Three-Dimensional Orofacial Changes Occurring After Proportional Condylectomy in Patients With Condylar Hyperplasia Type 1B (Unilateral Hemimandibular Elongation)

Waseem A. Abboud, DMD, Maria Krichmar, DMD,† Daniela Blinder, DMD, MD,‡ Alex Dobriyan, DMD,§ Gilad Yahalom, MD,|| and Ran Yahalom, DMD¶*

Purpose: To evaluate 3-dimensional orofacial changes that occurred after proportional condylectomy that was not followed by orthognathic surgery in patients with condylar hyperplasia type 1B (unilateral hemimandibular elongation).

Materials and Methods: This retrospective analysis used the medical records of 14 skeletally mature patients. Transverse, vertical, and horizontal cephalometric analyses of photographs and radiographs were undertaken. A comparison of preoperative and postoperative measurements was conducted.

Results: After proportional condylectomy, transverse chin position and vertical lip cant improved to various degrees, whereas ramus and condyle height and mandibular lower border discrepancy worsened to different extents. The prominence of the gonial angle of the affected (operated) side increased in all patients after surgery, and this contributed to better symmetry only when the preoperative prominence was small (flat), whereas the opposite occurred when the preoperative prominence was large (bulky). After condylectomy, there was posterior displacement of the pogonion point (setback), which was favorable in cases with a preoperative concave profile and unfavorable in cases with a preoperative convex profile.

Conclusion: Proportional condylectomy can successfully arrest the hyperplastic growth of the affected condyle; however, it rarely achieves perfect symmetry of the face. Although it improves some facial features, other facial traits are worsened. Surgeons should have a full understanding of the 3-dimensional

*Senior Surgeon and Head of TMJ Unit, Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

†Resident, Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

‡Senior Surgeon, Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

§Senior Surgeon, Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

||Attending Physician, Institute of Movement Disorders, Department of Neurology, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler school of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

¶Department Head, Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

Conflict of Interest Disclosure: None of the authors have any relevant financial relationship(s) with a commercial interest.

Address correspondence and reprint requests to Dr Abboud: Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Tel-Hashomer 5265601, Israel; e-mail: waseem.abboud@mail.huji.ac.il

Received July 9 2018
Accepted November 8 2018

0278-2391/18/31272-2
https://doi.org/10.1016/j.joms.2018.11.006

changes occurring after proportional condylectomy and should be able to predict, based on preoperative findings, the anticipated improvement or worsening of different facial features.

J Oral Maxillofac Surg 77:803-817, 2019

Facial symmetry is a trait that influences esthetics and beauty. A mild degree of asymmetry is considered normal and acceptable in the average face; however, if this mild disparity becomes obvious, it could be associated with a perception of an unesthetic appearance.[1,2] Condylar hyperplasia (CH) is a progressive overgrowth of the condylar growth site that causes various degrees of mandibular asymmetry, prognathism, malocclusion, and dentoalveolar compensations.[3] Obwegeser and Makek[4] and Nitzan et al[5] classified the disorder into 2 main subtypes based on morphologic characteristics: asymmetry with a transverse growth vector ("hemimandibular elongation") and asymmetry with a vertical growth vector ("hemimandibular hyperplasia"). Wolford et al[6] published a refined classification system and provided detailed clinical and radiographic morphologic characteristics and recommendations regarding surgical correction options depending on the age of the patient and the activity of the condition. Although this classification was broader than the previous classification and included other related disorders, the fact that CH had 2 main morphologic patterns was a constant finding in these 2 classification systems.

The treatment of CH is primarily surgical and depends on the activity of the hyperplastic condylar growth.[7-13] Patients with inactive CH can benefit from orthognathic surgery with the sole objective of correcting the dentofacial deformity.[1,14] Conversely, patients with an active form of CH should undergo, in addition to orthognathic surgery, some form of high condylectomy to stop the hyperplastic condylar overgrowth; otherwise, there is a risk of relapse of the asymmetry.[15-19] Orthognathic surgery in these cases can be performed simultaneously with condylar surgery or as a second-stage procedure.[1,6,16,20] Condylar surgery is usually in the form of a high condylar shave that removes 3 to 7 mm of the condylar head.[6,21,22]

Few investigators have reported that proportional condylectomy, in which a larger portion of the condyle is removed to equalize the lengths of both sides, can achieve, in addition to arresting the hyperplastic condylar growth, satisfactory improvement of the asymmetry, thus obviating simultaneous or secondary orthognathic surgery.[3,14,16,22-24] However, this theory has not gained great acceptance in the maxillofacial community, primarily because the available studies have some major limitations. In the authors' opinion, there are 5 main drawbacks of the currently available literature on the topic of condylectomy as the sole treatment for CH. The first is the lack of objective outcome tools. Some studies used cephalometric measurements in the transverse plane only.[25-28] Other studies evaluated the outcomes based on the surgeon's or patient's opinion of the results as being satisfactory or unsatisfactory[3] or the patient's willingness to undergo further corrective surgery after condylectomy.[23]

The second limitation is that many studies included young growing patients and skeletally mature patients,[3,14,16,21,29,30] thus overlooking the fact that the continued growth of the unoperated condyle in younger patients has a profound effect on the morphologic facial, skeletal, and dental position. This could be the actual reason behind the gradual achievement of symmetrical facies.

A third limitation of the existing literature is that some studies did not differentiate between the 2 types of CH. Although a movement in one plane could be beneficial for patients with transverse asymmetry, this same movement would be disadvantageous for patients with vertical asymmetry.[3,21]

A fourth drawback is the inconsistency in postoperative occlusal treatment. Intermaxillary fixation, guiding elastics, occlusal functional appliances, and orthodontic appliances using skeletal anchors produce different movements at substantially different magnitudes and thus have different effects on the jaw position.[1,31,32] The question is to what extent did these orthodontic forces contribute to attaining the final jaw position. The fifth and final limitation is that some investigators reported on their experience in treating patients with CH using various therapies without mentioning the basis on which the choice of treatment was made for the different patients.[1,3,20,33,34]

The purpose of this study was to examine the 3-dimensional changes after proportional condylectomy in adult patients with CH type 1B (unilateral hemimandibular elongation) that was not followed by orthognathic surgery for at least 1 year. The 3-dimensional changes were evaluated using standardized photographs and radiographs, and cephalometric analyses were performed in the transverse, vertical, and horizontal planes. The authors aimed to evaluate the postoperative changes to determine which parameters and the extent to which these parameters improved, worsened, or did not change after surgery.

Materials and Methods

A retrospective analysis was conducted of medical records, including photographs and radiographs, of consecutive adult patients diagnosed with active CH type 1B (unilateral hemimandibular elongation) who underwent proportional condylectomy at the authors' department during a 5-year period (September 2011 to August 2016).

The diagnosis was based on 4 criteria:

1. Anamnesis: A report of progressively worsening facial asymmetry. Patients were requested to augment their complaint by old photographs and, whenever available, old radiographs.
2. Clinical evaluation: Facial asymmetry manifested primarily by deviation of the chin to one side, deviation of the lower dental midline, and dental crossbite.
3. Radiographic evaluation: The panoramic radiograph depicted an elongated mandibular neck, with no prominent enlargement of the condylar head. The frontal radiograph displayed the chin shift off the midline, and the lateral radiograph showed even or almost even mandibular lower borders of both sides, with no evidence of double contour.
4. Nuclear imaging evaluation: At least 1 bone scan with 1 single-photon emission computerized tomogram of the skull showed increased uptake of the suspected condyle consistent with active CH. Two nuclear imaging specialists evaluated the scans separately.

DECISION MAKING REGARDING TREATMENT

After a diagnosis of active CH, patients were given 3 therapeutic options, from which they had to choose the one that suited them best:

1. Waiting for the hyperplastic overgrowth to run its course and delaying treatment until clinicians were confident the affected condyle ceased growing, at which time orthognathic surgery was planned. Patients were educated that this approach has some disadvantages, with the primary disadvantage being the unpredictable time to wait and worsening of the asymmetry with time, requiring considerably more orthodontic and surgical corrective measures, and compromising the chances of achieving optimal and stable results.[14,16]
2. Undergoing proportional condylectomy to arrest the hyperplastic condylar growth and prevent further worsening of the asymmetry. Patients were educated that some degree of correction of the asymmetry also could occur. The decision to perform orthognathic surgery would be made 1 year after condylectomy; patients were reevaluated and a decision regarding further corrective surgery was made, depending on the degree of residual asymmetry and the patient's satisfaction from treatment. Patients were informed of the surgical risks of condylectomy, with the primary risk being injury to the temporal and zygomatic branches of the facial nerve and injury to the ear canal.
3. Undergoing a simultaneous high condylar shave and orthognathic surgery to achieve an arrest of the hyperplastic growth and correction of the dentofacial deformity in 1 operation.

The following inclusion criteria were used in the present study:

1. A diagnosis of active CH type 1B based on the criteria listed earlier in skeletally mature patients (female patients, ≥16 yr of age; male patients, ≥18 yr of age).
2. Patients undergoing proportional condylectomy and not undergoing orthognathic, high condylar shave, or other corrective surgery for at least 1 year after the proportional condylectomy.
3. The absence of active orthodontic treatment for at least 6 months after the proportional condylectomy.
4. Medical file documentation required a full set of photographs and radiographs (panoramic, frontal, and lateral) performed immediately before condylectomy and approximately 12 months after condylectomy.

The following exclusion criteria were used in the present study:

1. A diagnosis of CH type 2 (hemimandibular hyperplasia) or combination forms.
2. Presence of resorptive degenerative changes on the contralateral condyle, raising suspicion of condylar resorption or hypoplasia of the contralateral condyle, rather than CH.
3. Undergoing additional orthognathic surgery before 1 year had elapsed since condylectomy.

SURGICAL PROCEDURE

Under general anesthesia by nasoendotracheal intubation, an endaural incision was made. Fine dissection was performed until the lateral surface of the capsule was clearly visible (Fig 1A). An incision was made on the inferior part of the capsule reaching the condylar

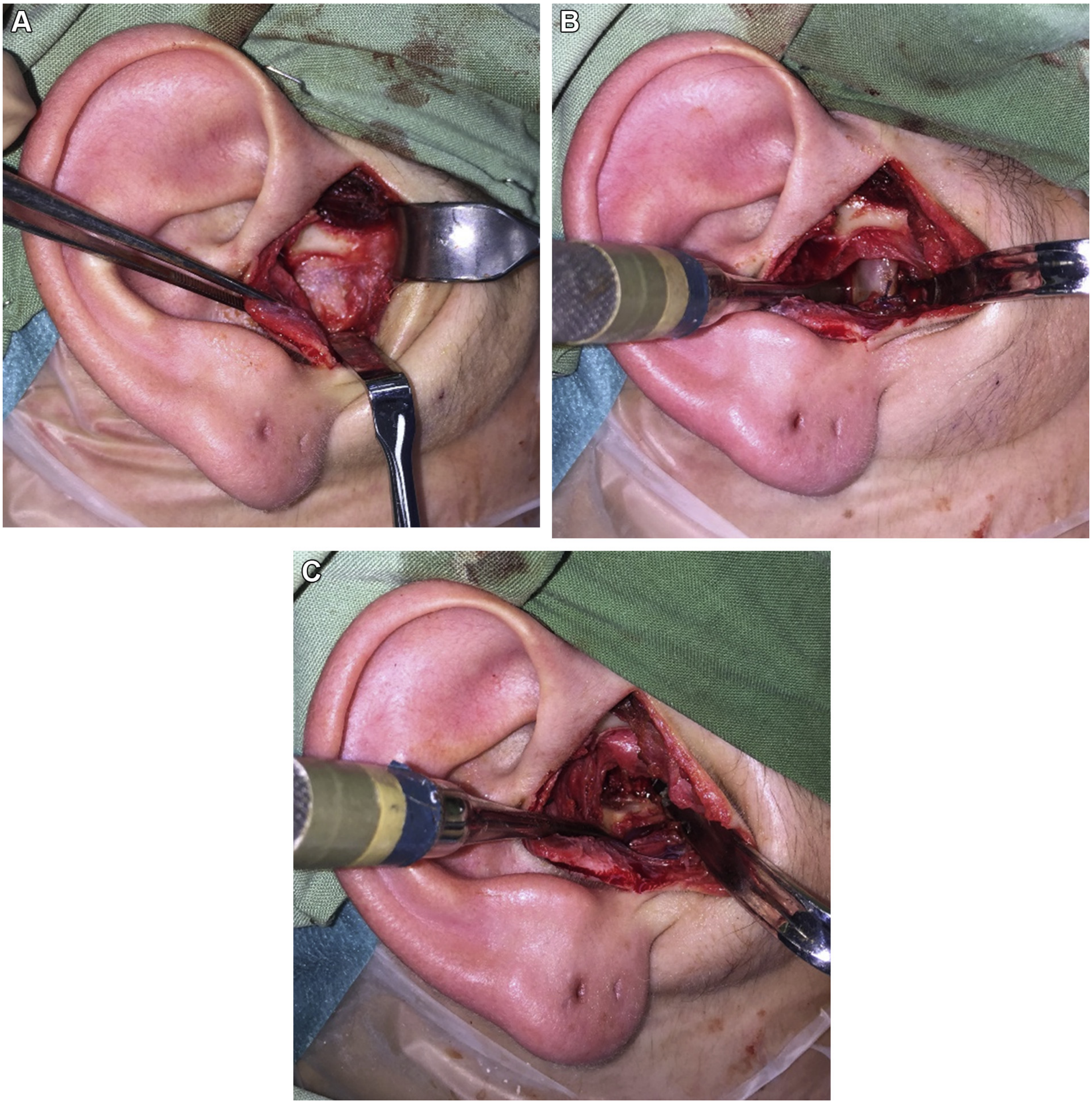

FIGURE 1. *A*, Lateral surface of capsule exposed. *B*, Condyle exposed. *C*, Condyle ostectomized. **(Fig 1 continued on next page.)**

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

neck, and then a subperiosteal dissection was made in a superior direction until reaching the condylar head (Fig 1B), which was then freed from attachments circumferentially. The superior joint space was not violated at any time during the operation, and the articular disc was palpated by the surgical instruments only from beneath. The size of the condylar segment removed was determined preoperatively by matching the affected side with the healthy side on the panoramic radiograph, aiming to achieve equal lengths of both sides. The length of the ramus was measured on the panoramic radiograph as the distance from the condylion point (the most posterosuperior point on the condylar head) to the gonion point (the most posteroinferior point at the mandibular angle). The ostectomy was performed using a Stryker sagittal electric saw (Micro Core, Stryker, Kalamazoo, MI) and an osteotome (Fig 1C). The ostectomized edges were not smoothed or reshaped. The main author (W.A.A.) performed all operations. The ostectomized segment was sent for histopathologic examination (Fig 1D).

POSTOPERATIVE CARE

Patients received antibiotics for 4 to 7 days after surgery. They were instructed to perform mandibular mobilizations 3 times a day to a pain-free range of motion

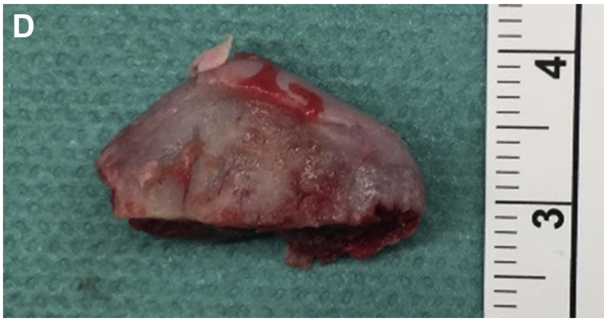

FIGURE 1 (cont'd). *D,* Condylar segment.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

and to increase the excursions as the pain decreased. These exercises included opening, laterotrusion, and protrusion for few seconds and they were supposed to be pain free. Patients were educated that full range of motion was expected to be attained gradually within 1 to 2 months and that normal chewing function should be regained within 3 to 6 months. When full range of motion was achieved, the physiotherapy was ended. Guided physiotherapy was not prescribed to any of the patients as a routine practice.[35] None of the patients received dental treatment that could influence the occlusion, such as active orthodontics, guiding elastics, or selective grinding, for at least 6 months after the operation, and the occlusion was allowed to settle gradually. After this time, minor selective grinding or, more commonly, orthodontic treatment was warranted in most patients. Few patients preferred to undergo selective grinding rather than orthodontic treatment to balance the occlusion, because of the financial costs of orthodontics or because of their reluctance to undergo bonding of orthodontic brackets with all their implications. However, attainment of perfect occlusion generally was not achieved without orthodontics.

OUTCOME PARAMETERS

The 3-dimensional changes after surgery were evaluated using standardized cephalometric measurements in the transverse, vertical, and horizontal planes.

Transverse Plane Evaluations

A corrected facial midline was drawn on the frontal photograph by connecting the soft tissue glabella and the center of the philtrum of the upper lip and extending the line to the chin (Fig 2A). A corrected skeletal midline was drawn on the frontal radiograph by connecting the midpoint of the cranial base plane and the midpoint of the mastoid plane and extending the line to the chin[36] (Fig 2B). The corrected facial and skeletal midlines were used to determine changes in the transverse plane.

Clinical chin deviation was measured on the frontal photograph as the angle formed by 2 lines: the corrected facial midline and a straight line connecting the central chin point to the corrected facial midline at the level of the glabella (Fig 2A).

Radiographic chin deviation was measured on the frontal radiograph as the angle formed by 2 lines: the corrected skeletal midline and a straight line connecting the center of the chin to the corrected skeletal midline at the level of the cranial base plane (Fig 2B).

Clinical gonial lateral prominence was measured on the frontal photograph as the difference in the distance between the soft tissue gonion (the most lateral and inferior point of the soft tissue overlying the mandibular angle) to the corrected facial midline on both sides. This was expressed as the ratio of the distance of the affected side to the healthy side in percentage. A value of 100% indicated equal distances, and a higher value indicated a longer distance on the affected side compared with the healthy side (Fig 2A).

Radiographic lateral gonial prominence was measured on the frontal radiograph as the difference in the distance between the gonion (the most lateral and inferior point of the angle of the mandible) to the corrected skeletal midline on both sides. This was expressed as the ratio of the distance of the affected side to the healthy side in percentage. A value of 100% indicated equal distances, and a higher value indicated a longer distance on the affected side compared with the healthy side (Fig 2B).

Vertical Plane Evaluations

Radiographic length of the mandibular ramus was measured on the panoramic radiograph as the difference in the distance between the condylion to the gonion on each side. This was expressed as the ratio of the height of the affected side to the healthy side in percentage. A value of 100% indicated even lengths, and a higher value indicated a longer distance on the affected side compared with the healthy side.

Lip commissure tilt was measured on the frontal photograph as the difference in distance between the interpupillary line and each commissure. This was expressed as the ratio of the height of the affected to the unaffected side in percentage. A value of 100% indicated parallel lip and interpupillary planes, and a higher value indicated a longer distance on the affected side compared with the healthy side.

Discrepancy of mandibular lower border was measured on the lateral radiograph as the

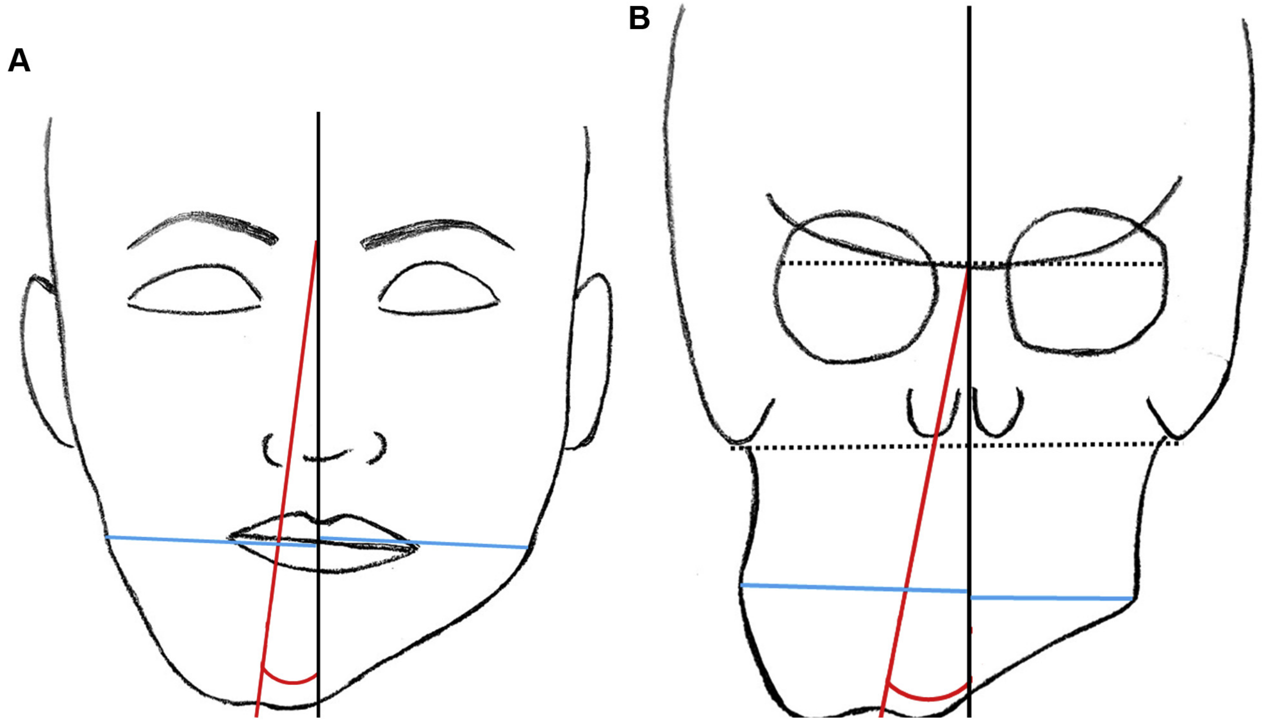

FIGURE 2. *A,* Transverse plane evaluations on the frontal photograph. The *black line* represents the corrected facial midline. The *red line* connects the central chin point to the corrected facial midline at the level of the glabella and forms the angle of the clinical chin deviation. The 2 *blue lines* connect the mandibular soft tissue gonion on each side to the corrected facial midline. The lateral gonial prominence is their ratio and is expressed in percentage as the distance of the affected side relative to the unaffected side. *B,* Transverse plane evaluations on the frontal radiograph. The *upper dotted line* represents the cranial base plane, which is drawn by connecting the left and right intersections of the smaller wing of the sphenoid to the medial orbital ridge. The *lower dotted line* represents the mastoid plane, which is drawn by connecting the most inferior points of the mastoid bones on both sides. The *black line* represents the corrected skeletal midline and is drawn by connecting the midpoint of the cranial base plane and the midpoint of the mastoid plane and extending the line to the chin. The *red line* connects the central chin point to the corrected skeletal midline at the level of the cranial base plane and forms the angle of the radiographic chin deviation. The 2 *blue lines* connect the mandibular bony gonion on each side to the corrected skeletal midline. Their ratio is expressed in percentage as the distance of the affected side relative to the unaffected side.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

discrepancy between the right and left mandibular lower borders measured in millimeters.

Horizontal Plane Evaluations

Angle of facial convexity was measured on the lateral photograph as the angle formed by the intersection of 2 straight lines: a line between the soft tissue nasion (deepest point between the forehead and nose, usually superficial to the frontonasal suture) and the subnasale (point where the columella of the nose merge with upper lip) and a line between the subnasale and the soft tissue pogonion (most prominent soft tissue point of chin). A smaller angle indicated a greater tendency toward a Class II convex profile.

The angle formed by the sella, nasion, and pogonion (S-N-Pog) was measured on the lateral radiograph as the angle formed by 2 straight intersecting lines: a line between the sella (center of the sella turcica) and nasion (most anterior point of the frontonasal suture) and a line between the nasion and pogonion (most anterior point of the chin). A smaller angle indicated a greater tendency toward a Class II convex profile.

EVALUATION OF OCCLUSION

The magnitude of open bite was measured and documented in the medical records at each clinical evaluation as routine practice. The open bite was measured at the area of non-contacting opposing teeth with the greatest vertical distance. These evaluations were performed by 1 of 2 authors (W.A.A. or D.B.).

EVALUATION OF TEMPOROMANDIBULAR JOINT FUNCTION

The function of the temporomandibular joints was assessed and documented in the medical records at each clinical evaluation as routine practice. Three parameters were checked: *1)* maximal interincisal opening measured in millimeters, *2)* joint sounds (subjective report or objective finding), and *3)* subjective complaint of pain or dysfunction in the masticatory system at rest or during function. These evaluations were performed by 1 of 2 authors (W.A.A. or D.B.).

TRACINGS AND MEASUREMENTS

Two authors (W.A.A. and M.K.) drew the tracings and performed the angular and linear measurements separately on photographs and radiographs. They performed the same cephalometric analyses together on a regular basis as part of the routine work of the department. For this study, the evaluations were made separately, and for measurements with different values between the 2 evaluations, an average was made.

TIME POINT EVALUATIONS

All patients included in the study had a full set of photographs and radiographs taken immediately before and 12 months after condylectomy. Most patients (n = 10) also had records taken approximately 6 months after condylectomy and 4 patients had records taken at 28, 30, 36, and 50 months postoperatively (mean, 36 months).

The study was approved by the ethical institutional review board.

STATISTICAL ANALYSIS

Means and standard deviations of all variables were calculated using descriptive tables. Differences in the different time points (preoperative and 6 and 12 months postoperative) were calculated using repeated-measures analysis of variance. Post hoc Bonferroni correction was used for pairwise comparisons. A P value less than or equal to .05 was defined as statistically significant. Analyses were performed by SPSS 25 (IBM SPSS, Armonk, NY).

Results

Fourteen patients (8 women, 6 men) met the inclusion criteria and were included in the study. The women's mean age was 18.9 years (range, 17 to 25 yr) and the men's mean age was 21.3 years (range, 18 to 27 yr). All patients had a full set of photographs and radiographs taken approximately 1 month before surgery (range, 0.2 to 3 months) and roughly 12 months after surgery (range, 11 to 14.1 months). In addition, 10 patients had photographs and radiographs taken approximately 6 months after condylectomy (range, 5.5 to 7 months) and 4 patients had the set taken at a mean of 36 months after condylectomy (28, 30, 36, and 50 months).

CHANGES IN TRANSVERSE PLANE

Chin Deviation

The clinical and radiographic chin deviations decreased from mean baseline values of 4.2° and 4.4° to 1.4° and 1.6° at the 6-month evaluation, respectively ($P < .001$ and $P = .001$, respectively). Chin deviation decreased further to 0.9° and 1.5° at the 12-month evaluation for the clinical and radiographic parameters, respectively ($P = .360$ and $P = 1$, respectively; Table 1, Fig 3). No further change was seen in the 4 patients available for the 36-month evaluation.

Lateral Gonial Prominence

The clinical and radiographic gonial prominences increased from baseline values of 95.7 and 96.7% to 106.8 and 104.8% at the 6-month evaluation, respectively ($P = .004$ and $P = .021$). At the 12-month evaluation, the values decreased to 99.6 and 102.1%, respectively ($P = .023$ and $P = .788$, respectively; Table 1). The decrease was relevant only for the clinical value. The clinical and radiographic gonial prominences of the 4 patients available at 36 months were similar to the 12-month values.

To gain a deeper understanding of the change of the gonial prominence, patients were categorized according to their preoperative values as having a smaller gonial prominence (more flat) on the affected side compared with the healthy side (n = 7) or a larger gonial prominence (more bulky) on the affected side (n = 5). Two patients had equal gonial prominences on both sides. The objective was to determine which patient group showed greater improvement after surgery, that is, values closer to 100% after condylectomy.

Table 1. CHANGES IN TRANSVERSE PLANE

	Preoperative	6 mo (P Value)	12 mo (P Value)
Clinical chin deviation (°)	4.2 ± 1.1	1.4 ± 1.1 (<.001)	0.9 ± 0.6 (.360)
Radiographic chin deviation (°)	4.4 ± 1.6	1.6 ± 1.3 (.001)	1.5 ± 1.2 (1)
Clinical gonial prominence (%)*	95.7 ± 8	106.8 ± 12.2 (.004)	99.6 ± 8.4 (.023)
Radiographic gonial prominence (%)*	96.7 ± 6.8	104.8 ± 7.6 (.021)	102.1 ± 5.5 (.788)

* Expressed as the percentage of the distance of the affected side to the healthy side.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

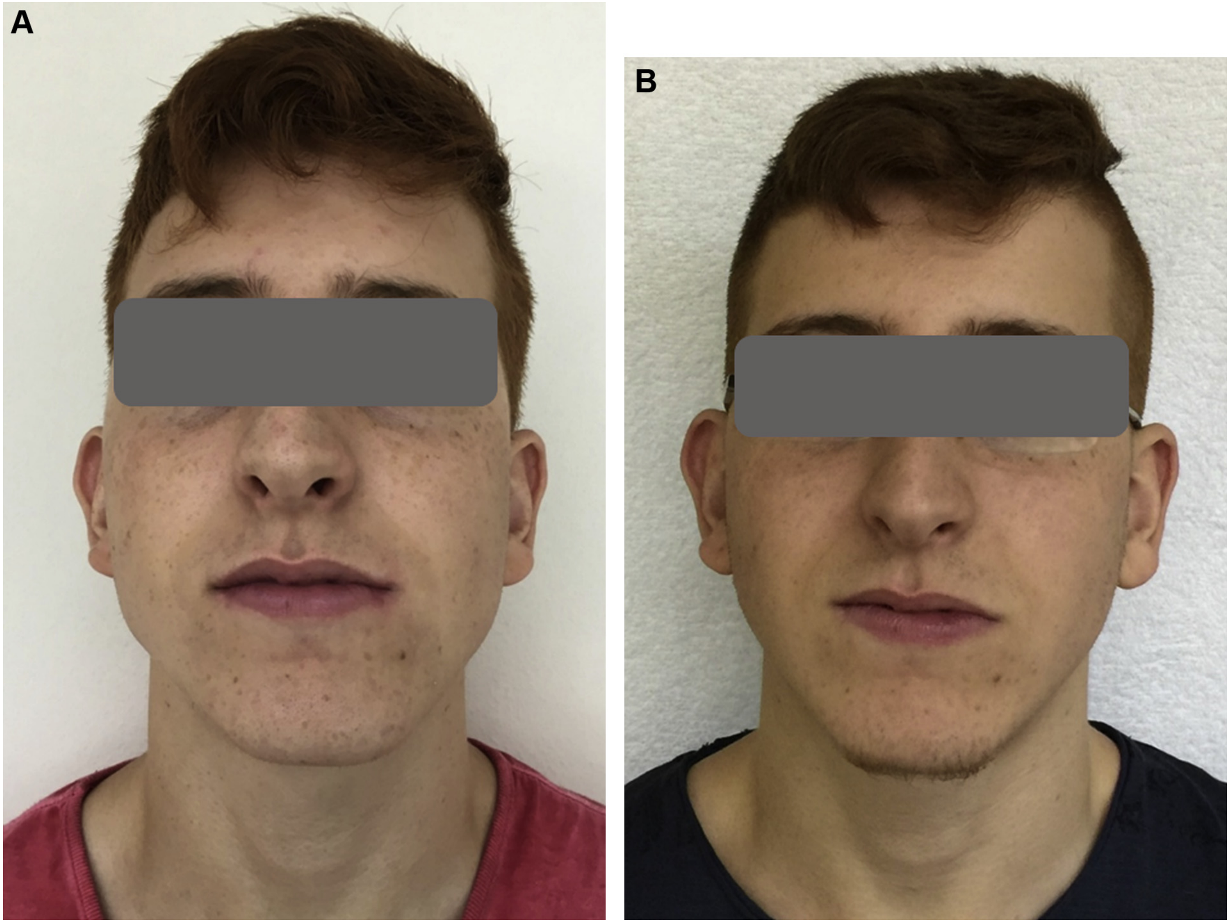

FIGURE 3. Frontal photographs of a 17-year-old patient with right condylar hyperplasia *A*, before and *B*, 12 months after right proportional condylectomy. **(Fig 3 continued on next page.)**

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

The gonial prominences of the 7 patients with a preoperative small gonial prominence increased from mean values of 90.7 and 92.7% to mean values of 96.5 and 100% at the 12-month evaluation for the clinical and radiographic gonial prominences, respectively (P = .006; Fig 4). The gonial prominences of the 5 patients with a large preoperative gonial prominence also increased after surgery, from mean values of 103.6 and 102.6% to 107.6 and 107% for the clinical and radiographic measurements, respectively (P = .004). However, this increase was unfavorable, because the postoperative outcome deviated further from the 100% value of left and right symmetry (Figs 3, 4).

CHANGES IN VERTICAL PLANE

Condyle and Ramus Height

At baseline, the length of the mandibular condyle and ramus unit on the affected side was 109.9% longer than on the healthy side (Table 2). Postoperatively, mean length decreased to 97.4% (P = .002) at the 6-month evaluation and further to 92.9% at the 12-month evaluation (P = .031). The values of the 36-month evaluation were almost equal to those of the 12-month evaluation.

Lip Commissure Tilt

Lip commissure tilt improved after condylectomy, from a mean difference of 104.5 to 101.7% at the 6-month evaluation (P = .002; Table 2, Fig 3). The result was stable at the 12-month evaluation (101.1%; P = .52) and at the 36-month evaluation.

Height of Mandibular Lower Border

The discrepancy of the height between the right and left mandibular lower borders worsened after condylectomy, from a mean difference of 2 mm preoperatively to values ranging from 3.9 to 4.3 mm postoperatively (P = .006 and .001; Table 2, Fig 5).

CHANGES IN HORIZONTAL PLANE

The angles of facial convexity and S-N-Pog decreased after surgery, corresponding to a slight (2° to 3°) posterior displacement of the chin (Table 3, Fig 5).

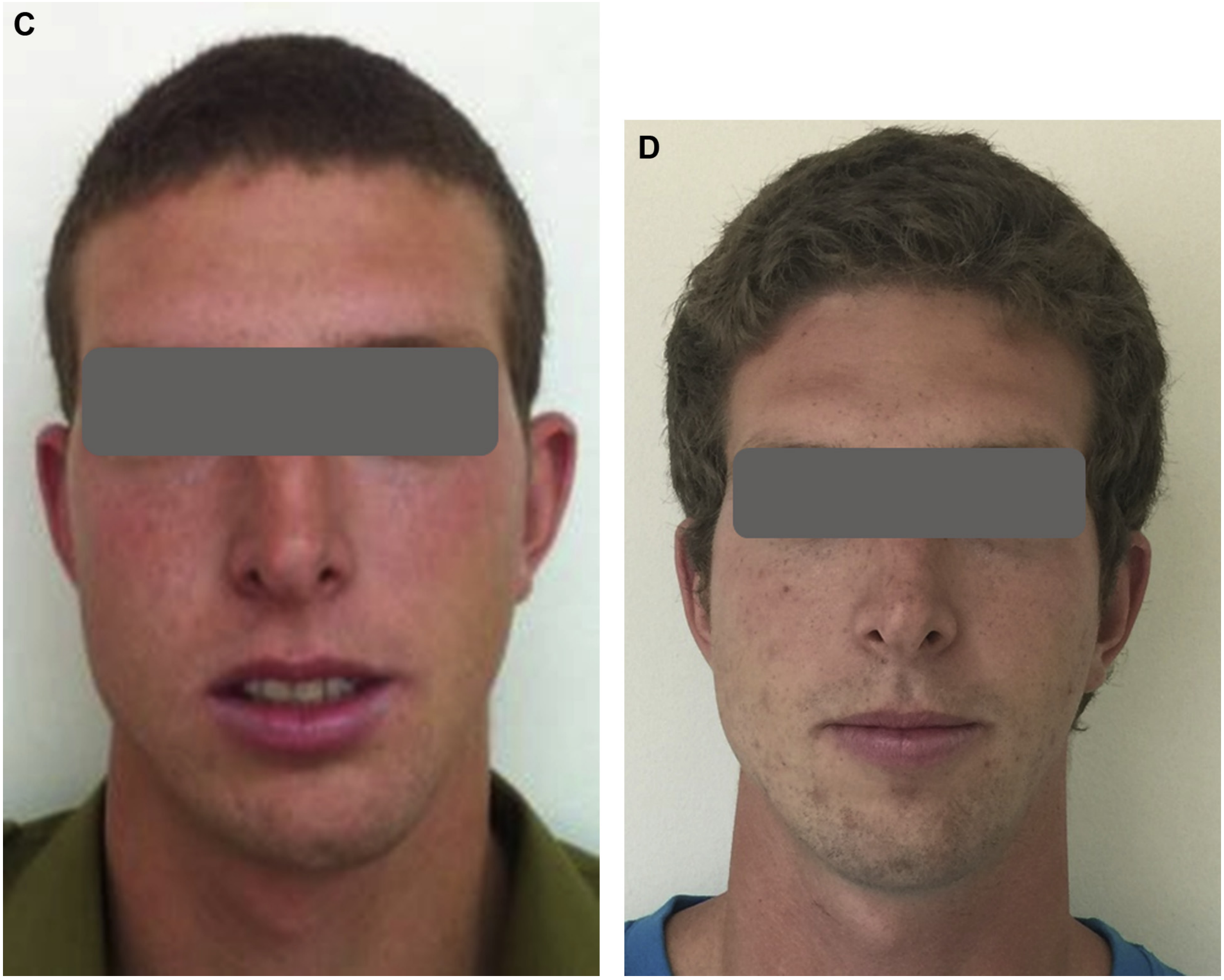

FIGURE 3 (cont'd). Frontal photographs of a 21-year-old patient with right condylar hyperplasia *C*, before and *D*, 14 months after right proportional condylectomy. Chin deviation showed improvement in these 2 patients, whereas the lateral gonial prominence showed improvement in the patient shown in *A* and *B* and worsening in the patient shown in *C* and *D*.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

Considering S-N-Pog values in the range of 78° to 82° and angle of facial convexity values in the range of 164° to 169° as corresponding to a Class I skeletal and facial profile, patients were categorized according to their preoperative and 12-month postoperative measurements into Class I, II, and III profiles. Preoperatively, 9 of 14 patients were categorized into Class I, whereas only 5 remained in a Class I relation (Table 4).

OCCLUSAL CHANGES

All patients developed a malocclusion immediately after surgery. In 12 patients it manifested as premature dental contacts on the operated side and open bite on the anterior and contralateral sides, and in 2 patients there was only a subjective report of more pronounced dental contacts on the operated side. The open bite was measured at the area of non-contacting opposing teeth with the greatest vertical distance, which was on the unoperated (contralateral) side. None of the patients received any form of guiding elastics or active orthodontic treatment or selective grinding in the first 6 postoperative months (Fig 6), and a combination of spontaneous intrusive and extrusive compensations facilitated the gradual decrease of the open bite (Table 5).

TEMPOROMANDIBULAR JOINT FUNCTION

All patients developed a temporary limitation of mouth opening. However, 3 months after surgery, all patients were in the range of their preoperative values.

Clicking of the temporomandibular joint(s) was noted in 8 patients preoperatively. Postoperatively, reports of clicking sounds appeared in the medical records of 9 patients.

Preoperatively, 6 patients complained of pain or dysfunction of the masticatory system, manifesting as intermittent locking or transient pain episodes.

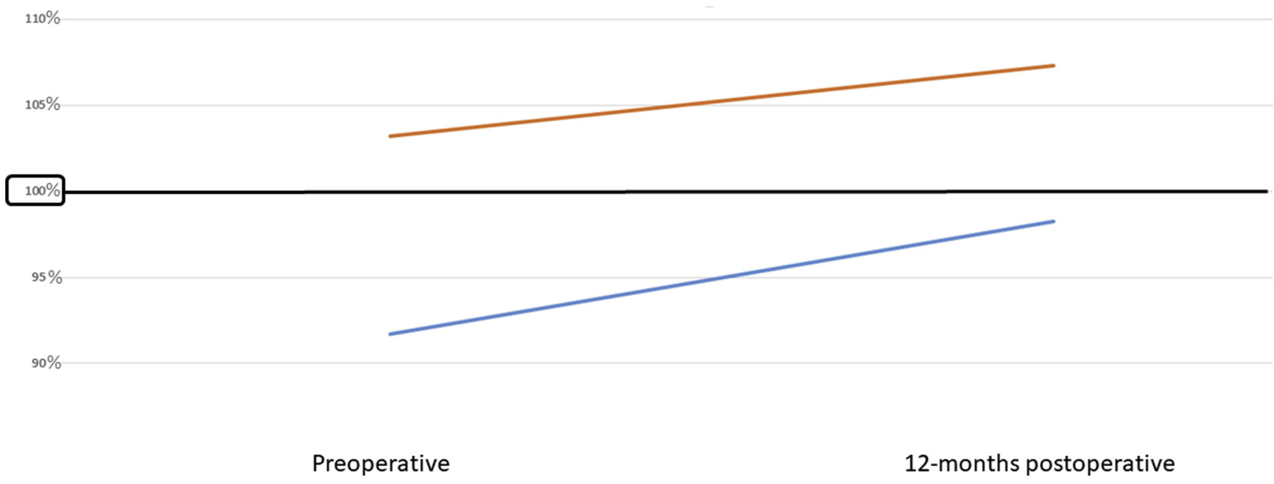

FIGURE 4. The *blue line* represents the 7 patients with a preoperative flat gonial prominence on the affected side, and the *orange line* represents the 5 patients with a preoperative bulky gonial prominence on the affected side. Although these 2 lines showed a similar increasing pattern, the *blue line* came closer to the 100% value, whereas the *orange line* deviated further from this value.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

Postoperatively, only 1 patient continued to have such complaints.

None of the patients had permanent damage to branches of the facial nerve. One patient complained of an unesthetic scar. The average hospital stay after surgery was shorter than 24 hours.

Discussion

The present study evaluated the 3-dimensional changes occurring after proportional condylectomy in skeletally mature patients with CH type 1B (unilateral hemimandibular elongation). The findings of the present study showed that some facial features improved (transverse chin position and vertical lip cant), some features worsened (ramus and condyle height and mandibular lower border discrepancy), and some features worsened or improved (lateral gonial prominence and horizontal chin position), depending on the patient's baseline values.

Chin deviation is probably the most important feature for the perception of asymmetric facies.[25-28] The preoperative mean chin deviation of the study population was approximately 4°, and their mean postoperative value decreased to roughly 1°. Other studies in the literature reported similar outcomes, with chin centralization after proportional condylectomy in the range of 3°.[14] This improvement could be sufficient for patients with mild or even moderate degrees of chin deviation; however, those with severe asymmetry will probably require more than a 3° correction. This is important and should be integrated in the treatment plan by the surgeon who should be able to predict before surgery whether satisfactory chin centralization could be achieved after proportional condylectomy only.

The issue of the lateral prominence or bulge of the gonial area should be given special attention. It is well known that the mandible is propelled to the operated side after condylectomy. This mandibular swing manifests with a lateral displacement and flare of the ramus on the affected (operated) side and medial and inward displacement of the ramus on the unaffected side, similar to what happens in displaced subcondylar fractures, with the resultant increase of the lateral gonial prominence of the operated side. Patients with a flat or small preoperative gonial prominence on the affected side benefited from this effect,

Table 2. CHANGES IN VERTICAL PLANE

	Preoperative	6 mo (*P* Value)	12 mo (*P* Value)
Ramus + condyle height (%)*	109.9 ± 7.9	97.4 ± 6.2 (.002)	92.9 ± 5.7 (.031)
Lip commissure cant (%)*	104.5 ± 1.7	101.7 ± 2.5 (.002)	101.1 ± 2.6 (.52)
Mandibular lower border discrepancy (mm)	2 ± 1.1	3.9 ± 1.2 (.006)	4.3 ± 1.1 (.001)

* Expressed as the percentage of the height of the affected side to the healthy side.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

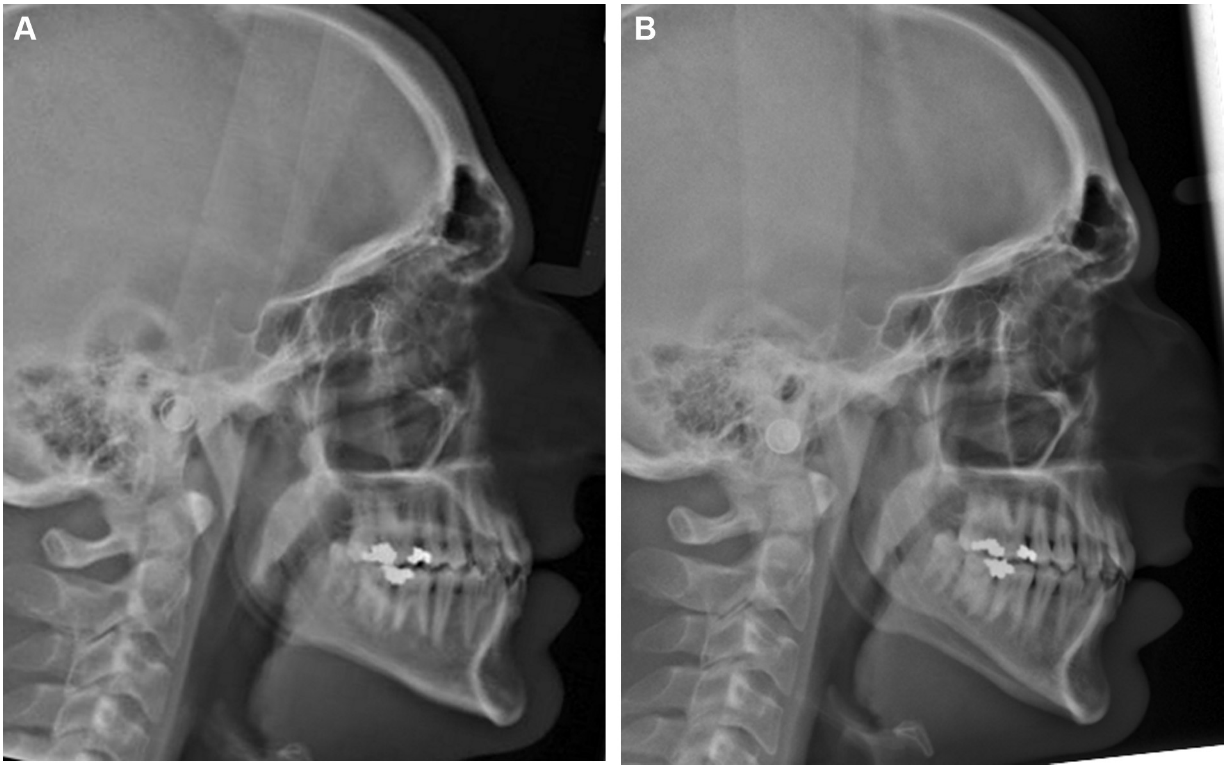

FIGURE 5. Lateral radiographs of a 23-year-old patient *A*, before and *B*, 23 months after proportional condylectomy. A double contour of the lower border of the mandible is evident in the postoperative radiograph, corresponding to the vertical asymmetry developing after proportional condylectomy. In addition, the slight mandibular setback is evident when comparing the postoperative with the preoperative radiograph.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

gaining more symmetric prominences of the right and left gonial areas, whereas patients with an already large or bulgy preoperative gonial prominence on the affected side showed worsening after surgery, becoming more asymmetric in this area. Few researchers have discussed this change. Jones and Tier[1] and Villanueva et al[3] argued that some patients could benefit from graft augmentation of the gonial area on the unaffected side to equalize the prominences of both sides after condylectomy. Kim et al[20] reported performing ostectomy of the mandibular angle on the affected side to gain symmetry of the gonial area between the 2 sides.

The bony and soft tissue gonial prominences behaved slightly differently with time. Initially, the 2 parameters increased after surgery; however, this was followed by a slight decrease in the soft tissue component, whereas the bony component did not change substantially with time. This soft tissue decrease could be attributed to the fact that proportional condylectomy results in shortening of the ramus and condyle height, and, as a result, excess masseter

Table 3. CHANGES IN HORIZONTAL PLANE

	Preoperative	12 mo Postoperatively (*P* Value)
Angle of facial convexity (°)	164.3 ± 6.7	161.2 ± 6.6 (.027)
S-N-Pog (°)	82.4 ± 2.9	80.5 ± 3.8 (.005)

Abbreviation: S-N-Pog, angle formed by sella, nasion, and pogonion.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

Table 4. CHANGES IN HORIZONTAL PLANE ACCORDING TO PROFILE TYPE

	Preoperatively	12 mo Postoperatively
Patients with Class I profile, n	9	5
Patients with Class II profile, n	3	7
Patients with Class III profile, n	2	2

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

A
B
C
D


FIGURE 6. *A,* Clinical photographs depicting the preoperative occlusion of a patient with left condylar hyperplasia. The lower dental midline is deviated 2 mm to the right and there is a slight crossbite on the right side. *B,* Occlusion 1 day after left proportional condylectomy. Premature contacts developed on the left side and an open bite developed on the anterior and right sides. *C,* Six months after the operation, the occlusion spontaneously and gradually improved to have balanced bilateral contacts, but with residual anterior open bite and right crossbite. *D,* Orthodontic treatment achieved full-arch stable occlusion within a few months.

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

muscle and associated soft tissues become proportionally elongated after surgery and bulge laterally on this side. However, this contribution was seen to be temporary. The masseter muscle and associated soft tissues probably remodel to adapt themselves to the newly created height, and with time, this lateral bulge out is minimized and the gonial contour is slightly decreased. Very few investigators have addressed this issue in the literature. Jones and Tier[1] recommended performing a facelift on the affected (operated) side or a soft tissue augmentation on the contralateral side to overcome this problem.

Table 5. CHANGE IN OCCLUSION

	Preoperatively	Immediately Postoperatively	3 mo	6 mo	12 mo
Open bite/range (mm)	0.5 ± 0.7/0-2	4.2 ± 1.9/0-7	2.2 ± 1.2/0-4	1.5 ± 1/0-3	0.7 ± 0.9/0-2
P		<.001	<.001	.017	.016

Abboud et al. Orofacial Changes After Condylectomy. J Oral Maxillofac Surg 2019.

The issue of posterior displacement of the mandible after condylectomy, although usually not of great concern to this patient population, cannot be overlooked by the surgeon. This study reported a slight setback of the bony and soft tissue chin points of approximately 3° after proportional condylectomy. Fariña et al[14] reported similar results. Although patients with a concave or straight profile might benefit from this side effect, patients with a preoperative convex profile will definitely end up with a retrognathic mandible, which could be an unesthetic sequela of this operation. This issue should be integrated in the decision making by the surgeon during workup and the patient should be informed of this inevitable side effect.

The vertical height of the ramus and condyle unit was relatively symmetrical in this patient population before surgery, and the lower border of the mandible was generally even on both sides. After condylectomy, an asymmetry was produced, and unevenness of the lower border of the mandible developed. Most patients did not notice or complain about this issue, even after informing them of it; however, 2 patients found this to be very unpleasing. In contrast, the vertical height of the maxilla did not change after surgery. Preoperatively, patients did not have or had a slight maxillary cant (~1 mm) on the affected side, and this feature did not change after surgery and throughout the follow-up period. The first reason behind the stable maxillary occlusal plane is the fact that the gradual balancing of occlusion happened primarily by grinding of the premature contacts on the affected side and only secondarily by the intrusion of teeth. The second reason for the apparently unchanged position of the maxilla is that the anterior teeth, which are the main contributors to the impression of the cant, were not involved in grinding or intrusion. The third reason is that the effects of the intrusive and grinding forces were divided by the maxillary and mandibular dento-alveoli, further minimizing any noticeable change in the maxillary vertical position. That said, minimal maxillary cant of the posterior areas probably did develop; however, this could not be noticed from the frontal photographs and lateral and frontal radiographs.

After condylectomy, there was an immediate development of premature contacts on the operated side and an open bite on the anterior and contralateral sides in most patients. This malocclusion underwent spontaneous self-correction in a slow and gradual manner, and patients exhibited a much better occlusion a few months after surgery. As mentioned earlier, this probably happened by a combination of grinding and intrusion of teeth on the operated side (which initially received all the masticatory loads) and simultaneous eruption of the teeth on the contralateral side (which were initially in an open bite position). As noted earlier, none of the patients received any form of dental treatment that could influence the occlusion for at least 6 months after surgery, so the patients actually "bit themselves" into occlusion. After condylectomy, the mandible swings to the operated side and the operated condyle "collapses" upward until it reaches the highest point allowed by ipsilateral dental contacts.[23] Because using elastics on the contralateral side will probably achieve the balancing of the occlusion primarily by the extrusion of teeth on the unaffected side and not by intrusion of the affected side, elastics were not used before at least 6 months elapsed after surgery. Choi et al[31] advocated using temporary anchor devices on the affected side in combination with guiding elastics on the contralateral side to achieve a combination of intrusive and extrusive forces on the operated and unoperated sides, respectively. Kim et al[20] advocated waiting for spontaneous adaptation of occlusion after condylectomy and initiated orthodontics 1 year after surgery. El Mozen et al[29] reported achieving maximum occlusion after condylectomy by the increase of the height of the maxillary dento-alveolus on the unaffected side and impaction of the maxillary dento-alveolus on the affected side. They concluded that this occurs spontaneously; however, orthodontic treatment enhances and accelerates this dentoalveolar remodeling and facilitates maximum occlusion more effectively and meticulously. Mouallem et al[33] concluded that the orthopedic action of chewing muscles acts on the operated side because they are shortened and thus intrusion of molars occurs, facilitating occlusal adjustment.

The main strengths of the present study are the strict inclusion of skeletally mature patients with CH type 1B (unilateral hemimandibular elongation), standardized cephalometric measurements, and uniformity of the surgical procedure and postoperative treatment and follow-up. The main weakness is the lack of a long-term follow-up evaluation for the entire study group, obviating statistical analysis for the last time point. However, the parameters of the 4 available patients showed no marked change 1 year after the operation. Another weakness could be the lack of a control group of patients receiving orthodontic treatment immediately after surgery.

To date, surgical removal of the upper part of the condylar head (high condylar shave or proportional condylectomy) is the only treatment proved to arrest the hyperplastic condylar growth in patients with active CH. Proportional condylectomy also can achieve some correction of the asymmetry, especially in the transverse chin position and lip cant, but with simultaneous worsening of other facial traits, namely the ramus and condyle height and mandibular lower border discrepancy. Bulging of the gonial prominence of the affected side is an inevitable side effect of proportional condylectomy that could have a favorable effect in patients with a baseline flat gonial area; otherwise, the gonial bulge will become more prominent, accentuating and worsening the asymmetry. Setback of the mandible could be considered trivial or even favorable in patients with a preoperative concave profile but very unfavorable for patients with a baseline convex profile.

Generally speaking, the 14 patients were pleased with the result and reported on improvement relative to the preoperative appearance. That said, 6 patients expressed interest in undergoing further corrective surgery to improve the result. At the writing of this article, 1 patient underwent secondary orthognathic surgery. However, one must bear in mind that the surgeon's or patient's opinion of the results as being satisfactory or unsatisfactory or the patient's willingness to undergo further corrective surgery after condylectomy does not necessarily correlate with the objective attainment of facial symmetry.

In conclusion, the findings of the present study showed that perfect symmetry cannot be achieved by proportional condylectomy as a sole treatment for CH type 1B. Patients with mild degrees of asymmetry, a concave profile or a tendency toward a concave profile, a relatively flat gonial prominence on the affected side, and who do not have high esthetic demands could be considered for proportional condylectomy as a sole treatment, with the objective of achieving a fair esthetic result and arrest of the hyperplastic condylar growth. However, most patients do not fit in this category and thus should be treated in the standard way of combined condylectomy and orthognathic surgery. Surgeons should be able to anticipate the 3-dimensional facial change occurring after proportional condylectomy and inform the patient of the expected outcome, with its positive and negative consequences on different facial features. This is important, especially when the treatment plan involves a 2-stage approach of condylectomy followed by orthognathic surgery.

References

1. Jones RHB, Tier GA: Correction of facial asymmetry as a result of unilateral condylar hyperplasia. J Oral Maxillofac Surg 70:1413, 2012
2. Kaya B, Arman A, Uçkan S: Orthodontic and surgical treatment of hemimandibular hyperplasia. Angle Orthod 77:557, 2007
3. Villanueva-Alcojol L, Monje F, González-García R: Hyperplasia of the mandibular condyle: Clinical, histopathologic, and treatment considerations in a series of 36 patients. J Oral Maxillofac Surg 69:447, 2011
4. Obwegeser H, Makek M: Hemimandibular hyperplasia—Hemimandibular elongation. J Oral Maxillofac Surg 14:183, 1986
5. Nitzan DW, Katsnelson A, Bermanis I, et al: The clinical characteristics of condylar hyperplasia: Experience with 61 patients. J Oral Maxillofac Surg 66:312, 2008
6. Wolford LM, Movahed R, Perez DE: A classification system for conditions causing condylar hyperplasia. J Oral Maxillofac Surg 72:567, 2014
7. Cisneros G, Kaban L: Computerized skeletal scintigraphy for assessment of mandibular asymmetry. J Oral Maxillofac Surg 42:513, 1984
8. Hodder SC, Rees JIS, Oliver TB, et al: SPECT bone scintigraphy in the diagnosis and management of mandibular condylar hyperplasia. Br J Oral Maxillofac Surg 38:87, 2000
9. Laverick S, Bounds G, Wong WL: [18F]-fluoride positron emission tomography for imaging condylar hyperplasia. Br J Oral Maxillofac Surg 47:196, 2009
10. Pripatnanont P, Vittayakittipong P, Markmanee U, et al: The use of SPECT to evaluate growth cessation of the mandible in unilateral condylar hyperplasia. Int J Oral Maxillofac Surg 34:364, 2005
11. Rushinek H, Tabib R, Fleissig Y, et al: Evaluation of three analysis methods for 99mTc MDP SPECT scintigraphy in the diagnosis of unilateral condylar hyperplasia. Int J Oral Maxillofac Surg 45: 1607, 2016
12. Saridin CP, Raijmakers PGHM, Tuinzing DB, Becking AG: Bone scintigraphy as a diagnostic method in unilateral hyperactivity of the mandibular condyles: A review and meta-analysis of the literature. Int J Oral Maxillofac Surg 40:11, 2011
13. Olate S, Duque Netto H, Rodriguez-Chessa J, et al: Mandible condylar hyperplasia: A review of diagnosis and treatment protocol. Int J Clin Exp Med 6:727, 2013
14. Fariña R, Pintor F, Pérez J, et al: Low condylectomy as the sole treatment for active condylar hyperplasia: Facial, occlusal and skeletal changes. An observational study. Int J Oral Maxillofac Surg 44:217, 2015
15. Lippold C, Kruse-Losler B, Danesh G, et al: Treatment of hemimandibular hyperplasia: The biological basis of condylectomy. Br J Oral Maxillofac Surg 45:353, 2007
16. Brusati R, Pedrazzoli M, Colletti G: Functional results after condylectomy in active laterognathia. J Craniomaxillofacial Surg 38: 179, 2010
17. Wolford LM, Morales-Ryan CA, García-Morales P, Perez D: Surgical management of mandibular condylar hyperplasia type 1. Proc (Bayl Univ Med Cent) 22:321, 2009
18. Wolford LM, Mehra P, Reich-Fischel O, et al: Efficacy of high condylectomy for management of condylar hyperplasia. Am J Orthod Dentofac Orthop 121:136, 2002
19. Rodrigues DB, Castro V: Condylar hyperplasia of the temporomandibular joint. Types, treatment, and surgical implications. Oral Maxillofac Surg Clin North Am 27:155, 2015
20. Kim HS, Kim JY, Huh JK, Park KH: A surgical strategy for severe facial asymmetry due to unilateral condylar overgrowth. Int J Oral Maxillofac Surg 45:593, 2016
21. Deleurant Y, Zimmermann A, Peltoma T: Hemimandibular elongation: Treatment and long-term follow-up. Orthod Craniofac Res 11:172, 2008
22. Chiarini L, Albanese M, Anesi A, et al: Surgical treatment of unilateral condylar hyperplasia with piezosurgery. J Craniofac Surg 25:808, 2014
23. Farina R, Olate S, Raposo A, et al: High condylectomy versus proportional condylectomy: Is secondary orthognathic surgery necessary? Int J Oral Maxillofac Surg 45:72, 2016
24. Delaire J, Gaillard A, Tulasne J: The place of condylectomy in the treatment of hypercondylosis. Rev Stomatol Chir Maxillofac 84: 11, 1983
25. Zaidel DW, Cohen JA: The face, beauty, and symmetry: Perceiving asymmetry in beautiful faces. Int J Neurosci 115: 1165, 2005
26. Naini FB, Donaldson ANA, Cobourne MT, McDonald F: Assessing the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, clinician, and layperson. Eur J Orthod 34:738, 2012
27. Ko EWC, Huang CS, Chen YR: Characteristics and corrective outcome of face asymmetry by orthognathic surgery. J Oral Maxillofac Surg 67:2201, 2009
28. Hagensli N, Stenvik A, Espeland L: Asymmetric mandibular prognathism: Outcome, stability and patient satisfaction after BSSO surgery. A retrospective study. J Craniomaxillofac Surg 42: 1735, 2014

29. El Mozen LA, Meng Q, Li Y, et al: Condylar and occlusal changes after high condylectomy and orthodontic treatment for condylar hyperplasia. J Huazhong Univ Sci Technolog Med Sci 35:265, 2015
30. Di Blasio C, Di Blasio A, Pedrazzi G, et al: How does the mandible grow after early high condylectomy? J Craniofac Surg 26:764, 2015
31. Choi YJ, Lee SH, Baek MS, et al: Consecutive condylectomy and molar intrusion using temporary anchorage devices as an alternative for correcting facial asymmetry with condylar hyperplasia. Am J Orthod Dentofac Orthop 147:S109, 2015
32. López DF, Aristizábal JF, Martínez-Smit R: Condylectomy and "surgery first" approach: An expedited treatment for condylar hyperplasia in a patient with facial asymmetry. Dental Press J Orthod 22:86, 2017
33. Mouallem G, Vernex-Boukerma Z, Longis J, et al: Efficacy of proportional condylectomy in a treatment protocol for unilateral condylar hyperplasia: A review of 73 cases. J Craniomaxillofac Surg 45:1083, 2017
34. Abuzinada S, Alyamani A: Management of patients with condylar hyperplasia: A diverse experience with 18 patients. Ann Maxillofac Surg 2(17), 2012
35. Abboud WA, Yarom N, Yahalom R, et al: Comparison of two physiotherapy programmes for rehabilitation after temporomandibular joint arthroscopy. Int J Oral Maxillofac Surg 47: 755, 2018
36. Reyneke J: Systematic patient evaluation, *in* Reyneke J (ed): Essentials of Orthognathic Surgery (ed 2). Batavia, IL, Quintessence Publishing, 2010, pp 19–113