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Clinical Paper
TMJ Disorders

No differences in morphological characteristics between hyperplastic condyle and class III condyle

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Abstract. The aim of this research was to compare the condylar morphology of patients with unilateral condylar hyperplasia (UCH) and patients with a class III skeletal relationship using cone beam computed tomography (CBCT). A prospective study was conducted on patients with facial asymmetry attending the division of oral and maxillofacial surgery of the study university in Chile. Fifteen patients with UCH and 15 with a class III skeletal relationship were selected. Linear measurements of the condylar processes were obtained at a scale of 1:1 using the software Ez3D Viewer Plus. Analysis of variance (ANOVA) and the paired *t*-test were used, considering $P < 0.05$. Patients with UCH presented statistical differences between the hyperplastic condyle and non-hyperplastic condyle for anteroposterior and mediolateral diameters, condylar neck length, and ramus height. Patients with a class III skeletal relationship showed no differences between the right and left sides; the morphology of their condyles was similar to the condyles with hyperplasia and presented statistical differences when compared with the non-hyperplastic condyles (one-way ANOVA, $P < 0.05$). The condylar morphology of UCH patients could be related to the development of a class III skeletal relationship. These findings provide an insight into the possibility of some class III patients presenting bilateral condylar hyperplasia.

Key words: mandibular condyle; facial asymmetry; condylar hyperplasia.

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Unilateral mandibular condylar hyperplasia (UCH) is a complex deformity of the condyle and the mandible that causes facial asymmetry.[1] UCH is diagnosed through the clinical findings of facial asymmetry; occlusal changes should be demonstrated clinically and radiographically, with active hyperplasia being confirmed by bone scan performed at the initial diagnosis and repeated at least 6 months later.[2] Condylar growth activity has traditionally been assessed by planar scintigraphy with technetium methylene diphosphonate (99m-Tc-MDP); however this method lacks anatomical precision. MDP-SPECT (single photon emission computed tomography) has the capability of three-dimensional (3D) reconstruction

and subsequent thin-sectioning.[1] The information is typically presented as cross-sectional slices through the patient, but can be freely reformatted or manipulated as required.

Classically, condylar hyperplasia has been described as a unilateral pathology and this could be related to the facility of identifying the facial asymmetry produced by differences in the sizes of the condyles.[3] Another factor is the difficulty in establishing the abnormal size when both condyles present hyperplasia, given that a certain asymmetry is normal to all human body structures.[4] Moreover, the diagnostic tools to assess condylar growth are based on the percentage differences in isotope uptake, which is higher in the condyle with hyperplasia.[5] Finally, the comparison between the hyperplastic condyle and non-hyperplastic condyle is one the most important factors for obtaining a final diagnosis of UCH.

Thus the use of SPECT and scintigraphy has no value in cases of bilateral condylar hyperplasia.[6] In contrast to most studies in the literature, there is a hypothesis that some patients with a class III occlusal and skeletal relationship present a bilateral condylar hyperplasia, called CH type 1A, as the primary cause.[6,7] From a biological point of view, it is possible; the concept of hyperplasia is an abnormal growth of cells, and hypothetically this could affect both sides.

The purpose of this study was to compare the temporomandibular joint (TMJ) morphology of patients with UCH and patients with a class III skeletal relationship using cone beam computed tomography (CBCT).

Materials and methods

This prospective study was conducted at the Division of Oral and Maxillofacial Surgery of the Universidad de La Frontera (Chile). A total of 30 patients, 15 consecutive patients with facial asymmetry related to UCH and 15 consecutive patients with a class III facial deformity, aged between 15 and 30 years, were assessed between January 2011 and June 2014. These patients had presented for the surgical correction of a mandibular or facial deformity. The study was conducted according to the recommendations for research involving human beings and was approved by the Ethics Committee in Research of the Universidad de La Frontera.

The inclusion criteria for patients with a class III facial deformity (Fig. 1, CH type 1A of Wolford's classification[7]) were: (1) overjet less than 0 mm with a class III dental occlusion and no missing teeth, (2) sella–nasion–B-point (SNB) angle of more than 84° with an established prognathism of the mandible, with or without hypoplasia of the maxilla, (3) A-point–nasion–B-point (ANB) angle $\leq 0°$, and (4) mandibular midline deviation of less than 4 mm.

Fig. 1. CBCT image of a class III patient included in this research (CH 1A in Wolford's classification).

The inclusion criteria for patients in the UCH group (Fig. 2, CH type 1B of Wolford's classification[7]) were (1) mandibular deviation from the midline more than 5 mm (evaluated on the chin in relation to the facial midline considering glabella, pronasale point, and superior labial philtrum), (2) dental occlusion with a unilateral crossbite, (3) lower dental midline deviated more than 4 mm, (4) patient's perception of active mandible deviation in the last year, (5) class I or class III dental occlusion with no absent teeth, (6) assessment by 99m-Tc-MDP SPECT showing a final difference in condyle absorption equal to or greater than 10%; the SPECT was done according to routine protocols and the result was assessed by a medical specialist in nuclear medicine.

The following data were collected: gender, age, and cephalometric parameters. All patients underwent standardized CBCT imaging (Pax Zenith 2011; Vatech, Yongin, Korea), with settings of 90 kV and 120 mA, voxel size 0.12 mm, and 1 mm cuts in a 90 mm × 240 mm window, which recorded the condition and morphology of the bilateral TMJ. The computed tomography images were obtained with the patients in maximum dental intercuspation and the head positioned with the Frankfort plane parallel to the floor.

Linear measurements of the condylar processes were obtained on a scale of 1:1 using the software Ez3D Viewer Plus (Vatech). The measurements were taken using a previously reported method.[3] The measurements are described in Table 1 and shown in Figs 3–5. Two further images were obtained for each measurement, immediately before and immediately after (1 mm cuts) the middle area, calculated in the 3D reconstruction (the middle point was obtained in the sagittal, coronal, and axial views). A final number was obtained from the average of the three measurements.

The data were analyzed using descriptive and correlational statistics in SPSS v. 18.0 for Windows software (SPSS Inc., Chicago, IL, USA). The paired Student's *t*-test was used for each measurement, to evaluate the average of the differences between the sides for each element of the sample. The Shapiro–Wilk test was performed and the sample was shown to be normally distributed. Levene's test was applied and showed homogeneity between the variances. The intra-class correlation coefficient (ICC) was used to assess

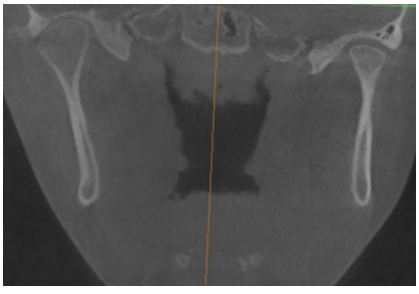

Fig. 2. CBCT image of a unilateral condylar hyperplasia patient included in this research (CH 1B in Wolford's classification).

Table 1. Description of the measurements obtained from the CBCT scans of patients with condylar hyperplasia and patients with an Angle class III dentofacial deformity.

Measurement	Description
Anteroposterior diameter of the condyle	This was measured on the sagittal view. A longitudinal line was drawn at the widest point of the condyle. This line started at the point on the most anterior cortical bone and ended at the point on the most posterior cortical bone. The middle point was obtained from the 3D reconstruction and applied.
Mediolateral diameter of the condyle	This was measured on the coronal view. A longitudinal line was drawn at the widest point of the condyle. This line was perpendicular to the axial axis of the condyle, starting and ending at the closest points of the most medial and lateral cortical bone (Fig. 3).
Condylar neck length	This was measured on the sagittal view. A longitudinal line was drawn that started at the uppermost cortical point of the condylar head and ended at a point of contact with the second line started in the sigmoid notch (the line was drawn starting at the sigmoid notch, perpendicular to the posterior border of the ramus).
Height of the mandibular ramus	This was measured on the sagittal view. The greatest dimension from the most superior aspect of the condyle to the line parallel to the inferior border of mandible. The line is parallel to the posterior border of the ramus (Fig. 4).
Depth of the mandibular condylar fossa	This was measured on the sagittal view. A line from the upper point of the mandibular fossa was drawn, perpendicular to another line from the most inferior point of the mandibular eminence. The measurement was taken from the upper point of the mandible fossa to the intersection between these two lines (Fig. 5).

CBCT, cone beam computed tomography; 3D, three-dimensional.

method error. Every measurement was performed by one operator and repeated twice at an interval of 1 week. The correlation coefficient between the measurements of the first and second tracings was 0.99 and had a *P*-value of 0.001. One-way analysis of variance (ANOVA) and Tukey's post hoc test were used to compare the measurements of patients with condylar hyperplasia and class III facial deformity, with results being significant at $P < 0.05$.

Results

Thirty patients were included in this study, 15 with a class III skeletal relationship and 15 with UCH. Most of the patients in both groups were women (UCH 53.3%, class III 66.7%) (Table 2). The mean age of those in the UCH group (Table 3) was 19.26 ± 3.59 years, and the UCH occurred mainly on the right side (53.3%). The patients with a class III skeletal relationship were older, with a mean age of 26.0 ± 3.61 years. No difference was observed between the groups regarding gender ($P = 0.46$).

In the group of patients with UCH, the condyle with hyperplasia showed greater measurements for all variables. Statistically significant differences between the condyle with hyperplasia and the contralateral side were observed for the anteroposterior diameter ($P = 0.014$), mediolateral diameter ($P = 0.000$), height of the condylar neck ($P = 0.001$), and height of the mandibular ramus ($P = 0.004$). The difference in the depth of the condylar fossa between the right and left sides was not statistically significant.

The class III patients showed relative symmetry between the left and right sides for the following measurements: anteroposterior diameter of the condyle, mediolateral diameter of the condyle, condylar neck length, and height of the mandibular ramus. No statistically significant difference was observed between the two sides in the depth of the mandibular condylar fossa ($P = 0.48$).

With respect to the non-hyperplastic condyles in the UCH group, there was a significant difference in the mediolateral diameter compared to the class III right condyle ($P = 0.009$), class III left condyle ($P = 0.003$), and condyle with hyperplasia

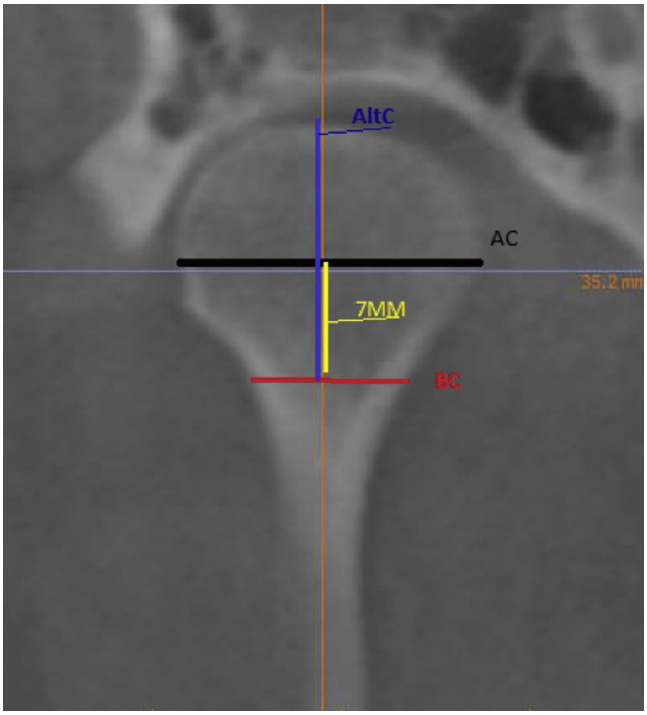

Fig. 3. CBCT image showing the condyle measurement in the coronal view; the condylar height and mediolateral diameter of the condyle can be observed.

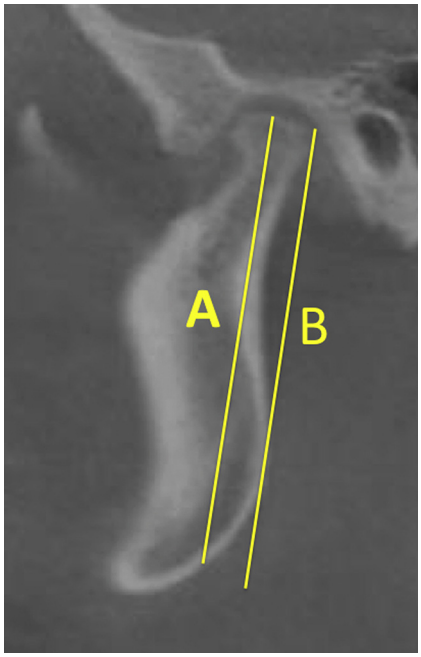

Fig. 4. CBCT image showing the length of the ramus – line 'A'. Line 'B' is the posterior border of the ramus in contact with the two more posterior points of the ramus (considering the condylar head).

($P < 0.001$). Additionally, they presented a shorter condylar neck length compared to the class III condyle ($P = 0.02$) and condyle with hyperplasia ($P = 0.01$). No statistically significant difference was observed in the anteroposterior diameter of the condyle, the height of the mandibular ramus, or the depth of the condylar fossa when compared with the class III condyle. The condyle morphology data are presented in Table 4.

Discussion

Condylar hyperplasia includes conditions that create excessive growth and enlargement of the condyle, by fibrocartilage growth, which can cause alterations in the bone architecture of the mandible, malocclusion, and dentofacial deformity.[7] Obwegeser and Makek reported that condylar hyperplasia was always observed to be unilateral[8]; however, they stated that a bilateral case could theoretically exist.

The literature indicates that condylar hyperplasia affects the condylar morphology as well as other areas of the mandible and anatomical sites adjacent to the articular fossa.[9] Classically, condylar hyperplasia is reported as unilateral; however, if both condyles present hyperplasia, this could represent an overgrowth leading to the development of a mandibular prognathism and class III dentofacial deformity.[10]

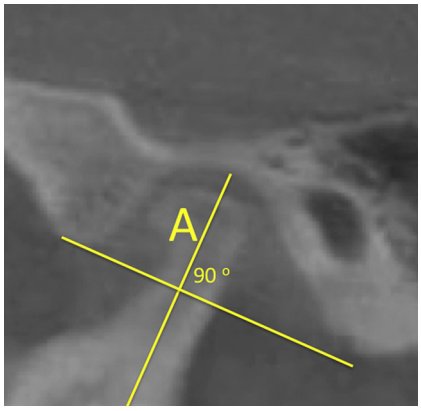

Fig. 5. CBCT image showing the measurement of the depth of the articular fossa (line 'A').

The mandible and the TMJ can be loaded differently in people with diverse dentofacial morphologies, and one could hypothesize that the condyle and the fossa might differ in shape between people with various malocclusions.[10] Angle class II has been associated with some degree of condylar remodelling.[11] Another study has shown statistically significant differences in the length of the condylar process between class II and class III patients, revealing this anatomical structure to be longer in class III cases.[12]

The class III patients in this study showed symmetry between the right and left condyles. The lack of asymmetry between the measurements is similar to that reported elsewhere, in which a different methodology was applied for different types of malocclusion.[13]

In this research the condyles with hyperplasia were found to be very similar in linear dimensions when compared with the condyles of patients with a class III skeletal relationship. With these findings, it is possible that patients with a class III skeletal relationship are presenting an overgrowth of both condyles. In the literature this was recently named CH type 1A.[7] Wolford et al.[6,7] have shown that this pathology usually begins as a class I or mild to moderate class III occlusion and skeletal relationship, which develops into a worse class III relationship as the pathological process progresses.

Condylar hyperplasia occurs at different ages, but with a greater incidence in teenagers.[2,7] Features include elongation of the condylar head and neck and a smooth, relatively normal-appearing morphology at the top of the condyle; in the coronal view, the top of the condyle appears more rounded than normal, and the mandibular body is elongated.[7] For this condition, it is important to consider that cases showing accelerated and excessive mandibular growth that continues beyond the normal growth years could be related to condylar hyperplasia. The diagnosis is complex and demands a clinical evaluation that includes facial photography, articulator-mounted models, and lateral cephalometric X-rays at 6- to 12-month intervals.[7]

The growth rate of condylar hyperplasia type 1A (bilateral condylar hyperplasia) is not a tumourous rate, but it is somewhat faster than the normal condylar growth rate; thus, it is usually difficult to differentiate condylar hyperplasia type 1 from normal growth, particularly because both the right and left joints are involved. In unilateral cases, it may also be difficult to determine an increased uptake on the affected side, particularly if the contralateral

Table 2. Demographic characteristics and diagnosis conditions for the class III patients.

ID	Age, years	Sex	Overjet (mm)	ANB angle	SNB angle
1	29	Female	−1	0	84
2	22	Male	−3	−2	86
3	28	Female	−5	−3	85
4	28	Female	−8	−5	86
5	25	Female	−7	−5	88
6	27	Male	−5	−2	85
7	19	Female	−2	−1	87
8	26	Female	−8	−4	87
9	19	Female	−1	0	84
10	22	Male	−4	−1	90
11	29	Female	−8	−4	92
12	30	Male	−10	−6	89
13	29	Female	−2	−2	87
14	28	Female	−6	−2	92
15	29	Male	−8	−5	95

ANB, A-point–nasion–B-point; SNB, sella–nasion–B-point.

Table 3. Demographic characteristics and diagnosis conditions for the unilateral condylar hyperplasia patients.

ID	Age, years	Sex	Hyperplastic condyle side	Chin deviation, mm
1	15	Female	Right	5
2	17	Male	Left	6
3	15	Female	Right	8
4	18	Female	Right	5
5	22	Female	Left	9
6	27	Male	Left	5
7	17	Male	Right	7
8	16	Female	Left	9
9	19	Female	Right	10
10	21	Male	Right	6
11	24	Female	Left	5
12	17	Male	Left	8
13	20	Female	Right	7
14	17	Male	Right	9
15	24	Male	Left	10

TMJ develops a displaced disc and associated arthritic changes, because this contralateral TMJ may also have a slightly increased uptake.[7]

Historically the best clinical approach to diagnosing UCH has been through the clinical history and SPECT-assisted confirmation of greater 99m-Tc uptake.[14] However, these nuclear medicine methods are non-specific, because a positive result is obtained for any kind of increase in bone metabolism, whether infectious, inflammatory, traumatic, or neoplastic, even in normal growth processes.[15] Another factor is that some patients affected by condylar hyperplasia might show positive SPECT scans unrelated to the clinical progression of the asymmetry.[5] Additionally, it is difficult to correlate SPECT with other clinical and histological findings due to its great variability.[15]

Although bone scintigraphy and SPECT have been used to evaluate the active growth in UCH, this has no value in cases of bilateral condylar hyperplasia.[6] Condylar SPECT may detect active growth when the left condyle is compared to the right condyle, so it is necessary for one condyle to show an overgrowth of the fibrocartilage layer.[16]

Facial asymmetry could be related to dimensional changes in the condyle with hyperplasia and it is hypothesized that morphological and functional changes in both condyles could determine facial deformities.[3] The question that remains as a result of these findings is: If bilateral condylar hyperplasia exists, when should the patient with a class III skeletal relationship receive surgical treatment? For UCH, surgical treatment is undertaken before completion of the abnormal growth. If this growth is allowed to proceed, it exacerbates the facial deformity and asymmetry, and causes dental compensations, affecting dentoskeletal development and producing excessive soft tissue development. This may increase the difficulties in obtaining optimal functional and aesthetic results.[6]

So when a teenager presents with a mandibular prognathism related to

Table 4. Distributions of measurements obtained from the CBCT scans of patients with unilateral condylar hyperplasia and patients with a dentofacial class III deformity (in millimetres).

Measurement	Unilateral condylar hyperplasia			Class III deformity			One-way ANOVA‡	
	Hyperplastic condyle (mm) (mean ± SD)	Non-hyperplastic condyle (mm) (mean ± SD)	*P*-value*	Right condyle (mm) (mean ± SD)	Left condyle (mm) (mean ± SD)	*P*-value†	*F*	*P*-value
Anteroposterior diameter of condyle	9.57 ± 1.05	8.86 ± 0.98	0.014	9.18 ± 0.63	9.31 ± 0.62	0.328	1.76	0.165
Mediolateral diameter of condyle	17.34 ± 1.49	13.95 ± 2.43	0.000	16.58 ± 2.18	16.91 ± 2.51	0.369	7.29	0.000
Condylar neck length	20.12 ± 2.92	16.45 ± 3.58	0.001	19.98 ± 3.45	19.40 ± 3.21	0.147	4.06	0.011
Height of mandibular ramus	65.15 ± 6.67	59.85 ± 4.72	0.004	63.08 ± 6.43	62.46 ± 6.45	0.299	1.89	0.142
Depth of mandibular condylar fossa	14.26 ± 1.60	13.21 ± 2.04	0.064	13.75 ± 1.53	13.04 ± 1.28	0.480	1.71	0.174

CBCT, cone beam computed tomography; SD, standard deviation; ANOVA, analysis of variance.
* Paired samples *t*-test between condyles with and without hyperplasia.
† Paired samples *t*-test between right and left condyles in patients with class III facial deformity.
‡ One-way ANOVA and Tukey's post hoc test.

bilateral condylar hyperplasia, should this situation be treated like UCH? Wolford et al.[6,7] have reported a protocol related to the hyperplastic condyle condition and this could be a response for this matter.

The results of this research provide preliminary information to suggest that some patients with a class III skeletal relationship could present a morphology similar to UCH. Further studies are required to provide a better understanding of this biological condition with bilateral overgrowth of the condyle unit. These results constitute an objective comparison between condyles involved in UCH and those involved in mandibular prognathism.

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Competing interests

None declared.

Ethical approval

Ethics Committee in Research of the Universidad de La Frontera (number 066/2013).

Patient consent

Not required.

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