Simultaneous Orthognathic Surgery and Condylectomy for Active Unilateral Condylar Hyperplasia: Indications and Outcomes of a Single-Stage Protocol

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Background: Active unilateral condylar hyperplasia (AUCH) leads to progressive facial asymmetry and occlusal imbalance and may coexist with preexisting skeletal discrepancies. In such cases, a single-stage approach combining condylectomy and orthognathic surgery can address both pathological growth and the associated dentofacial deformity.

Purpose: The aim of this study was to present a treatment protocol and surgical algorithm for simultaneous orthognathic surgery and condylectomy in subjects with AUCH and to evaluate clinical outcomes in a retrospective case series.

Study Design, Setting, and Sample: This retrospective case series included 24 adult subjects with AUCH treated between 2012 and 2018 in Santiago, Chile. Diagnosis was based on clinical evaluation, cone beam computed tomography, and single-photon emission computed tomography demonstrating ≥55% condylar activity. All subjects had completed growth and presented AUCH associated with dentofacial deformities requiring orthognathic correction, including maxillary hypoplasia, reduced upper airway, or mandibular advancement.

Predictor/Exposure/Independent Variables: Not applicable.

Outcome Variables: Primary outcomes included postoperative occlusal stability (achievement and maintenance of Class I occlusion), facial symmetry (clinical and patient-reported), temporomandibular joint symptoms, mouth opening, complications, and need for reintervention.

Covariates: Covariates included age, sex, follow-up duration, type of condylectomy (high or adapted), type of mandibular osteotomy, surgical sequence, and concomitant procedures, all determined through virtual surgical planning.

Analyses: Descriptive statistics were used to summarize subject characteristics and outcomes. No inferential analyses were performed.

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Results: Twenty-four subjects (mean age 20.8 ± 3.6 years; 66.7% female, 33.3% male) were included, with a median follow-up of 6 years. All subjects achieved stable Class I occlusion and satisfactory facial symmetry. No temporomandibular joint symptoms or reinterventions were observed. The mean mouth opening was 45 mm. Minor complications (transient facial paresis) occurred in 12.5% of subjects.

Conclusions and Relevance: Simultaneous orthognathic surgery and condylectomy is an effective approach for managing AUCH associated with dentofacial deformities, providing stable functional and aesthetic outcomes. Virtual surgical planning enables a structured surgical algorithm, guiding both the surgical sequence and the selection of the appropriate type of condylectomy, and may reduce the need for more invasive mandibular procedures.

J Oral Maxillofac Surg ■*:1-11, 2026*

Active unilateral condylar hyperplasia (AUCH) is a progressive growth disorder characterized by abnormal enlargement of one mandibular condyle, resulting in facial asymmetry, occlusal discrepancies, and functional impairment.[1-5] The etiology remains unclear, with both intrinsic factors, such as vascular, hormonal, and genetic influences—and extrinsic factors, including microtrauma and infection.[3,4] Diagnosis relies on comprehensive clinical evaluation supplemented by imaging and functional studies, such as single-photon emission computed tomography, which demonstrates increased metabolic activity on the affected condyle.[6,7]

Several classifications of condylar hyperplasia have been proposed, including those by Obwegeser et al and Nitzan et al, both based on the vector of overgrowth (horizontal, vertical, or mixed).[1,4]

Early surgical intervention is aimed at removing the etiopathogenic factor to halt overgrowth and to prevent secondary dentofacial deformities. Previous reports by Fariña et al have demonstrated that early proportional condylectomy can achieve favorable functional and aesthetic outcomes, preventing the need for secondary orthognathic surgery in approximately 85% of cases.[8-10] Likewise, Nitzan introduced the concept of "adaptable condylectomy," in which the type of condylectomy is tailored to each subject's occlusion, with good results.[11]

However, in skeletally mature subjects with AUCH associated with maxillary malposition (such as severe maxillary hypoplasia), Class II or vertical Class III malocclusions, or obstructive sleep apnea (OSA) requiring mandibular advancement, isolated condylectomy alone is insufficient.[12,13] Fariña et al demonstrated that isolated condylectomy moves the mandible and chin backward, increasing the risk of worsening the upper airway and intensifying OSA symptoms.[10]

For these subjects, a single-stage surgical approach combining condylectomy and orthognathic surgery is required to remove the hyperactive condylar growth center and simultaneously correct the skeletal and occlusal discrepancies.[13,14] Although several protocols have been proposed to combine these procedures, there remains limited consensus regarding the optimal surgical sequence and type of condylectomy.[12,13] Moreover, few studies provide structured treatment algorithms that minimize morbidity while ensuring long-term skeletal and occlusal stability.[13,15]

The aim of this study was to evaluate the clinical outcomes of a single-stage protocol combining orthognathic surgery and condylectomy in subjects with AUCH. Specifically, we aimed to define the type of condylectomy indicated according to virtual surgical planning (VSP), to describe a structured surgical algorithm based on VSP, and to assess postoperative occlusal stability, facial symmetry, and temporomandibular joint (TMJ) outcomes.

Materials and Methods

STUDY DESIGN AND SAMPLE

A retrospective case series was conducted between 2012 and 2018 at the Department of Oral and Maxillofacial Surgery, Hospital del Salvador, Santiago, Chile, and in the lead author's private practice (R.F.).

PARTICIPANTS

The inclusion criteria were subjects diagnosed with AUCH, associated with dentofacial deformities not directly attributable to AUCH, that required surgical correction, including maxillary hypoplasia, reduced upper airway requiring mandibular advancement, or a vertical Class III skeletal pattern. All subjects had completed skeletal growth, as assessed by hand-wrist radiography (radial epiphyseal fusion). A total of 24 subjects met the inclusion criteria.

The diagnosis of AUCH was established based on clinical and imaging findings. Clinically, subjects presented progressive facial asymmetry. Cone beam computed tomography demonstrated differences in ramus height between sides, and single-photon emission computed tomography showed ≥55% uptake in the affected condyle.

Subjects were excluded if facial asymmetry was attributable to other etiologies or if they had undergone prior condylectomy.

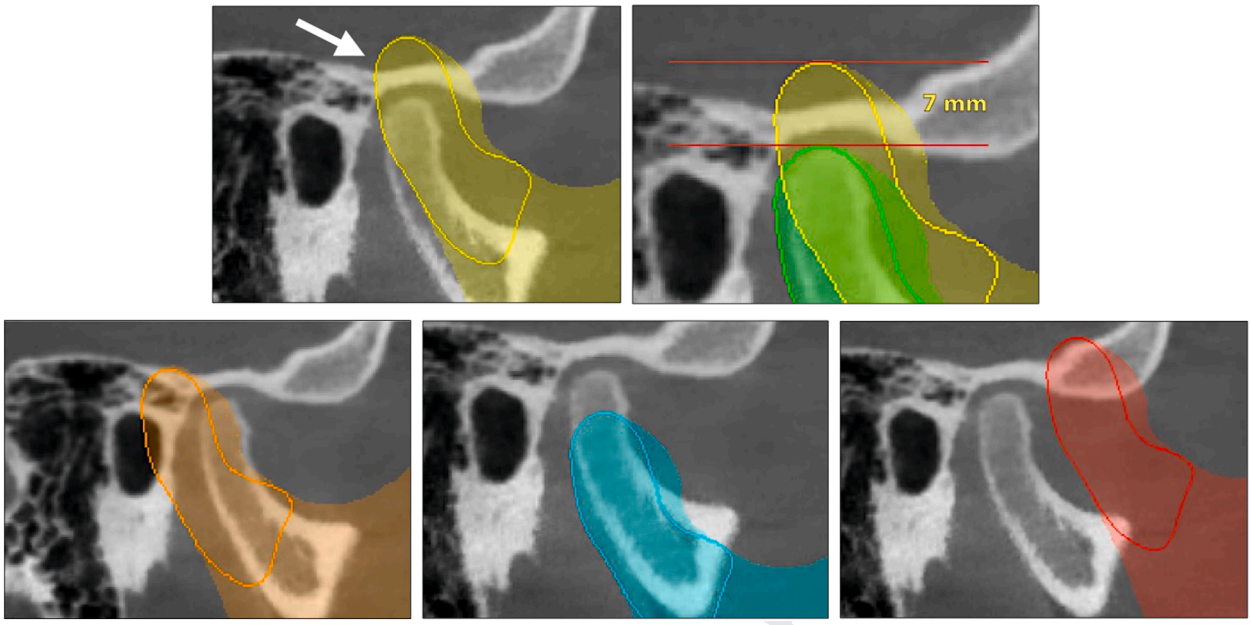

FIGURE 1. Virtual surgical planning illustrating determination of condylectomy type. The initial condylar position (*green*) is compared with the planned position after orthognathic simulation (*yellow*). *Arrow* indicates the discrepancy between positions, allowing calculation of the required resection (7 mm in this case) for adapted condylectomy. When the condyle is repositioned centrally within the glenoid fossa, sagittal split ramus osteotomy on the affected side is not required. Conversely, when virtual planning demonstrated posterior (*orange*), inferior (*blue*), or anterior (*red*) displacement patterns, high condylectomy combined with bilateral sagittal split ramus osteotomy is indicated.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

SURGICAL PLANNING AND PROCEDURE

Q6 VSP was performed using ProPlan CMF and Mimics software. Maxillary and mandibular movements were simulated to correct transverse, sagittal, and vertical discrepancies.

In the VSP model, the mandibular ramus (including the condyle) on the affected side was left unsegmented from the mandibular body and dental arch. After simulation of maxillomandibular movements, the position of the condyle relative to the glenoid fossa was analyzed.

If the condyle projected into the middle cranial fossa, the required resection depth was calculated. This procedure was defined as an adapted condylectomy (AC) guided by planned orthognathic movements, avoiding ipsilateral sagittal split ramus osteotomy (SSRO) (Fig 1). The minimum resection was 4 to 5 mm to ensure the removal of the

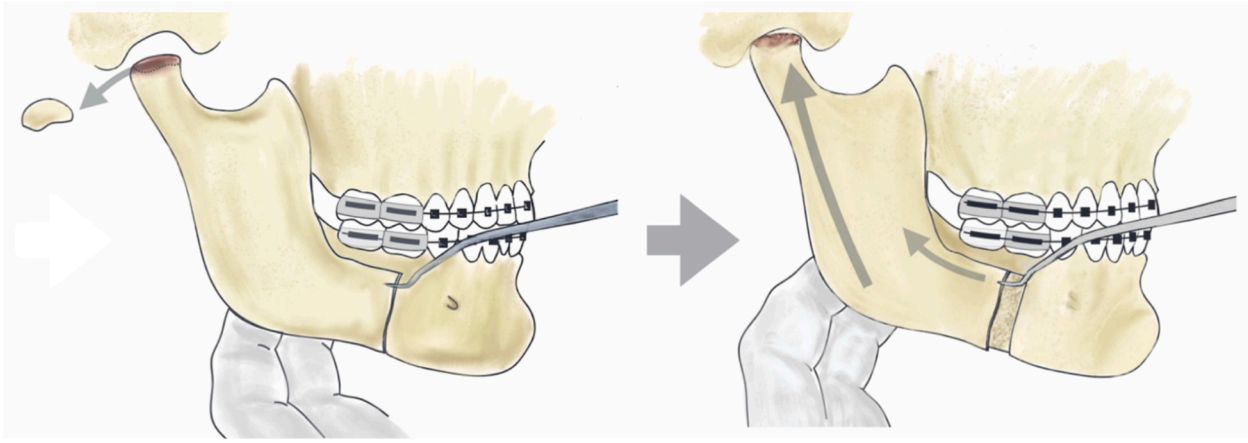

FIGURE 2. Intraoperative sequence of high condylectomy. *Arrow* indicates the condylar resection performed prior to sagittal split ramus osteotomy on the affected side, allowing improved control of the proximal segment during mandibular manipulation.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

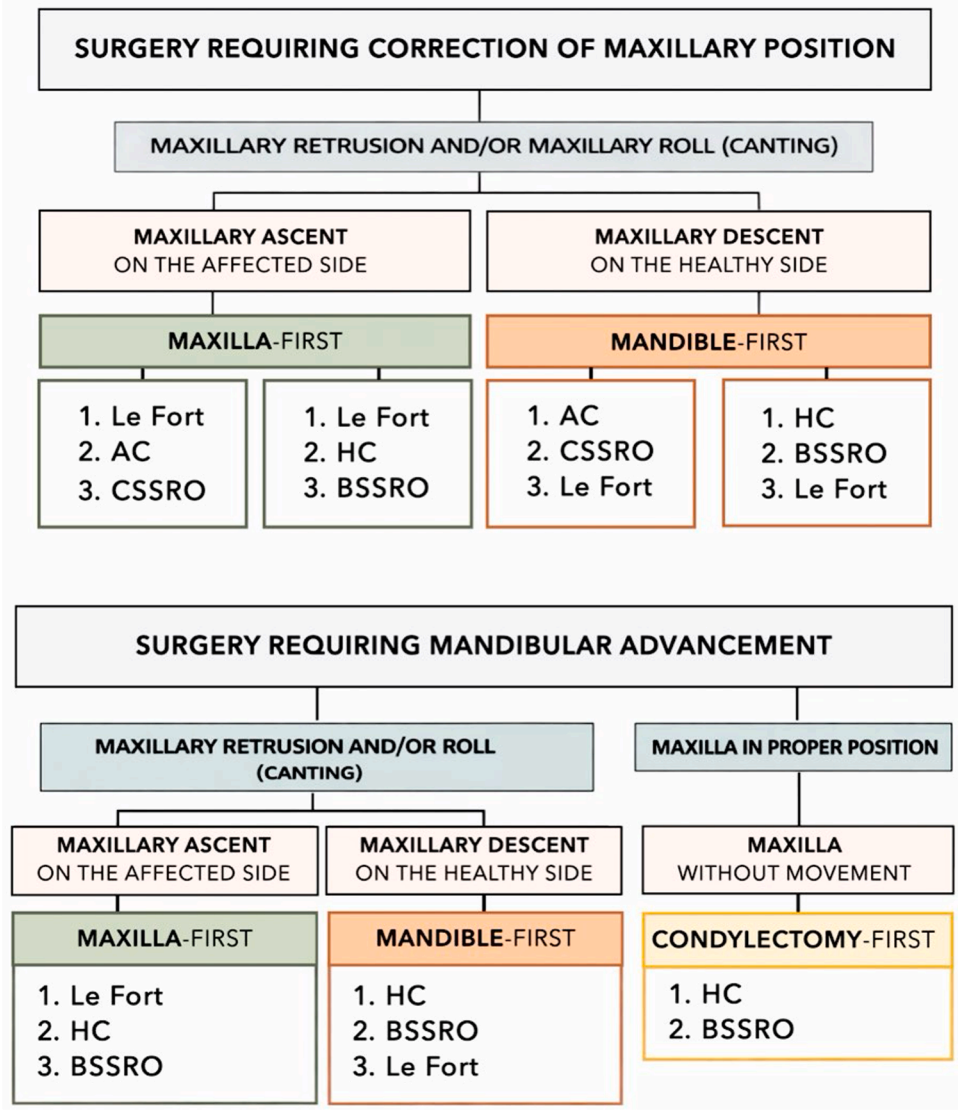

FIGURE 3. Surgical algorithm for simultaneous condylectomy and orthognathic surgery. Abbreviations: AC, adapted condylectomy; BSSRO, bilateral sagittal split ramus osteotomy; CSSRO, contralateral sagittal split ramus osteotomy; HC, high condylectomy. When adapted condylectomy is indicated, it is systematically combined with CSSRO, and when high condylectomy is indicated, it is consistently combined with BSSRO.

Fariña et al. ■■■. *J Oral Maxillofac Surg 2026.*

fibrocartilaginous layer responsible for hyperactivity. In these cases, unilateral sagittal split ramus osteotomy (USSRO) was performed on the contralateral side.

When the condyle was displaced posteriorly, inferiorly, or anteriorly in relation to the glenoid fossa, a high condylectomy (HC) combined with bilateral sagittal split ramus osteotomy (BSSRO) was performed. HC allows removal of the mesenchymal layer of the hyperplastic condyle and provides greater control of the proximal segment during mandibular manipulation (Fig 2).

Condylectomy was performed through an endaural approach and always preceded mandibular osteotomy on the affected side.

The surgical sequence (maxilla-first or mandible-first) was determined based on VSP and the degree of occlusal interference, prior to fabrication of the intermediate splint, thereby minimizing the need for mandibular autorotation. Accordingly, when correction required vertical elevation of the affected side, a maxilla-first approach was used. Conversely, when correction required lowering of the contralateral side, a mandible-first approach was selected (Fig 3).

In splintless procedures using customized plates, maxillary surgery was performed first.

COVARIATES

The covariates included age (years) at the time of surgery, sex (male/female), follow-up duration (years)

Table 1. DESCRIPTIVE STATISTICS OF COVARIATES (N = 24)

Variable	Value
Age (yr)	20.8 ± 3.6 (range, 16-32)
Sex, n (%)	Female, 16 (66.7%); male, 8 (33.3%)
Follow-up (yr)	Median 6.4 (range, 4-10), median 6 (IQR, 2.25)
Type of condylectomy, n (%)	Adapted condylectomy: 18 (75%), High condylectomy: 6 (25%)
Type of mandibular osteotomy, n (%)	USSRO: 18 (75%); BSSRO: 6 (25%)
Surgical sequence	Maxilla first: 18 (75%), mandible first: 6 (25%)
Le Fort I osteotomy, n (%)	19 (79%)
Genioplasty, n (%)	12 (50%)

Note: Continuous variables are presented as mean ± standard deviation (range) and categorical variables as number of subjects (%). Percentages may exceed 100% because some subjects underwent more than one procedure.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

calculated from surgery to the last clinical evaluation, type of condylectomy (high or adapted) as determined by VSP, type of mandibular osteotomy (USSRO or BSSRO), surgical sequence (maxilla-first or mandible-first) as determined by VSP, and concomitant procedures, including Le Fort I osteotomy and genioplasty.

OUTCOME VARIABLES

Postoperative outcomes were evaluated at 6 months, 1 year, and 4 years by 2 independent surgeons not involved in the primary treatment, using standardized clinical examinations and cone beam computed tomography. The assessed outcomes included occlusal stability, defined as the achievement and maintenance of Class I occlusion; facial symmetry, evaluated clinically by 2 independent surgeons and by patient-reported satisfaction; TMJ symptoms, defined as the presence of pain or functional limitation; maximal mouth opening, measured in millimeters as the maximum interincisal distance; complications, defined as any intraoperative or postoperative adverse events; and the need for reintervention, defined as the requirement for additional surgical procedures.

DATA COLLECTION AND ANALYSIS

Descriptive statistics were used to summarize covariates and outcomes. Continuous variables were reported as means and standard deviations or medians and interquartile ranges, and categorical variables as frequencies and percentages. No inferential statistical analyses were performed due to the descriptive nature of the study.

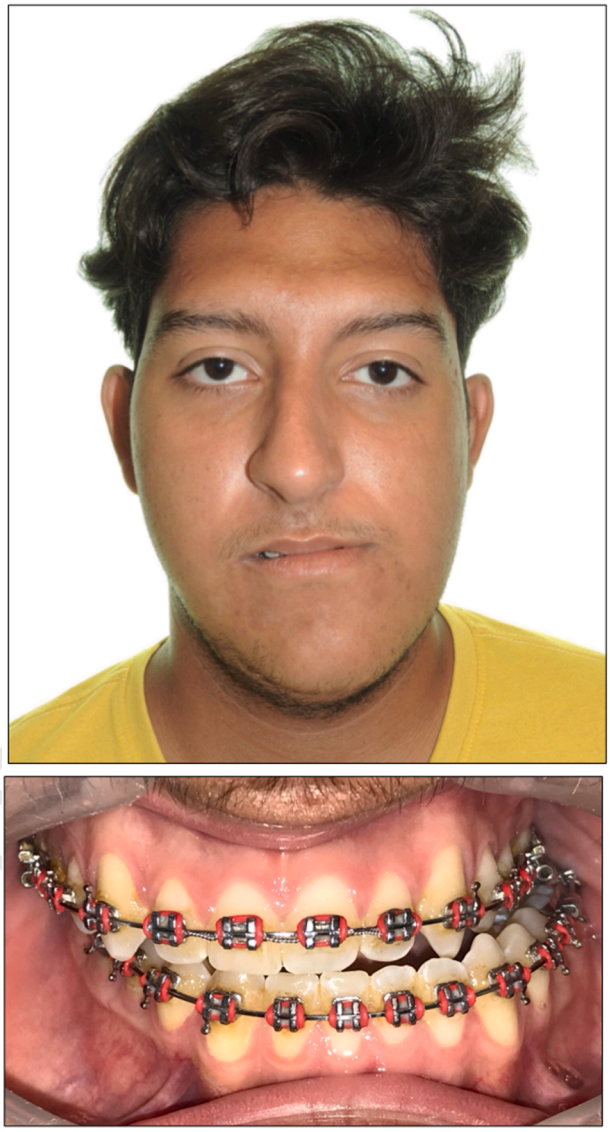

FIGURE 4. Preoperative frontal and occlusal views of a subject with right-sided active unilateral condylar hyperplasia and maxillary hypoplasia.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

POSTOPERATIVE MANAGEMENT

Following condylectomy, physiotherapy was considered essential. All subjects initiated physiotherapy on the first postoperative day and continued for 45 days, including opening, closing, lateral, and protrusive exercises (20 repetitions, 4 times daily). Intermaxillary elastics were maintained during the first postoperative month to facilitate occlusal guidance and neuromuscular adaptation.

ETHICAL CONSIDERATIONS

This study was approved by the Institutional Review Board of Hospital del Salvador. Written informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

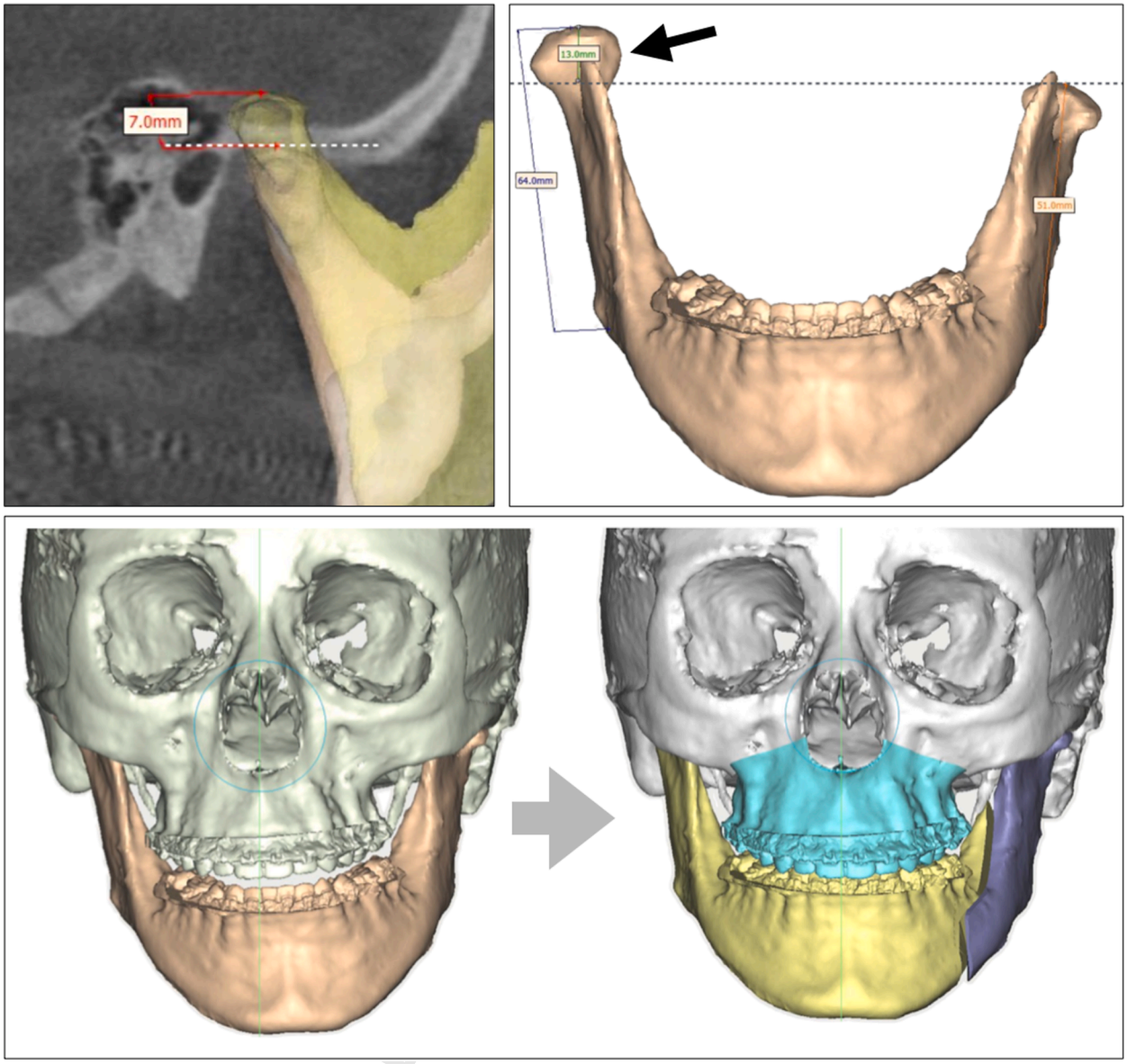

FIGURE 5. Virtual surgical planning illustrating maxillary advancement with Le Fort I osteotomy and occlusal plane leveling. Arrow indicates the discrepancy in condylar height and the difference between proportional (13 mm) and adapted condylectomy (7 mm). Based on the planned movements, a reduced resection was selected. Three-dimensional cone-beam computed tomography reconstructions were used to simulate the surgical outcome.

Fariña et al. ■■■. *J Oral Maxillofac Surg 2026.*

Results

A total of 24 subjects were included, with a mean age of 20.8 ± 3.6 years (range, 16 to 32 years). The sample comprised 16 females (66.7%) and 8 males (33.3%). The median follow-up was 6 years (IQR, 2.25). A descriptive summary of covariates is presented in Table 1.

The surgical procedures performed included Le Fort I osteotomy in 19 subjects (79%), AC in 18 (75%), HC in 6 (25%), USSRO in 18 (75%), BSSRO in 6 (25%), and genioplasty in 12 (50%).

All subjects achieved stable Class I occlusion at 6 months, 1 year, and 4 years of follow-up. Satisfactory facial symmetry was observed in all subjects at 1 year and 4 years, as assessed clinically by 2 independent surgeons and by patient-reported outcomes.

The mean maximal mouth opening at 6 months postoperatively was 45 mm (range, 42 to 50 mm) and remained stable at the final follow-up. Lateral and protrusive mandibular movements returned to normal within 6 months.

No subject developed postoperative TMJ symptoms (pain or functional limitation), required

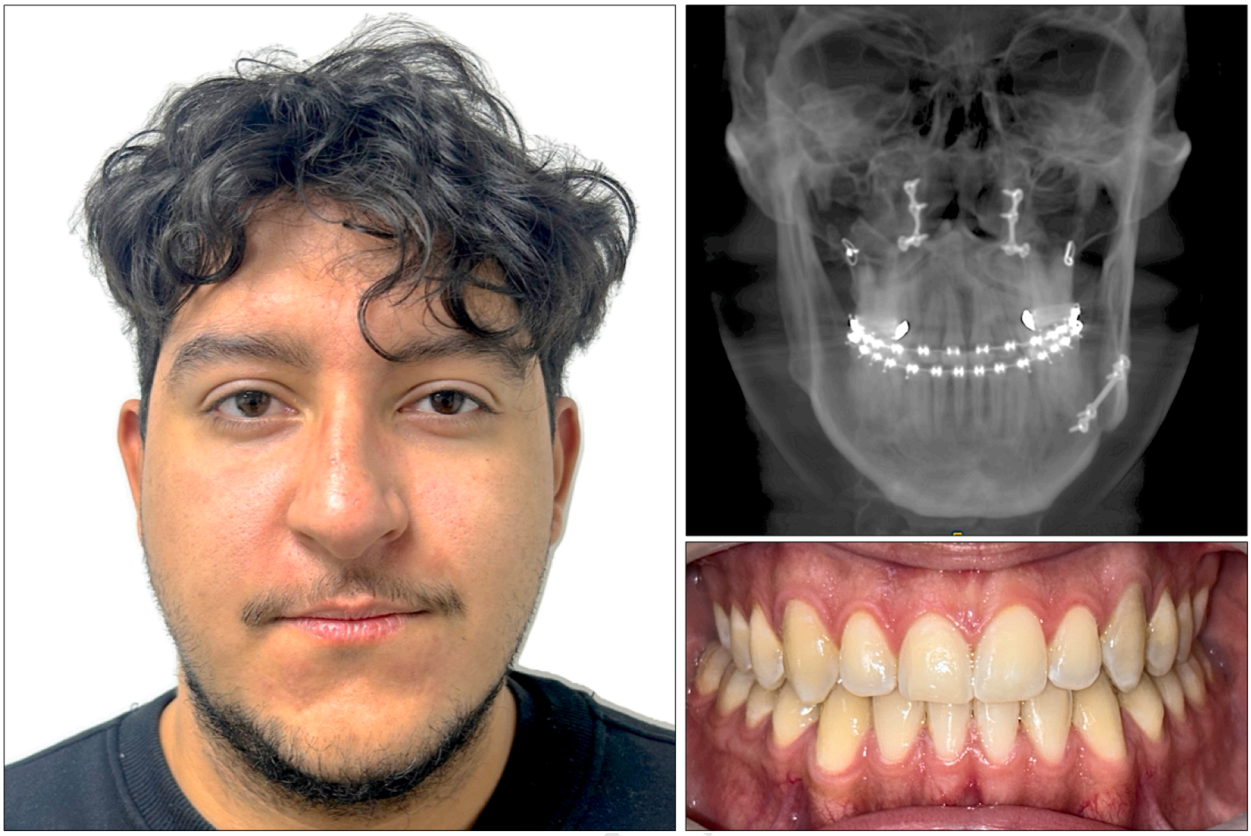

FIGURE 6. Postoperative frontal, occlusal, and CBCT views of the same subject (Figs 4 and 5), showing the correction of facial asymmetry, occlusal cant, and normalization of condylar position following Le Fort I osteotomy, adapted condylectomy, and CSSRO. Abbreviations: CBCT, cone beam computed tomography; CSSRO, contralateral sagittal split ramus osteotomy.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

reintervention, or developed major complications, including infection, relapse, or condylar resorption. Minor complications occurred in 3 subjects (12.5%) and consisted of transient paresis of the frontal branch of the facial nerve, which resolved spontaneously within 6 months.

No subject reported persistent sensory disturbance in the auriculotemporal nerve distribution, and no cases of Frey syndrome were observed (Figures 4, 6-11).

Eighteen subjects underwent third molar extraction prior to orthognathic surgery, whereas in 6 subjects, extractions were performed concomitantly with orthognathic surgery.

Scars from endaural incisions were minimally perceptible, and no subjects reported aesthetic concerns.

Outcome variables are summarized in Table 2.

Discussion

The present study describes a treatment protocol and surgical algorithm for simultaneous orthognathic surgery and condylectomy in subjects with AUCH and demonstrates that a single-stage approach can achieve stable occlusion, facial symmetry, and long-term joint function. After a mean follow-up of 6.4 years, no subject required secondary intervention or developed new TMJ symptoms, supporting the safety and long-term stability of this approach.

The literature supports that isolated condylectomy can effectively correct facial asymmetry and occlusal discrepancies in AUCH. However, a group of subjects has concomitant maxillary or mandibular deformities requiring orthognathic correction. In such cases, the key clinical question is whether treatment should be performed in staged procedures or as a single-stage intervention.

The distinction between proportional and AC lies in how the extent of resection is determined. Proportional condylectomy aims to remove the etiologic growth center and restore symmetry by equalizing mandibular ramus height. When performed early, it may prevent secondary deformities and eliminate the need for subsequent orthognathic surgery[5,9,10,16] On the other hand, AC removes only the portion of the condyle that projects into the cranial fossa after VSP. This approach is particularly suited for skeletally

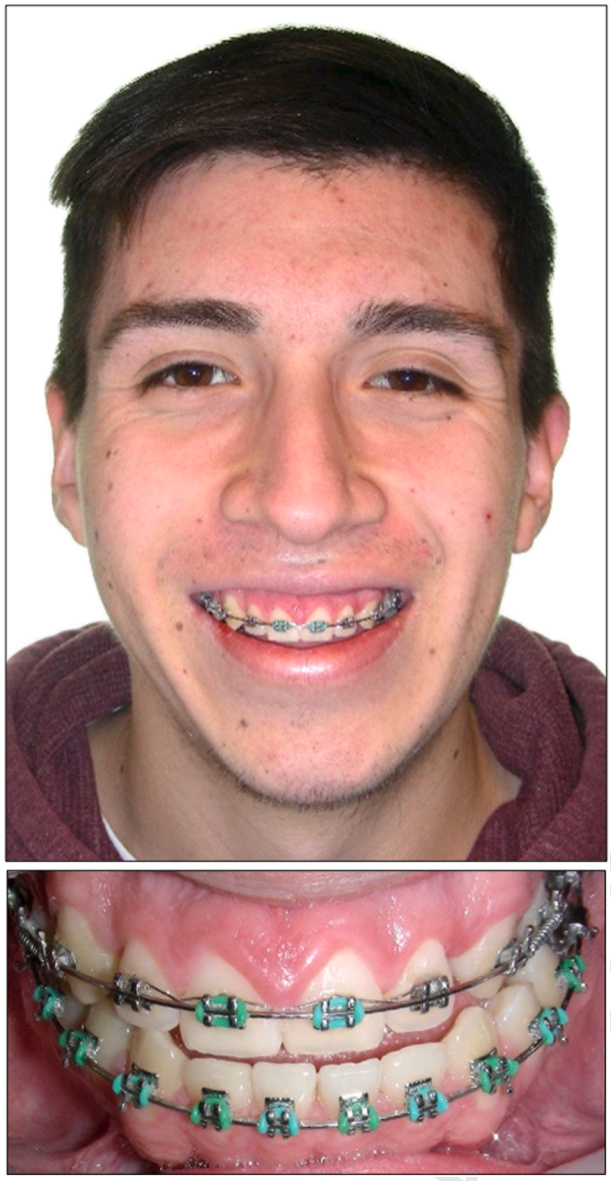

FIGURE 7. Preoperative frontal and occlusal views of a subject with right-sided active unilateral condylar hyperplasia.

Fariña et al. ■■■. J Oral Maxillofac Surg 2026.

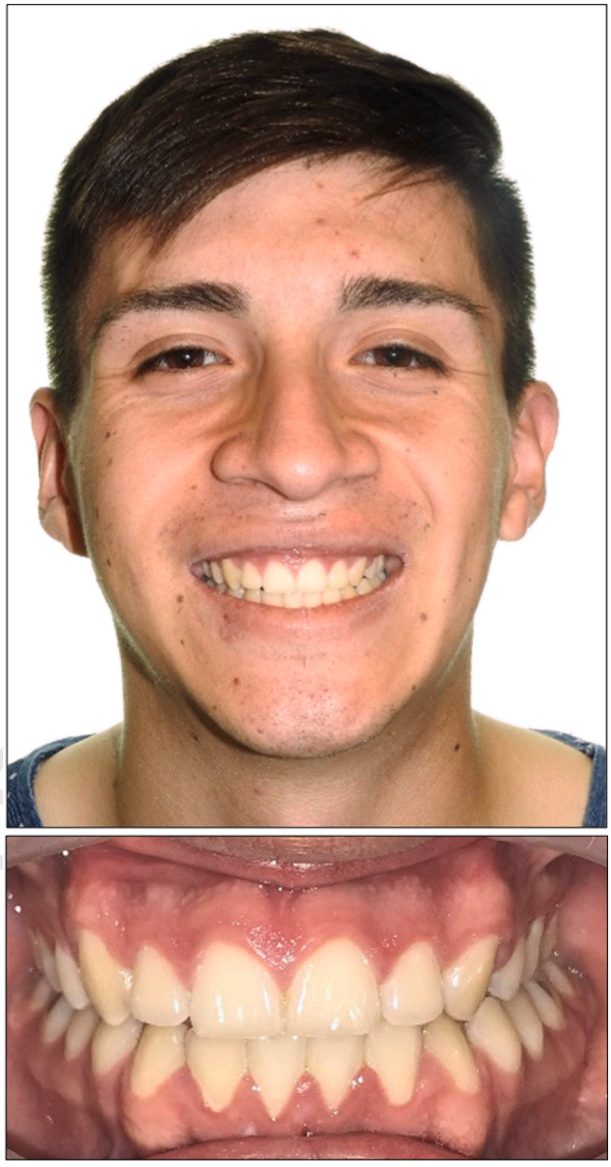

FIGURE 8. Postoperative frontal and occlusal views following Le Fort I osteotomy, adapted condylectomy, CSSRO, and genioplasty. Abbreviation: CSSRO, contralateral sagittal split ramus osteotomy.

Fariña et al. ■■■. J Oral Maxillofac Surg 2026.

mature subjects with AUCH and concomitant dentofacial deformities, in whom proportional condylectomy alone would not restore appropriate skeletal relationships (Figs 4-6).

In practical terms, the discrepancy between condylar height and the required resection may differ substantially. For example, in Figure 5, a 13 mm height discrepancy between the condyles was observed, whereas the resection required to reposition the condyle within the glenoid fossa after orthognathic simulation was only 7 mm. Performing a proportional condylectomy in this scenario would have required a larger resection (an additional 6 mm) and necessitated an ipsilateral SSRO. In contrast, an AC guided by VSP allows for a more limited resection and enables the use of a contralateral SSRO instead of a BSSRO (Fig 5)

The proposed surgical algorithm emphasizes the use of AC when VSP demonstrates that skeletal and occlusal symmetry can be achieved without performing an ipsilateral SSRO. In this cohort, this approach reduced the need for BSSRO in 18 (75%) cases thereby minimizing surgical morbidity and operative time. HC, in contrast, was reserved for cases in which ipsilateral SSRO was required to effectively reposition the mandible.[12-14,17-19]

These findings are consistent with previous reports demonstrating that condylectomy effectively halts abnormal condylar growth and improves facial

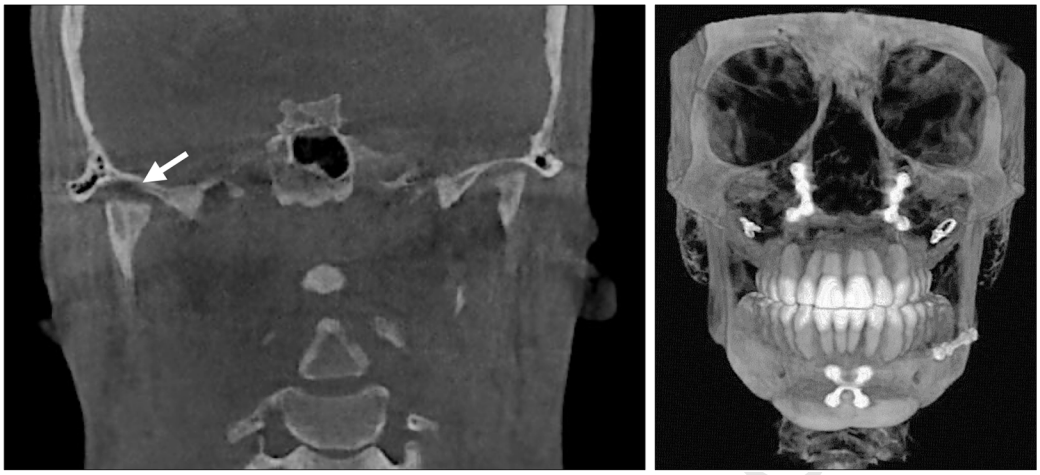

FIGURE 9. Coronal CBCT slice and three-dimensional reconstruction at 3-year follow-up after adapted condylectomy. *Arrow* indicates stable condylar position and evidence of bone remodeling. Abbreviation: CBCT, cone beam computed tomography.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

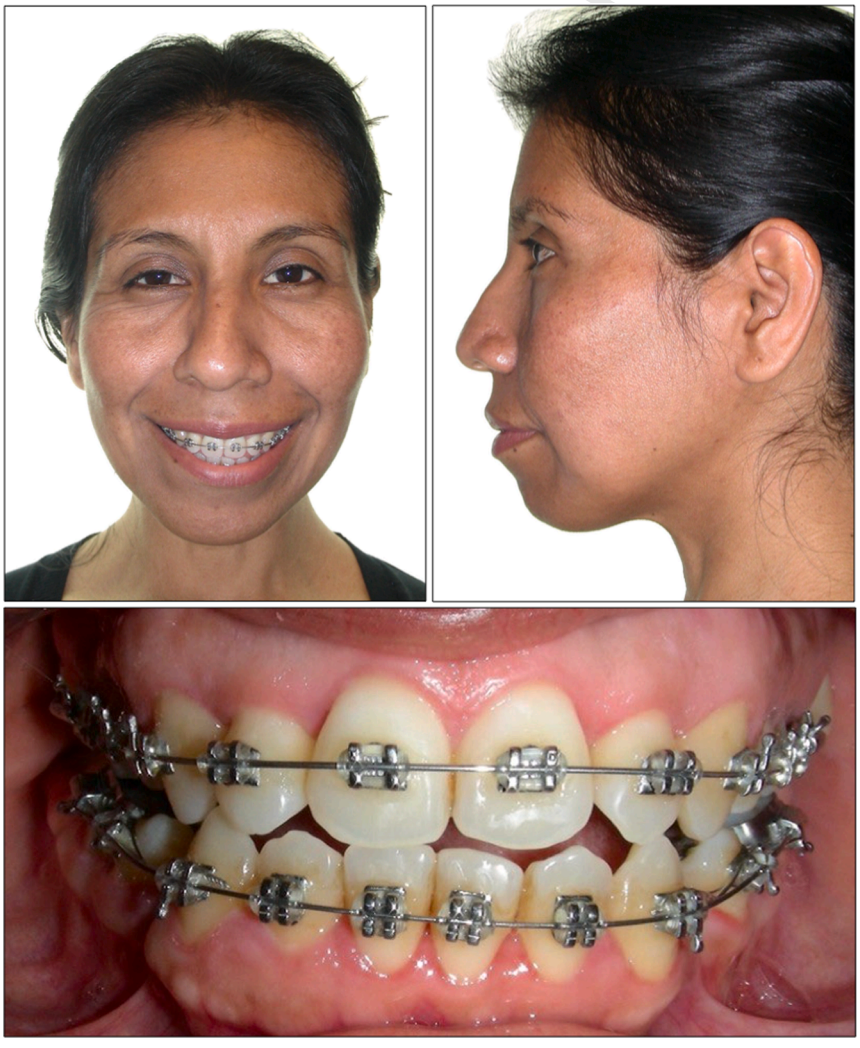

FIGURE 10. Preoperative frontal, lateral, and occlusal views of a subject with left-sided active unilateral condylar hyperplasia and vertical class III pattern.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

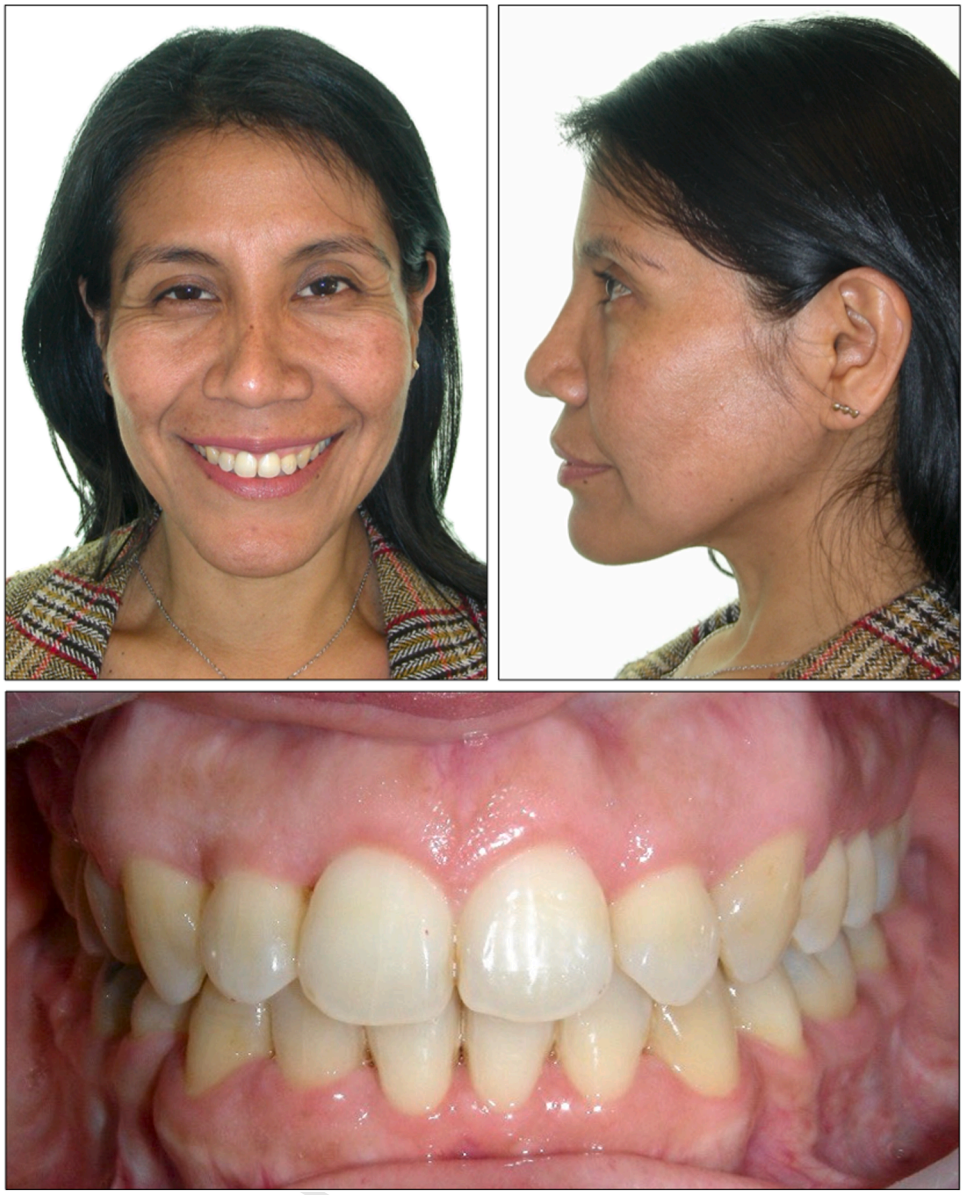

FIGURE 11. Postoperative frontal, lateral, and occlusal views following adapted condylectomy, CSSRO, Le Fort I osteotomy, genioplasty, and rhinoplasty. Abbreviation: CSSRO, contralateral sagittal split ramus osteotomy.

symmetry.[8-11,16] The present study extends existing knowledge by proposing a structured and reproducible decision-making algorithm that integrates VSP to guide the selection of condylectomy type and surgical sequence.

An alternative strategy involves performing condylectomy as an initial procedure, followed by orthognathic surgery as a second stage. Although effective, this approach requires 2 surgical interventions and may prolong functional impairment, particularly in subjects with airway compromise or OSA. In this case series, all subjects opted for a single-stage procedure despite its greater surgical complexity, allowing simultaneous resolution of both the condylar pathology and the dentofacial deformity.

Although no major complications occurred in this series, the potential risks of combined procedures must be acknowledged. Reported complications include malocclusion relapse, infection, condylar resorption, and neurosensory disturbances.[11-13] In this cohort, only minor complications were observed, consisting of transient paresis of the frontal branch of the facial nerve in 3 subjects, which resolved spontaneously within 6 months. These findings suggest a low morbidity associated with the technique.

Table 2. DESCRIPTIVE STATISTICS OF OUTCOMES VARIABLES (N = 24)

Outcomes	Value
Occlusal stability (Class I), n (%)	24 (100%)
Maximum mouth opening (mm)	45 ± 2 mm (range, 42-50)
TMJ symptoms (pain, functional limitations), n (%)	0 (0%)
Facial symmetry (clinical and patient-reported), n (%)	24 (100%)
Complication, n (%)	Minor (transient facial paresis), 3 (12.5%)
Need for reintervention, n (%)	0 (0%)

Note: Outcomes are presented as number of subjects (%) or mean values with range, as appropriate.

Fariña et al. ■ ■ ■. J Oral Maxillofac Surg 2026.

The present data support simultaneous orthognathic surgery and condylectomy as a safe and effective option for subjects with AUCH associated with dentofacial deformities. The proposed algorithm provides a practical and reproducible framework for surgical planning and highlights the importance of VSP in optimizing both functional and aesthetic outcomes.

In conclusion, this approach is particularly indicated in skeletally mature subjects with AUCH and associated maxillary malposition, Class II or vertical Class III malocclusion, or airway compromise requiring mandibular advancement.

The limitations of this study include its retrospective design and lack of a control group treated with a staged approach. Future prospective, multicenter studies with larger cohorts and standardized outcome measures are needed to validate these findings and to compare long-term outcomes between adapted and HC protocols.

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