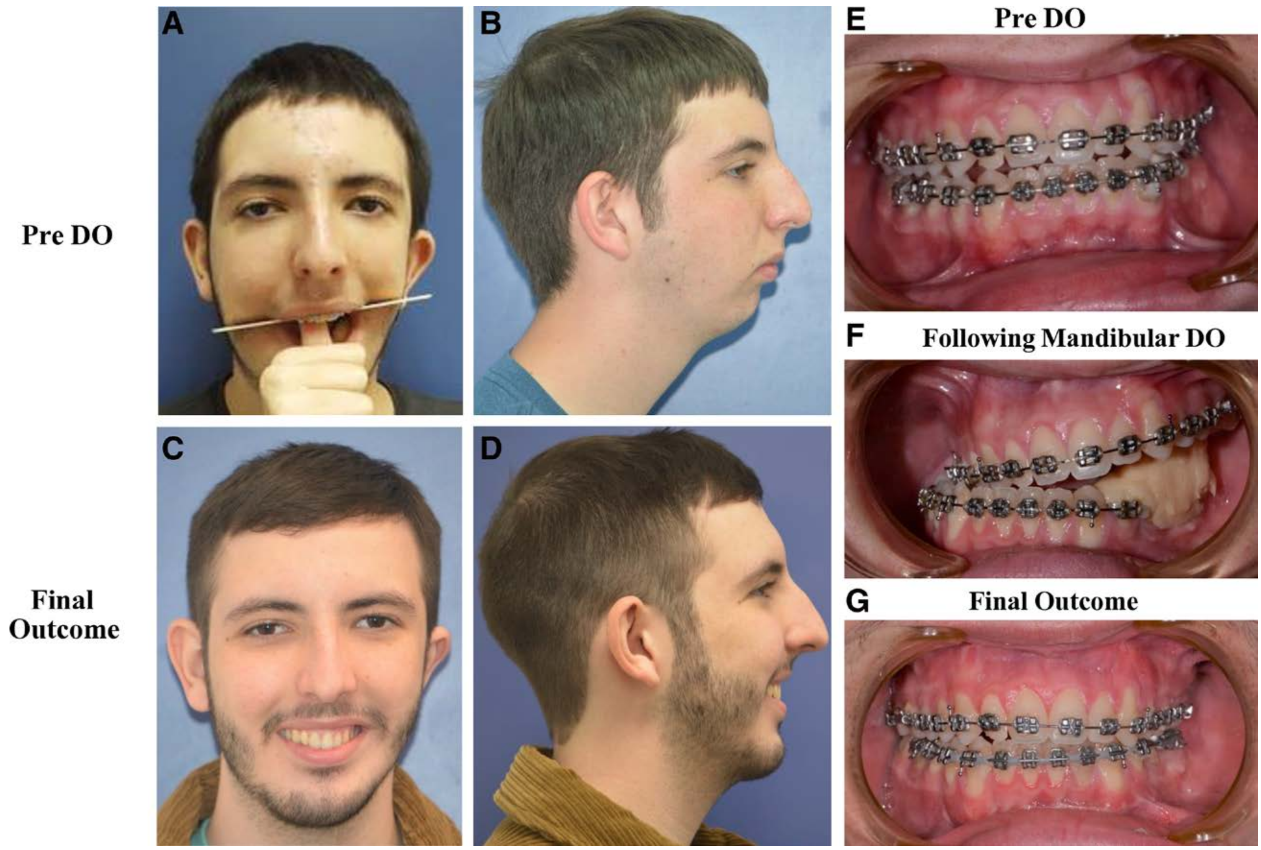

Fig. 6. Patient treated using an internal distraction device. Photographs before treatment (A, B, E), post the mandibular distraction phase (F—please note the unilateral surgical created open bite maintained by an acrylic wafer and the contralateral dental crossbite), and post maxillary decanting and orthodontic treatment (C, D, G).

maxilla, and duration of treatment includes the distraction and retention periods (Table 1).

The key point of our protocol is attending the mandible at the first stage. We distract the mandible in a downward and forward direction until proper horizontal and vertical correction is achieved. We use elastics and an interocclusal adjustable wafer on the affected side to assist and support the desired mandibular vector correction. The unoperated maxilla acts as an anchor for the guidance of the vector of elongation. Once proper correction of the mandible is achieved and maintained by an interocclusal wafer which preserves the surgically created open bite, a 3-month consolidation period is required. Two weeks into the consolidation period, the intermaxillary fixation elastics are removed. The consolidation period allows for the mineralization and maturation of the newly created bone. Next, the second operation phase includes the Le-Fort I osteotomy for the transverse occlusal canting correction and mandibular device removal. In some cases, this phase includes an additional genioplasty for additional transverse and anteroposterior correction. Thus, at the first stage, the unoperated maxilla serves as an anchorage for the distracted mandible, whereas in the second stage, the elongated mandible serves as an anchorage for the placement of the osteotomized maxilla.

It is important to use elastics during the mandibular lengthening phase to guide the mandible to the correct midline. It is also critical to place intermaxillary elastics on the opposite side to avoid creating an open bite in the nonaffected side.

Several groups claim patients treated at an early age will undergo major relapse and thus exhibit a similar result as nontreated patients at the end of the growth period.[22,23] Our protocol prevents this relapse by performing the distraction phase in the adolescent age group (patients aged 14 and older), maintaining the result by an acrylic wafer directly followed by the maxillary adjustment, which allows for superior stability over time.

As mentioned and observed in our results, the ideal timing for performing this method when treating asymmetry of the jaws is 14–18 years of age. This timing was also chosen because the dentition is mostly permanent at this age, and the growth period of the jaws is at its final stage.[24] On the other hand, an advantage of performing DO at an earlier age is the psychological effect due to the improvement in skeletal discrepancy.

Some authors advocate performing a simultaneous maxillary-mandibular unilateral distraction.[25,26] This procedure has some drawbacks. First, the ideal skeletal proportions are not always obtained; there is a tendency to produce an elongated facial appearance and occlusal difficulties. Another drawback is the difficulty in controlling the vector of lengthening in the vertical and horizontal planes. In addition, a long duration of intermaxillary fixation is required during the distraction and

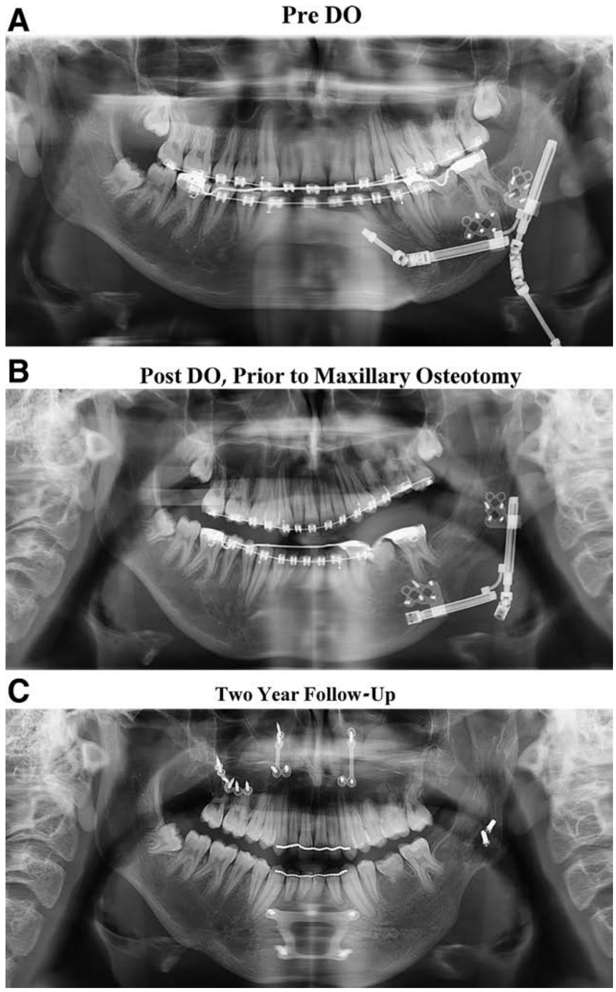

Fig. 7. Radiographic surveillance. Pre DO (A), postmandibular DO (B), and final (C) panoramic radiographs of the patient described in Figure 5.

consolidation periods, which results in discomfort to the patients.

As was noted, the transverse deficiency of the gonial angle is less controllable and requires further surgical interventions, such as autogenous bone grafting or patient specific implants, which can be performed during the operation for distraction device removal.

In conclusion, the two-stage surgical management protocol using mandibular gonial angle elongation by DO followed by maxillary adjustment using Le-Fort I osteotomy in adolescence or early adulthood is a reliable treatment method for improving facial asymmetry in cases of congenital or posttraumatic dysplastic pattern of facial growth.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Patients provided written consent for the use of their images.

REFERENCES

1. Siebert JW, Anson G, Longaker MT. Microsurgical correction of facial asymmetry in 60 consecutive cases. *Plast Reconstr Surg.* 1996;97:354–363.
2. Kaban LB, Mulliken JB, Murray JE. Three-dimensional approach to analysis and treatment of hemifacial microsomia. *Cleft Palate J.* 1981;18:90–99.
3. Mulliken JB, Kaban L. Analysis and treatment of hemifacial microsomia in childhood. *Clin Plast Surg.* 1987;14:91–100.
4. Kaban LB, Moses MH, Mulliken JB. Surgical correction of hemifacial microsomia in the growing child. *Plast Reconstr Surg.* 1988;82:9–19.
5. Kearns GJ, Padwa BL, Mulliken JB, et al. Progression of facial asymmetry in hemifacial microsomia. *Plast Reconstr Surg.* 2000;105:492–498.
6. Murray JE, Mulliken JB, Kaban LB, et al. Twenty year experience in maxillocraniofacial surgery. An evaluation of early surgery on growth, function and body image. *Ann Surg.* 1979;190: 320–331.
7. Obwegeser HL. Correction of the skeletal anomalies of oto-mandibular dysostosis. *J Maxillofac Surg.* 1974;2:73–92.
8. Polley JW, Figueroa AA. Distraction osteogenesis: its application in severe mandibular deformities in hemifacial microsomia. *J Craniofac Surg.* 1997;8:422–430.
9. Rune B, Sarnäs K-V, Selvik G, et al. Roentgen stereometry with the aid of metallic implants in hemifacial microsomia. *Am J Orthod.* 1983;84:231–247.
10. Pruzansky S. Not all dwarfed mandibles are alike. *Birth Defects.* 1969;5:120–129.
11. Giannakopoulos HE, Quinn PD, Granquist E, et al. Posttraumatic temporomandibular joint disorders. *Craniomaxillofac Trauma Reconstr.* 2009;2:91–101.
12. Rachmiel A, Manor R, Peled M, et al. Intraoral distraction osteogenesis of the mandible in hemifacial microsomia. *J Oral Maxillofac Surg.* 2001;59:728–733.
13. Ilizarov G, Ilizarov GA. Plastic reconstruction of longitudinal bone defects by means of compression and subsequent distraction. *Acta Chir Plast.* 1980;22:32–41.
14. Ilizarov GA. The principles of the Ilizarov method. *Bull Hosp Jt Dis Orthop Inst.* 1988;48:1–11.
15. McCarthy J, Schreiber J, Karp N, et al. Lengthening the human mandible by gradual distraction. *Plast Reconstr Surg.* 1992;89:1–8.
16. Rachmiel A, Aizenbud D, Eleftheriou S, et al. Extraoral vs. intraoral distraction osteogenesis in the treatment of hemifacial microsomia. *Ann Plast Surg.* 2000;45:386–394.
17. Rachmiel A, Levy M, Laufer D. Lengthening of the mandible by distraction osteogenesis: report of cases. *J Oral Maxillofac Surg.* 1995;53:838–846.
18. Emodi O, Israel Y, Almos ME, et al. Three-dimensional planning and reconstruction of the mandible in children with craniofacial microsomia type III using costochondral grafts. *Ann Maxillofac Surg.* 2017;7:64–72.
19. Emodi O, Shilo D, Israel Y, et al. Three-dimensional planning and printing of guides and templates for reconstruction of the mandibular ramus and condyle using autogenous costochondral grafts. *Br J Oral Maxillofac Surg.* 2017;55:102–104.
20. Rachmiel A, Emodi O, Rachmiel D, et al. Internal mandibular distraction to relieve airway obstruction in children with severe micrognathia. *Int J Oral Maxillofac Surg.* 2014;43:1176–1181.
21. Rachmiel A. Treatment of maxillary cleft palate: distraction osteogenesis versus orthognathic surgery—part one: maxillary distraction. *J Oral Maxillofac Surg.* 2007;65:753–757.

22. Meazzini MC, Mazzoleni F, Bozzetti A, et al. Comparison of mandibular vertical growth in hemifacial microsomia patients treated with early distraction or not treated: follow up till the completion of growth. *J Craniomaxillofac Surg.* 2012;40:105–111.
23. Bertin H, Mercier J, Cohen A, et al. Surgical correction of mandibular hypoplasia in hemifacial microsomia: a retrospective study in 39 patients. *J Craniomaxillofac Surg.* 2017;45: 1031–1038.
24. Proffit W. *Contemporary Orthodontics*. 3rd edition. St. Louis: Mosby; 2000.
25. Nakajima H, Sakamoto Y, Tamada I, et al. Maxillary-driven simultaneous maxillo-mandibular distraction for hemifacial microsomia. *J Craniomaxillofac Surg.* 2011;39:549–553.
26. Padwa BL, Kearns GJ, Todd R, et al. Simultaneous maxillary and mandibular distraction osteogenesis with a semiburied device. *Int J Oral Maxillofac Surg.* 1999;28:2–8.