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Three-dimensional skeletal changes after early proportional condylectomy for condylar hyperplasia

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Abstract. The purpose of this study was to evaluate volumetric and dentoskeletal changes in 21 patients with active unilateral condylar hyperplasia (AUCH) after proportional condylectomy. A split-mouth design was used: control group healthy joints (HS, healthy side) and test group affected joints (AS, affected side) (21 per group). Cone beam tomography scans were obtained at T0 (preoperative), T1 (10 days after the intervention), and T2 (approximately 12 months post-surgery). The condylar unit volume (CUV), articular cavity volume (ACV), and dentoalveolar units (DAUs) were measured. CUV showed a difference of 1.12 cm^3 between T0 and T1, increasing 0.4 cm^3 between T1 and T2 on AS. There was no difference between T0 and T2 on HS. ACV increased 0.65 cm^3 between T0 and T1 on AS, after which it decreased by 0.36 cm^3 at T2 (0.30 cm^3 larger than the initial articular cavity at T0). ACV showed no post-surgery differences on HS. Midline DAU showed extrusion of 0.20 mm for maxilla and 0.52 mm for mandible, while in the lateral area, maxilla was extruded by 0.3 mm on HS and was intruded 0.12 mm on AS. For the mandible, both sides showed extrusion (0.4–0.6 mm). In the distal to canine and molar areas, intrusion of 0.2 mm and 0.9 mm, respectively, was observed on AS; there was extrusion of 0.6 mm distal to the canine on HS. At the mandibular level, AS distal to the canine showed extrusion of 1 mm, while intrusion of 0.2 mm was observed in the molars. For HS, only extrusion at the molar level (0.2 mm) was observed. In conclusion, after proportional condylectomy, a neocondyle forms within 12 months to equal the healthy contralateral side. The articular cavity, which is reduced in the initial stage, increases in size after surgery and the volume gradually approaches that of the healthy side. Dentoalveolar changes occur at the anterior and posterior levels, causing intrusion and extrusion of the interdental crests. An early proportional condylectomy as the sole surgical treatment for patients with AUCH allows normalization of the maxillomandibular relationship.

Key words: condylar hyperplasia; hemimandibular elongation; hemimandibular hypertrophy; facial asymmetry; class III asymmetry; temporomandibular joint; facial asymmetry; mandibular condyle; condylectomy; low condylectomy; proportional condylectomy.

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Active unilateral condylar hyperplasia (AUCH) corresponds to progressive, pathological, non-neoplastic excessive growth of one of the mandibular condyles. It usually appears between the ages of 11 and 30 years[1,2]. This pathology can alter the mandibular morphology, modifying normal occlusion and indirectly altering the upper jaw, resulting in different degrees of facial asymmetry. It also causes alterations such as an increase in posterior facial height, lateral mandibular prognathism, contralateral deviation of the chin, open posterior bite, tilt of the maxillary plane, and contralateral crossbite, among others. The aetiology is not completely clear, although both extrinsic factors (trauma and infection) and intrinsic factors (vascular alterations of the condyle, hormonal disorders, and cartilaginous exostosis) that could participate in its origin have been described[3,4]. Karssemakers et al.[5] assessed the three-dimensional (3D) microstructure of resected hyperplasic condyles and showed an increased cortical porosity, in addition to 19% lower mineralization compared to the unaffected condyles. The cortical pores in a hyperplasic condyle could play a role in nutritional bone growth, without the need for increased vascularization, thereby facilitating the exchange of nutrients and growth factors. This could explain the condylar bone growth without an increase in local blood flow, as noted by Saridin et al., who did not find differences in the local blood flow between the healthy and affected sides[6].

AUCH can be classified in multiple ways, but the classification of Nitzan et al.[7] simplifies the clinical features and is mainly focused on the vector of the mandibular asymmetry, as follows: AUCH with a vertical pattern, AUCH with a transverse pattern, and AUCH with a mixed pattern.

In 2015, Fariña et al.[8] proposed a treatment for AUCH based on a lower condylectomy, in which the excess condylar segment on the affected side is removed to achieve a balance with the unaffected side. This was defined as a proportional condylectomy. This technique allows the main treatment objectives to be achieved, which are to eliminate the pathogenic agent, prevent progression of the disease, and equalize the mandibular ramus and posterior facial height. The corrective effects of this treatment achieve secondary facial balance through correction of the mandibular occlusal plane and centring of the chin and the lower dental midline, in addition to levelling of the maxillary occlusal plane, which ultimately translates into a stable occlusion. This should be performed as early as possible as primary treatment to allow the morphological alterations to be resolved and avoid the progression of skeletal alterations. This would likely be the only surgical treatment required in a large percentage of patients; however, additional surgical treatment may be required if the AUCH is associated with dentofacial dysmorphosis.

More recently, in 2017, Mouallem et al.[9] published a series of cases in which a proportional condylectomy was performed to treat AUCH. The results showed that it was a reliable option for treatment of the disease, regardless of the state of activity of the pathology. However, some of the patients included in that study underwent complementary surgeries, hence the results must be interpreted with caution. Despite this, it appears that no study that explains the mechanisms through which a 3D correction of the alterations is achieved has been published. The purpose of this study was to evaluate the changes in the condylar unit, articular cavities, and dentoalveolar units before and after early proportional condylectomy as the sole treatment for patients with AUCH.

Materials and methods

This prospective clinical study was designed to evaluate the effects of the proportional condylectomy as the sole treatment for patients diagnosed with AUCH at 10 days after surgery and at 12 ± 1 months post-surgery. Twenty-one patients with AUCH were included in the study. The patients were selected from the private practice of the first author (R.F.) and from the Department of Oral and Maxillofacial Surgery of the Hospital del Salvador, Santiago, Chile, between 2013 and 2016. All of these patients gave their detailed informed consent to participate in the study and to undergo the procedures. This study was approved by the Ethics Committee of Hospital del Salvador.

The AUCH was confirmed in the study patients according to the protocol of Fariña et al.[10] and by >55% radiopharmaceutical uptake on the affected side on single photon emission computed tomography (SPECT) (difference of over 10% between the affected and healthy sides). The clinical parameters for the diagnosis of condylar hyperplasia were as follows: progressive mandibular deviation with occlusal changes; facial midline not aligned with the lower dental midline or with the middle of the chin. The patients had to have orthodontic devices, without the need for dental alignment.

Patients with a difference of less than 10% between the two temporomandibular joints on SPECT, mandibular asymmetry for reasons other than AUCH, and those treated with orthognathic surgery and condylectomy in the same surgical session were excluded from this study.

The surgical planning for all patients was based on a previous study by Fariña et al.[10]. Physiotherapy was started immediately after the condylectomy and was complemented with elastic traction therapy 15 days later; the vectors tended towards a class I canine and centring of the dental midlines. This was done using a stainless steel orthodontic arch, calibre 17×25 or higher, and micro-screws.

A split-mouth design was used, with the assignment of the healthy joints (HS, healthy side) to the control group and the affected joints (AS, affected side) to the test group (21 joints per group). Each patient was subjected to a full clinical examination prior to the intervention.

All patients were subjected to three cone beam computed tomography (CBCT) examinations at the following time points: T0, preoperative; T1, 10 days following the surgical intervention; T2, 12 ± 1 months post-condylectomy. The CBCT scans were performed at a private radiology centre (Cimex) using a Kodak 9500 CBCT scanner (Carestream Health, Rochester, NY, USA), with settings of 90 kV, 10 mA, 0.2-mm^3 voxel size, and field of view (FOV) of 20×18 cm. From the CBCT, a cephalometric tracing of the mandibular ramus and the condyle was performed on both sides to determine their lengths, following a protocol established by Fariña et al.[10,11]. All measurements were made by the same radiologist.

The condylar unit volume (CUV) and articular cavity volume (ACV) were obtained at T0 and T1 for the HS and at T0, T1, and T2 for the AS. The dentoalveolar units (DAUs) were measured at T0 and T1 for the AS and the HS using OsiriX-MD software (Pixmeo, Geneva, Switzerland).

Five patients were excluded from the statistical analysis for volumetric measurements because the T1 scan was not taken. Four patients were excluded from the DAU measurements because the scan at T0 was obtained with a smaller FOV. Thus, a total of 16 patients were included for the volumetric analysis and 17 for the DAU measurements, with a total of 476 DAU measurements and 160 volumetric measurements analyzed (Fig. 1). The measurement data were recorded in a blinded

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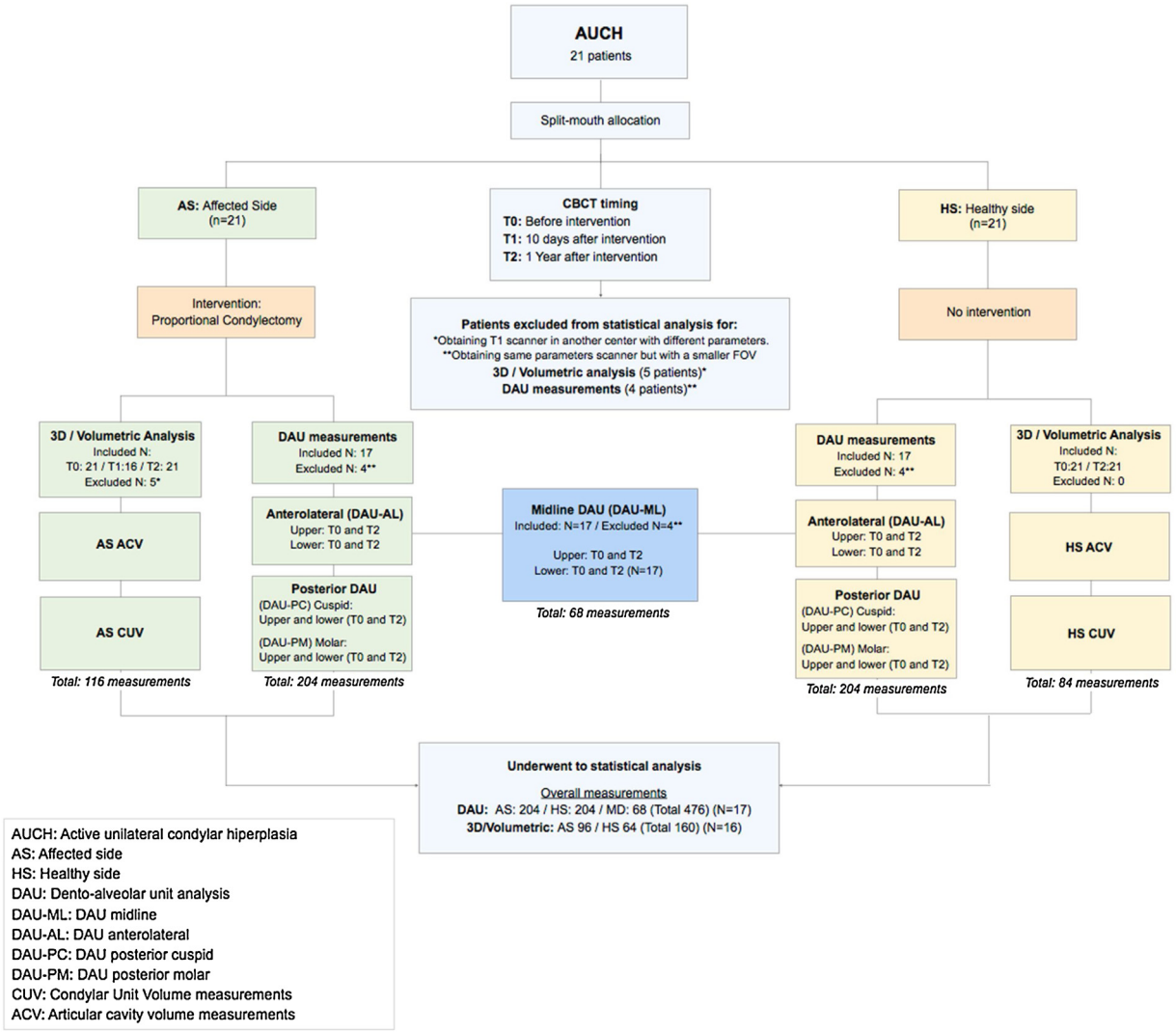

Fig. 1. Flowchart of the study design and patient distribution.

manner by two calibrated operators without knowledge of the side affected. In addition, the statistical analysis was performed by an expert with no knowledge of the patients' clinical conditions regarding the measurements recorded.

Measurements were taken in the sagittal plane, with the axial and coronal planes as references to establish the measurement limits, as described in the points that follow. In all cases, once the limits of the study area had been defined, the volumes were calculated using the region of interest (ROI) function in each 0.3-mm thick cross-section in the sagittal plane. The 'Compute-ROI' tool was used to generate the volumes.

Condylar unit volume (CUV)

The mandibular condyle unit was established taking the mandibular lingula (point L), defined on the coronal plane and transferred to the sagittal plane in all cross-sections, as a reference. The cross-section thickness was subsequently increased to 20 mm to establish the posterior limit at a tangent to the posterior border of the mandibular ramus from the mandibular angle to the condyle neck (line L–P), which had to have a 90° orientation originating at point P; the anterior limit (L–S) is a straight line, 90° from point L and the line L–P in the cephalic direction towards the sigmoid notch. Lastly, the measurements were taken in the sagittal plane, establishing as ROI the radiopaque elements contained within the limits established for the condylar unit, to obtain the volume in cubic centimetres (cm^3) (Fig. 2).

Articular cavity volume (ACV)

The measurement protocol for both condyles was implemented only in the sagittal plane, taking the lateromedial axis of the condyle defined in the coronal plane as a reference, determined to be the largest diameter on this plane, using cross-sections 6 mm thick and where two parallel lines were drawn that were tangents to the medial and lateral poles of the condyle. This measurement was defined at T0, using the same one for T2 to preserve anatomical references after a proportional condylectomy. It was delimited in the sagittal plane by drawing a line that runs tangential to the lower part of the anterior and posterior limits of the glenoid cavity. The ROIs were delimited in the consecutive segments to calculate the ACV.

The volumes CUV and ACV obtained on both sides were calculated individually for T0 and T1 on the HS and T0, T1, and T2 on the AS, and recorded for subsequent statistical analysis (Figs. 3 and 4).

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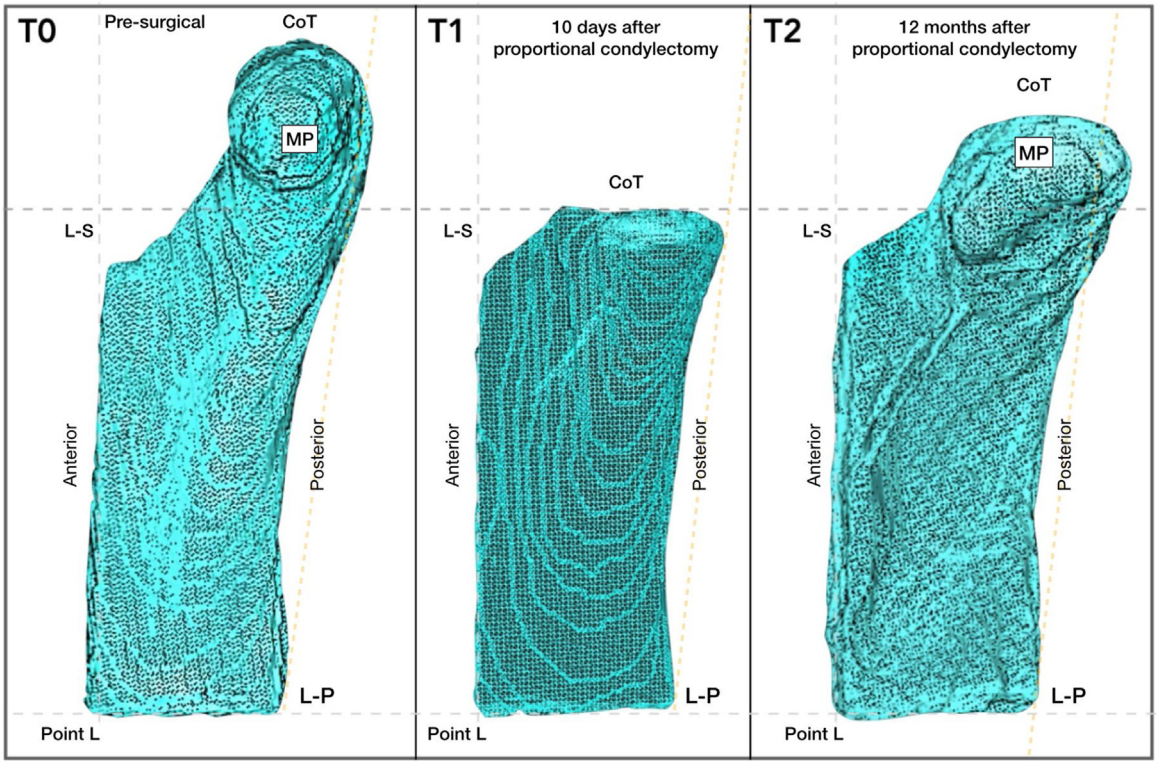

Fig. 2. Condylar unit volume (CUV) for patient 1—volumetric reconstruction of the left condylar unit (affected side) at T0, T1, and T2 from the medial view. The upper dotted line shows the limit of the proportional condylectomy (7 mm removed). Point L: mandibular lingula; L–P: lingula–posterior line; L–S: lingula–sigmoid line; CoT: condylar top; MP: medial pole. T0 volume: 2.939 cm^3; T1 volume: 1.545 cm^3; T2 volume 2.274 cm^3.

Dentoalveolar units (DAUs)

The DAU data were divided into three groups by area: the anterior DAU and two posterior DAUs (HS and AS). Measurements were done in the frontal and sagittal planes, respectively, with a cross-section thickness of 38 mm. In addition, the axial and coronal planes were used for the measurements of the posterior and anterior DAUs, both with 0.25 mm cross-sections, with the goal being to accurately establish the starting point for measurement, located in the uppermost and vestibular area of the interdental alveolar bone crest.

For anterior DAU, the anterior–superior plane was a line that passes between the outermost region of the fronto-zygomatic sutures. The anterior–inferior plane was a line that passes between the mental foramens. A 38-mm cross-section on the sagittal plane was chosen for measurement and the frontal plane was positioned in such a way that the anterior edge of the cross-section coincided with the vestibular surface of the incisors. Three points were drawn on both, corresponding to the interincisive crest and the mesial crests of the canines. Subsequently, each of the points was measured at a 90° angle to the corresponding plane.

For posterior DAU, the posterior–superior plane corresponded to the Frankfort horizontal (FH). The posterior–inferior plane was a tangent to the basilar edge. Both planes were plotted for the HS and AS independently. Four posterior points were drawn in the upper and lower jaw, corresponding to the distal crest of the first molar and the distal crest of the canines on each side. Subsequently, each of the points was measured at a 90° angle to the corresponding plane.

All of the DAU measurements were made in millimetres and were calculated individually both at T0 and T2 and recorded for subsequent statistical analysis (Fig. 5).

Statistical analysis

The CUV data did not show a normal distribution when evaluated with a Shapiro–Wilk test, meaning that they could not be compared by paired test; they were therefore analyzed using the range test, producing *P*-values. The data for the ACV showed a normal distribution, so these were analyzed by paired *t*-test and the *T* and *P* values were obtained, adjusted with the Bonferroni correction. The DAU measurements showed a normal distribution and were analysed by paired *t*-test. A value of $P \leq 0.05$ was considered statistically significant (*). The measurements were reported in box-plot dispersion diagrams (Figs. 6 and 7).

Results

Patient demographic and measurement data are given in Table 1; 81.0% were female and 19.0% were male. The average size of the condylectomy (length removed) was 7.857 ± 2.43 mm. The average duration of follow-up at T2 was 11.85 months. The age differences and the sides affected were not statistically significant.

3D volumetric analysis

Ipsilateral analysis

With regard to the CUV, a difference of 1.124 cm^3 was found between T0 and T1 (95% confidence interval (CI) 0.9494–1.298; $P = 0.000$*); this corresponds to the average volume resected during surgery. There was evidence that this condyle grew by 0.42 cm^3 between T1 and T2 (from 10 days post-condylectomy to 11.85 months post-condylectomy) (95%

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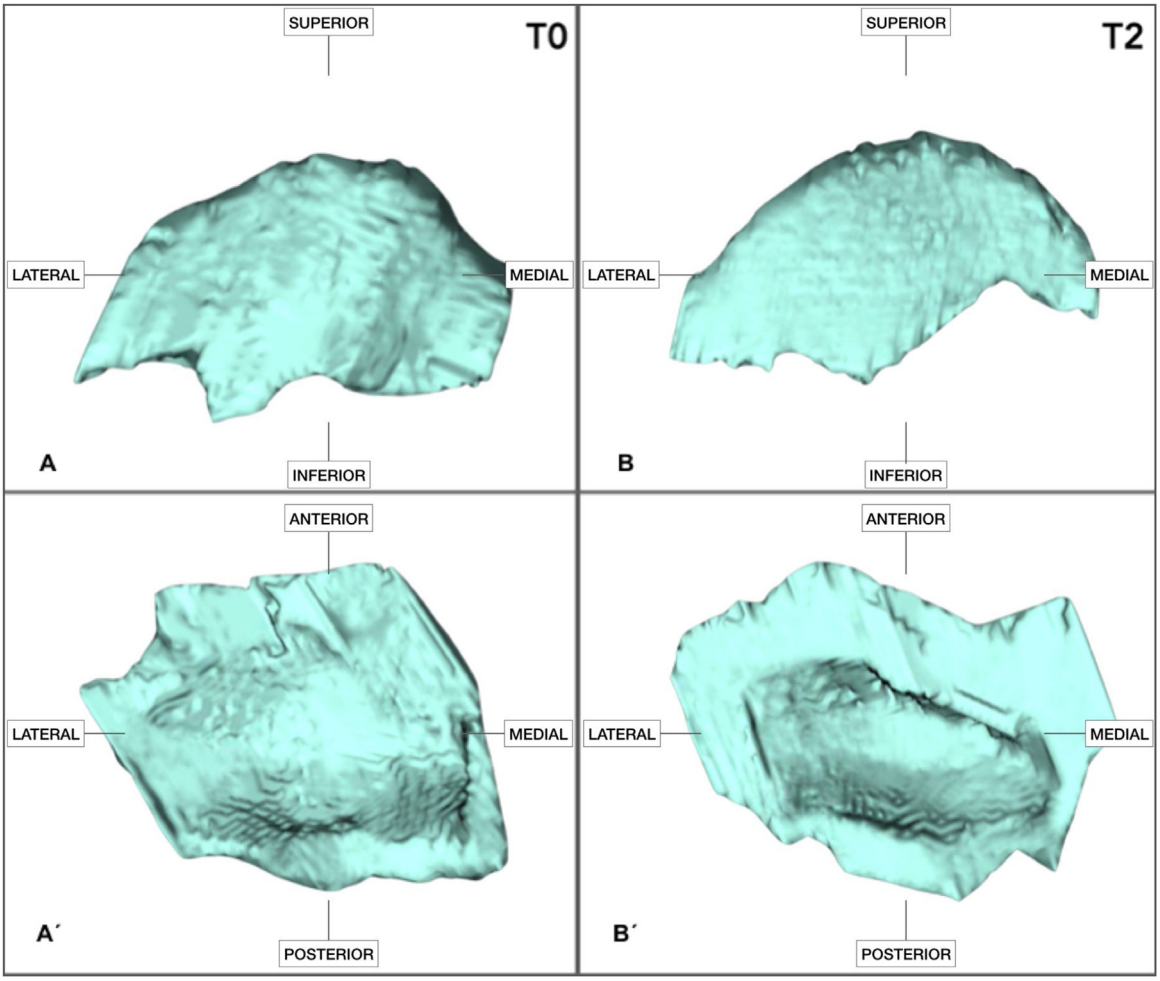

Fig. 3. Articular cavity volume (ACV) for patient 1—volumetric reconstruction of the right joint space (healthy side) at T0 (A) and T2 (B) from anterior view; A′ and B′ from caudal view. T0 volume: 0.432 cm^3; T2 volume: 0.413 cm^3.

CI −0.523 to −0.316; $P = 0.000$*). There was no volumetric difference between T0 and T2 on the HS (−0.009 cm^3, 95% CI −0.044 to 0.027; $P = 0.918$) (Table 2).

With regard to ACV, the articular cavity on the AS increased in size by 0.652 cm^3 between T0 and T1 (95% CI −0.884 to 0.420; $P = 0.000$*), because of the condylectomy, after which it was reduced by 0.356 cm^3 (95% CI 0.222–0.491; $P = 0.000$*) at T2, showing a difference of 0.296 cm^3 (95% CI −0.489 to −0.102; $P = 0.053$) larger than the initial articular cavity (T0). The articular cavity on the HS did not present post-surgery differences (Table 3).

Contralateral analysis (HS vs. AS)

For CUV, there was a statistically significant difference between the HS and AS at T0. The condylar volume on the AS was an average of 0.780 cm^3 (95% CI 0.559–1.001; $P = 0.000$*) larger than on the HS. In addition, there was no significant difference between the two condyles (HS and AS) at T2 (0.067 cm^3) (95% CI −0.060 to 0.195; $P = 0.301$) (Table 4).

For ACV, there was no statistically significant difference between the HS and AS measured at T0 (difference of 0.033 cm^3) (95% CI −0.226 to 0.159; $P = 1.000$). However, the AS measured at T2 showed a total increase of 0.276 cm^3 (95% CI 0.107–0.444; $P = 0.033$*), compared to the HS (Table 4).

Analysis of dentoalveolar units

Anterior DAU

For the midline unit (DAU-ML), the measurements at the anterior maxilla level did not show significant variation between T0 and T2. However, at the mandibular level, the midline was extruded by an average of 0.529 mm (Table 5).

For the anterolateral unit (DAU-AL), the lateral measurements (mesial to canine) at the superior maxilla level showed a slight variation. There was an average intrusion on the AS of 0.118 mm, and the HS was extruded by an average of 0.294 mm. Extrusion in the anterior inferior lateral region (mesial to canine) on the AS was 0.412 mm and extrusion on the HS was 0.647 mm (Table 6).

Posterior DAU

With regard to the distal measurements to canines (DAU-PC), this increased by 0.118 mm in the upper DAU-PC measurements on the AS, while there was extrusion of 0.647 mm on the HS. At the mandibular level on the AS, there was extrusion of 1.059 mm, while the HS preserved its length (Table 7).

For molar measurements (DAU-PM), the height was reduced by 0.941 mm at the level of the upper molars on the AS, while the HS remained constant. There was an intrusion of 0.176 mm in the lower

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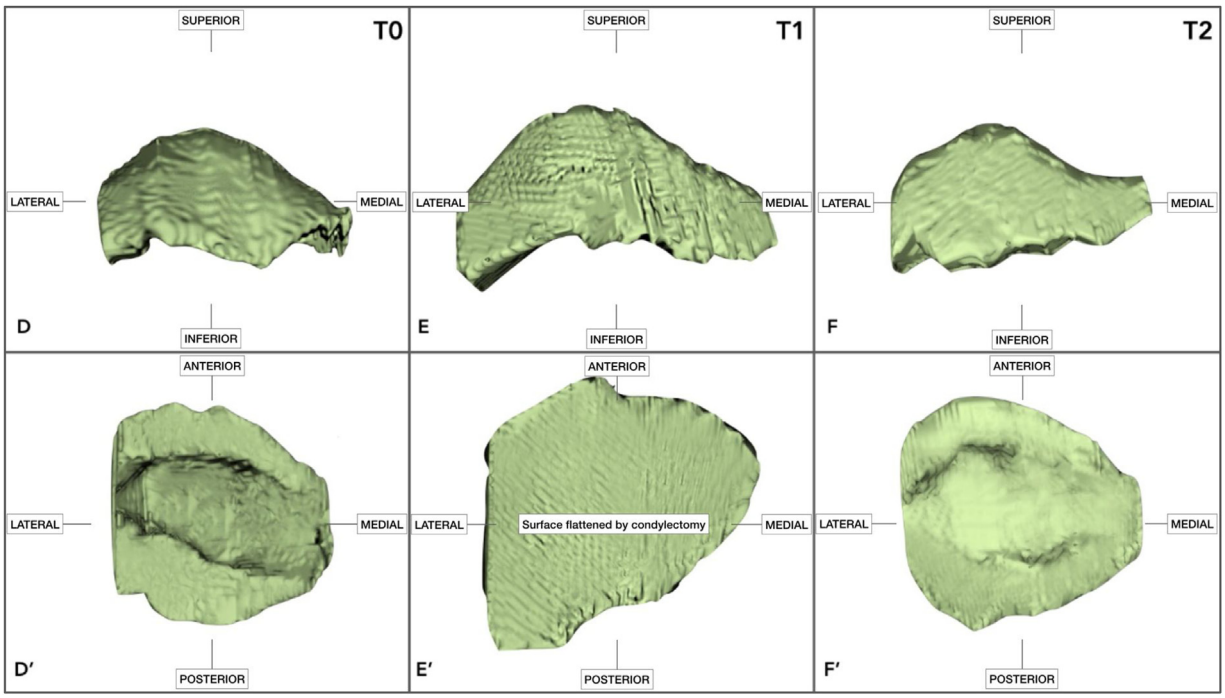

Fig. 4. Articular cavity volume (ACV) for patient 1—volumetric reconstruction of the left joint space (affected side) at T0 (A), T1 (B), and T2 (C) from anterior view; A′, B′, and C′ from caudal view. T0 volume: 0.992 cm^3; T1 volume: 1.534; T2 volume: 1.305 cm^3.

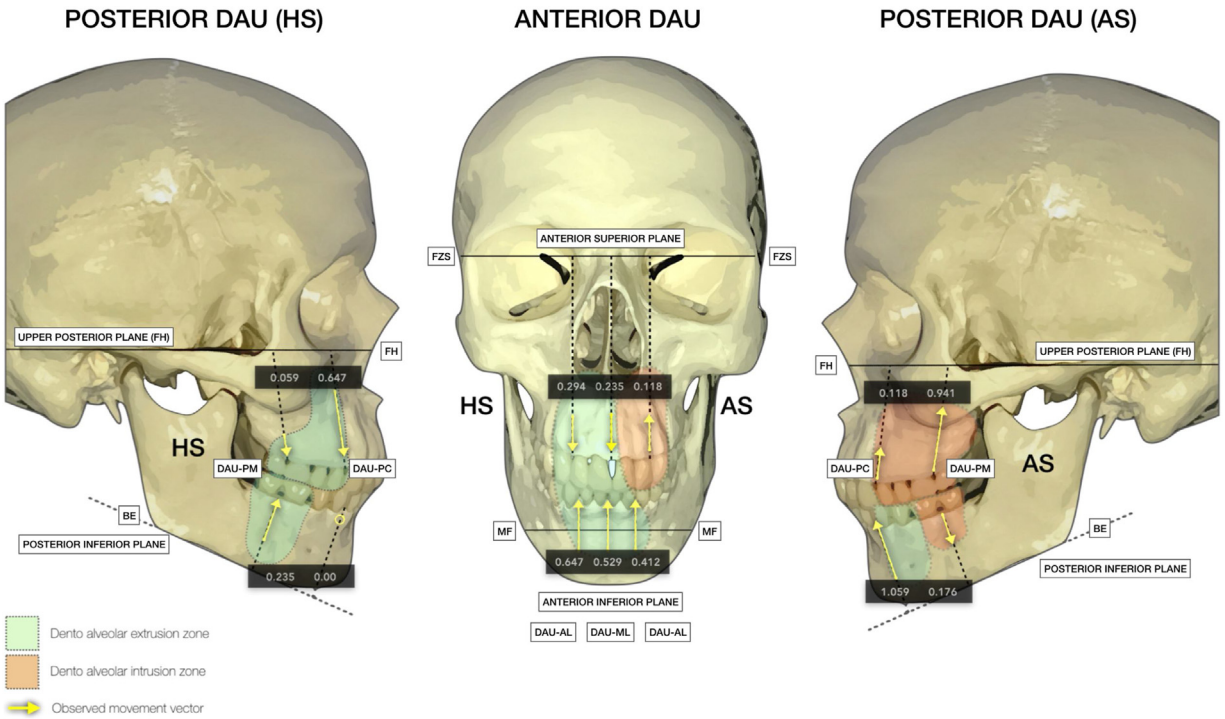

Fig. 5. Image showing global vertical dentoalveolar unit (DAU) changes observed from T0 to T2. HS: healthy side; AS: affected side; FH: Frankfort horizontal; BE: mandibular basilar edge; FZS: fronto-zygomatic sutures; MF: mental foramen; DAU-ML: DAU midline level; DAU-AL: anterolateral level (medial to canine); DAU-PC: posterior cuspid (distal to canine); DAU-PC: posterior molar. Green zones: dentoalveolar extrusion; orange zones: dentoalveolar intrusion; yellow arrows: movement observed.

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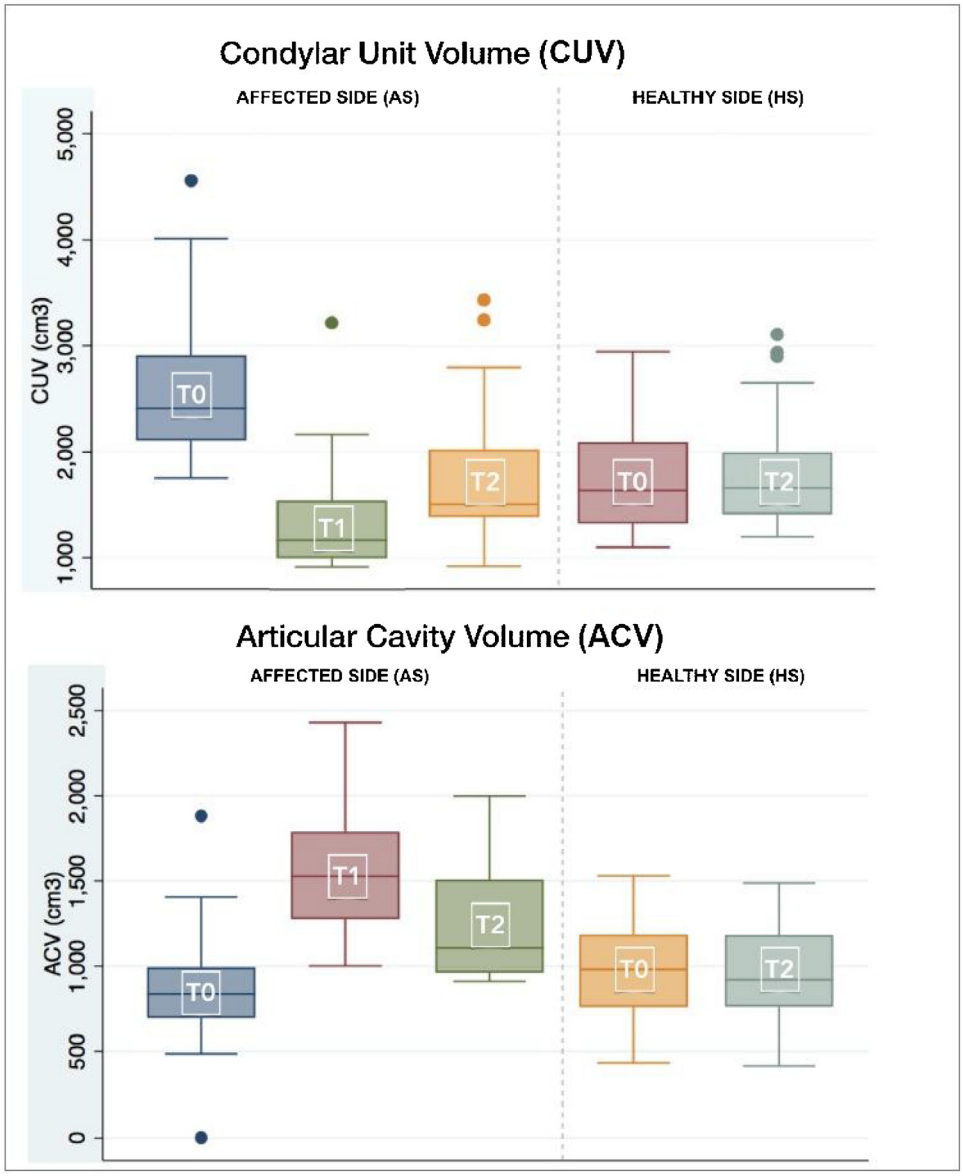

Fig. 6. Box-plot showing the 3D/VOL analysis results in cm^3 for CUV and ACV. Affected side on the Left and healthy side on the right. Middle line of the box is the median, whiskers indicating variability outside the upper and lower quartiles.

molars on the AS and 0.235 mm was extruded on the HS (Table 7).

Discussion

Nolte et al.[12] found significant differences between the AS and HS in segments of the condyle, ramus, and body in a group of patients, for both linear and volumetric measurements. The condylar region appeared to be the segment most affected by a significantly larger volume. However, it was impossible to classify the cases according to the existing Obwegeser classification of AUCH, as the growth pattern was unclear. This research showed that the volume of the hyperplasic condyle was approximately 43% larger than on the HS and was reduced in size by 42.6% with a proportional condylectomy. The articular function allowed the stump to be remodelled to the shape of a corticalized condyle, resulting in neoformation or growth of 27.4% when examining the changes observed between T1 and T2, almost equalling the contralateral condyle and with a difference of 0.5% after 11.85 months.

According to Arnett et al.[13,14], the factors that influence remodelling are patient age, the presence of systemic pathologies, and hormonal factors, in addition to the possible occurrence of mechanical stress. Thus, remodelling of the mandibular condyle is mainly related to neoformation with displacement of the cephalic portion of the condyle. This scenario changes following the condylectomy, which produces a sudden reduction in the intra-articular pressure on both joints. The remodelling is a consequence of normalizing mechanical forces. The occlusal changes favour condylar re-corticalization and neoformation on the intervention side despite resection of the cartilaginous core. Moreover, the results of ACV analysis suggest a compression of this by the hyperplasic condyle, being 2.54% smaller on average in comparison to the contralateral joint space. The articular cavity increased in size by approximately 68% after the proportional condylectomy was performed, which was later reduced to 37%, due to the functional condylar remodelling and neoformation.

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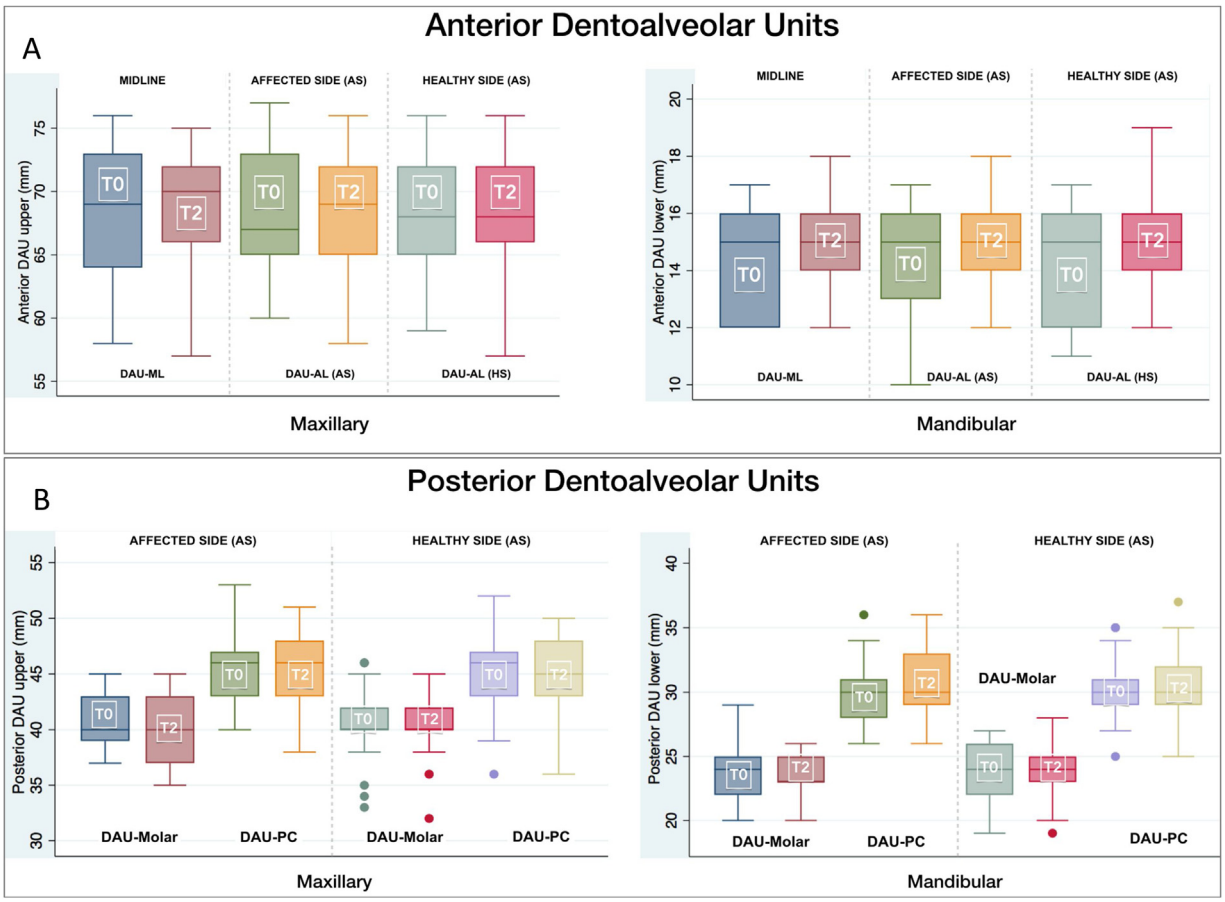

Fig. 7. Box-plot showing the dentoalveolar unit (DAU) results in millimetres (mm) for anterior DAU (A) and posterior DAU (B). The line in the middle of the box is the median and the whiskers indicate variability outside the upper and lower quartiles.

The dentoalveolar changes to the maxilla on the AS occurred after the condylectomy, causing mandibular autorotation. The molars on the AS can be modified with micro-screws, which would allow greater mandibular autorotation. On this point, the importance of postoperative functional therapy must be emphasized, as the bone and dental changes achieved are to a great degree due to the mandibular function guided by elastic traction, as noted by Fariña et al.[8] and Brusati et al.[15].

Levelling of the occlusal plane at approximately 12 months after the surgery and subsequent elastic traction therapy is due to the system's ability to adapt by following the concept of functional matrixes[16].

The main changes observed were due to intrusion and extrusion movements. At the midline level of the anterior sector, there was no variation in the maxilla; however, there was significant dentoalveolar bone extrusion at the mandibular level, possibly caused by the vertical orthodontic control. An extrusion could be observed on the upper canines in the medial areas of the HS and intrusion on the AS, allowing maxillary cant correction. Meanwhile, there was a bilateral extrusion on the mandibular level, which was greater on the HS (0.6 mm). In the posterior sector, at the distal level of the upper canines, the AS showed a slight intrusion (0.1 mm) and the HS showed significant extrusion (0.6 mm), which is consistent with what was observed at the anterior level, while the alveolar crest distal to the lower canines showed considerable extrusion (1 mm) on the AS and the HS did not show any variation. At the upper molar level, the distal bone crest of the first molar intruded approximately 1 mm on the AS, while there was practically no change on the HS. The distal zone of the first mandibular molar on both sides showed slight variation, expressed as 0.1 mm intrusion on the AS and 0.2 mm extrusion on the HS. It is worth noting that 1 mm of intrusion at the level of the molars due to mandibular autorotation can lead to 3 mm closing of open anterior bite.

Wolford et al. published an update of their classification of condylar hyperplasia and argued that the treatment of choice for patients with AUCH and also for cases of bilateral hyperplasia consists of combined upper condylectomy with orthognathic surgery[17]. Jones and Tier[18] presented 17 patients who had also received an upper condylectomy with repositioning of the condyle and orthognathic surgery in a single surgical session. Villanueva-Alcojol et al.[18] presented 36 patients diagnosed with unilateral condylar hyperplasia who were treated with high condylectomies, of whom just six needed secondary orthognathic surgery. Despite the limited literature analyzing condylectomies, Fariña et al.[1,8,10] have shown that a proportional condylectomy as the sole procedure for AUCH can offer a highly predictable and stable result if performed at an early stage, not just avoiding the presence of secondary dental and maxillary compensations, but also to a certain extent allowing the asymmetries caused by the disease development to be reversed and lowering the need for secondary surgery by 85%[10]. This

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Table 1. Patient data and summary of the measurements from the 3D volumetric analysis. Averages were calculated with values taken from the patients with complete values.

Patient data				Condylar unit volume (CUV; cm^3)					Articular cavity volume (ACV; cm^3)				
Patient	Age, years (T0)	Sex	Length removed (mm)/ side affected	Affected side (AS)			Healthy side (HS)		Affected side (AS)			Healthy side (HS)	
				T0	T1	T2	T0	T2	T0	T1	T2	T0	T2
1	19	F	7/L	2.939	1.545	2.274	2.088	2.095	0.992	1.534	1.305	0.432	0.413
2	30	F	9/R	2.269	1.417	2.026	1.473	1.507	0.723	1.588	1.204	0.565	0.606
3	20	F	14/R	4.013	2.744	3.244	2.906	3.106	0.694	1.801	1.546	1.091	1.121
4	19	M	10/R	4.560	3.217	3.434	2.911	2.938	1.881	2.135	1.599	1.530	1.487
5	17	F	10/R	2.784	0.999	1.479	1.281	1.297	0.910	2.429	1.647	1.220	1.254
6	20	F	8/R	2.425	1.084	1.492	1.676	1.658	0.667	1.431	0.963	1.109	1.058
7	20	M	8/L	1.749	1.282	1.509	1.453	1.409	1.163	1.477	1.063	0.856	0.874
8	16	F	7/R	3.054	2.168	2.798	2.947	2.897	1.185	1.734	0.943	0.980	0.913
9	26	F	5/L	2.896	1.385	1.701	1.860	1.835	1.405	2.308	1.998	1.233	1.256
10	18	M	7/R	2.476	1.169	1.447	1.731	1.731	0.877	1.275	0.961	0.699	0.703
11	19	F	8/L	2.124	1.163	1.865	1.589	1.538	0.988	1.787	1.507	0.887	0.867
12	16	F	13/R	2.149	1.021	1.380	1.098	1.198	0.749	1.034	1.211	1.262	1.198
13	27	F	9/L	1.813	0.920	1.018	1.272	1.198	0.836	1.272	1.043	0.755	0.702
14	14	M	5/L	3.102	1.955	2.529	2.618	2.652	1.318	1.001	1.052	1.245	1.205
15	15	F	7/R	1.833	0.993	1.174	1.215	1.201	0.486	1.489	0.969	0.920	0.920
16	16	F	9/R	1.838	0.983	1.390	1.428	1.421	0.509	1.528	1.106	1.132	1.131
17	24	F	8/L	2.301	N/I	0.926	2.090	1.996	0.782	N/I	0.910	1.165	1.121
18	15	F	5/L	2.910	N/I	1.992	1.290	1.302	0.695	N/I	0.914	0.761	0.798
19	12	F	5/R	2.409	N/I	1.783	1.320	1.415	0.870	N/I	1.242	0.891	0.764
20	26	F	6/L	2.106	N/I	0.983	1.636	1.675	1.099	N/I	1.722	0.729	0.728
21	17	F	5/L	1.985	N/I	1.475	1.633	1.674	0.809	N/I	9.435	1.184	1.182
Mean (±SD)	19.3	17 F/4 M	7.857 ± 2.43 11 R/10 L	2.679	1.537	1.958	1.874	1.884	0.961	1.619	1.267	0.986	0.972

L, left; R, right; SD, standard deviation; N/I; T0, preoperative; T1, 10 days after the intervention; T2, 12 ± 1 months post-surgical.

Table 2. Statistical analysis of the condylar unit volume (CUV; cm^3).

	MD T0 vs. T1	*P*-value[a]	MD T1 vs. T2	*P*-value[a]	MD T0 vs. T2	*P*-value[a]
Affected side (AS)	1.124	0.0005*	−0.420	0.0005*	0.704	0.0005*
Healthy side (HS)	NM	NM	NM	NM	−0.009	0.918

MD, mean difference; NM, not measured (T1 missing); T0, preoperative; T1, 10 days after the intervention; T2, 12 ± 1 months post-surgical.

[a] $P < 0.05$ indicates statistical significance (*).

Table 3. Statistical analysis of the articular cavity volume (ACV; cm^3).

	MD T0 vs. T1	*P*-value[a]	MD T1 vs. T2	*P*-value[a]	MD T0 vs. T2	*P*-value[a]
Affected side (AS)	−0.652	0.0005*	0.356	0.0005*	−0.296	0.053
Healthy side (HS)	NM	NM	NM	NM	0.013	1.000

MD, mean difference; NM, not measured (T1 missing); T0, preoperative; T1, 10 days after the intervention; T2, 12 ± 1 months post-surgical.

[a] $P < 0.05$ indicates statistical significance (*).

Table 4. Comparison of 3D volumes (cm^3) between the affected side (AS) and healthy side (HS).

	MD T0 AS vs. HS	*P*-value[a]	MD T2 AS vs. HS	*P*-value[a]
Condylar unit volume (CUV)	0.780	0.0005*	0.067	0.301
Articular cavity volume (ACV)	−0.033	1.000	0.276	0.033*

MD, mean difference; T0, preoperative; T1, 10 days after the intervention; T2, 12 ± 1 months post-surgical.

[a] $P < 0.05$ indicates statistical significance (*).

Table 5. Average dentoalveolar unit midline (DAU-ML; mm).

Midline	Mean T0	Mean T2	MD ± SD
Upper	68.529	68.765	−0.235 ± 1.640
Lower	14.529	15.059	−0.529 ± 1.463[a]

MD, mean difference; SD, standard deviation; T0, preoperative; T2, 12 ± 1 months post-surgical.

[a] Greatest change.

was also seen in the present investigation, in which no patient required secondary orthognathic surgery.

Thus, after a proportional condylectomy, a neocondyle is formed in approximately 12 months, showing recorticalization and equalling the healthy contralateral side in volumetric terms, restoring the posterior facial height. At the same time, the articular cavity that was reduced in the initial stage increases in size after the surgery and progressively approaches the volume of the healthy side. Changes to the interdental crests are produced both at the anterior and posterior levels, allowing maxillary cant correction and mandibular self-rotation caused by vertical control. Hence, an early proportional condylectomy as the sole and aetiological treatment for patients with AUCH

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Table 6. Average dentoalveolar unit anterolateral (DAU-AL; mm).

Anterolateral (mesial to cuspid)	Affected side (AS)			Healthy side (HS)		
	Mean T0	Mean T2	MD ± SD	Mean T0	Mean T2	MD ± SD
Upper	68.412	68.294	0.118 ± 2.058	68.059	68.353	−0.294 ± 1.759
Lower	14.529	14.941	−0.412 ± 1.278	14.235	14.882	−0.647 ± 1.412[a]

MD, mean difference; SD, standard deviation; T0, preoperative; T2, 12 ± 1 months post-surgical.
[a] Greatest change.

Table 7. Average posterior dentoalveolar unit (DAU-PC and DAU-PM; mm).

Site	Affected side (AS)			Healthy side (HS)		
	Mean T0	Mean T2	MD ± SD	Mean T0	Mean T2	MD ± SD
PC upper	45.235	45.118	0.118 ± 1.799	44.824	45.471	−0.647 ± 1.618[a]
PC lower	29.882	30.941	−1.059 ± 1.886[a]	30.941	30.941	0.0005
PM upper	40.882	39.941	0.941 ± 2.164[a]	40.353	40.412	−0.059 ± 1.713
PM lower	23.471	23.294	0.176 ± 1.185	23.647	23.882	−0.235 ± 1.251

MD, mean difference; PC, at canine; PM, at molar; SD, standard deviation; T0, preoperative; T2, 12 ± 1 months post-surgical.
[a] Greatest changes.

allows regression of the facial asymmetry and normalization of the maxillomandibular relationship.

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Competing interests

None.

Ethical approval

This study was approved by the Ethics Board of Hospital del Salvador.

Patient consent

Patient consent was obtained.

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