Clinical Paper
TMJ Disorders

Measuring the condylar unit in condylar hyperplasia: from the sigmoid notch or from the mandibular lingula?

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Abstract. The objective of this study was to determine, in patients with active unilateral condylar hyperplasia, which is the most reliable point to measure the length of the condylar unit: from the sigmoid notch or from the mandibular lingula to the condylar head. On cone beam computed tomography, an observational cross-sectional study was designed for 20 patients with active unilateral condylar hyperplasia. We measured and compared ramus length (affected and healthy sides) and condylar length (measured from the mandibular lingula and from the mandibular sigmoid notch) on both sides. The average of all the differences in ramus height (D.1) was 7.97 mm; the average of all the differences in condylar heights measured from mandibular lingula (D.2) was 7.16 mm, and measured from the sigmoid notch (D.3) was 4.89 mm. No significant difference between D.1 and D.2 ($P = 0.818$). There was a significant difference between D.1 and D.3 ($P = 0.005$) and between D.2 and D.3 ($P = 0.0005$). It can be concluded that the mandibular lingula is the lowest point of the condylar skeletal unit and is therefore a stable parameter to be used in patients with condylar hyperplasia. On the other hand, the sigmoidal notch is not a stable parameter in patients with asymmetry due to condylar hyperplasia.

Mandibular asymmetry is one of the main causes of facial asymmetry. It can be caused by a deficit or excess in the size of one of its components[1]. Patients with facial asymmetry require a clinical and radiographic analysis that allow a proper diagnosis and in that way design an appropriate treatment plan[2]. The measurement of the size of the condyle is usually done from the highest point of the condylar head to the sigmoid notch (SN)[2–4].

During embryonic development, the mandibular body presents a membranous ossification guided by the Meckel cartilage (primary cartilage), which subsequently retrogresses and completely disappears from the mandibular body, transforming itself into two bones of the medial ear, and the sphenomandibular ligament, which will shape the mandibular lingula (ML) through traction[5]. At the

same time, the coronoid process of the mandible appears due to traction of the temporal muscle[5].

The sigmoid notch (SN) is the depression located between two skeletal units whose origins are secondary cartilages (condylar and coronoid cartilage) that appear on the ramus in the third month of intrauterine development[6]. They are called secondary because they appear at a later stage of development than the Meckel cartilage, and because their growth depends on the function[6]. The coronoid unit will develop based on the traction exercised by the tendon of the temporal muscle, whereas the condylar unit will do so based on the action of the lateral pterygoid muscle, which stimulates growth through the negative intraarticular pressure produced by suction and mandibular movements[5].

Thus, it can be deduced that, embryologically, the mandibular body forms, guided by the Meckel cartilage, from the mental foramen to the ML (posterior contour of the body) and the formation of the condylar cartilage are secondary, occupying the space from the ML to the glenoidal cavity of the temporal bone. In that way, the uppermost point of the condylar unit is the condylar head and its lowest point is the ML[7,8].

That is why it is proposed that the evaluation of the condylar unit ought to include the ML as it is the lowest part. The SN is the depression between two mandibular skeletal units (coronoids and condyle) and could be affected if either of these units presents with an alteration of any kind. Thus, it would not be stable when evaluating condyle length.

Unilateral condylar hyperplasia is a complex pathology that causes serious alterations to facial functions and esthetics. It typically presents itself as a progressive facial asymmetry more frequently in females[9]. The diagnosis is essentially linked to the clinical progression of the disease. Radiological studies and the analysis of mandibular length are crucial for planning an optimal treatment[10,11].

Nuclear medicine studies, such as scintigraphy, and single photon emission computed tomography (SPECT) studies are used for diagnostic confirmation of the increased metabolic activity at the condylar affected side. Through the administration of radiomedicine (technetium Tc 99), multiplanar (SPECT) images are produced that show the distribution of this radioactive compound in the patient.

The SPECT study consists of three phases: an angiographic phase, a tissular perfusion phase, and an osseous phase. This phase measures the degree of the existing metabolism and bone formation. The normal value (nonpathologic) is an average of 50% ± 5%.[2].

The purpose of this study is to determine, in patients with active unilateral condylar hyperplasia (AUCH), which are the most reliable points to measure the length of the condylar unit: from the SN or from the ML to the condylar head.

Materials and Methods

An observational cross-sectional study was designed to compare, with CBCT, the development of the ML and SN in patients with AUCH, and which of those are the most reliable to measure the condylar length.

All 20 patients included in this study were selected from Dr. Rodrigo Fariña's private practice and from Department of Maxillofacial Surgery, Hospital del Salvador, during 2013 to 2015.

All CBCT was performed at a private radiological center (Cimex) in the city of Santiago, Chile, between 2013 and 2015. The images were obtained using a Kodak 9500 Cone Beam 3D System (Carestream Health Inc, Rochester, NY) tomograph operating at 90 kV, 10 mA, with a 0.2-mm^3 voxel and a 9×15-cm field of vision (FOV). Volumetric reconstruction was calculated using the mathematical algorithms contained in the same company's software. The CBCT images were visualized using Kodak Dental Imaging Software 3D module version 2.4.

A cephalometric tracing of the mandibular ramus and condyle on both sides was done on the cone beam computed tomogram to determine their lengths according to a protocol established for this study (Fig. 1). All measurements were made by the same radiologist.

The inclusion criteria were AUCH (mixed with vertical and horizontal pattern) corroborated with positive bone scintigraphy findings for hyperplasia (hyperuptake of over 10% compared to healthy side in SPECT[2]), progressive mandibular asymmetry, with a facial midline that did not coincide with the lower dental midline and with center of the chin.

Patients with negative bone scintigraphy findings were excluded, as were patients with any other asymmetry that did not correspond to AUCH.

Variables in study included the following: ramus length on both sides (affected and healthy side); condylar length on both sides, measured from the ML; condylar
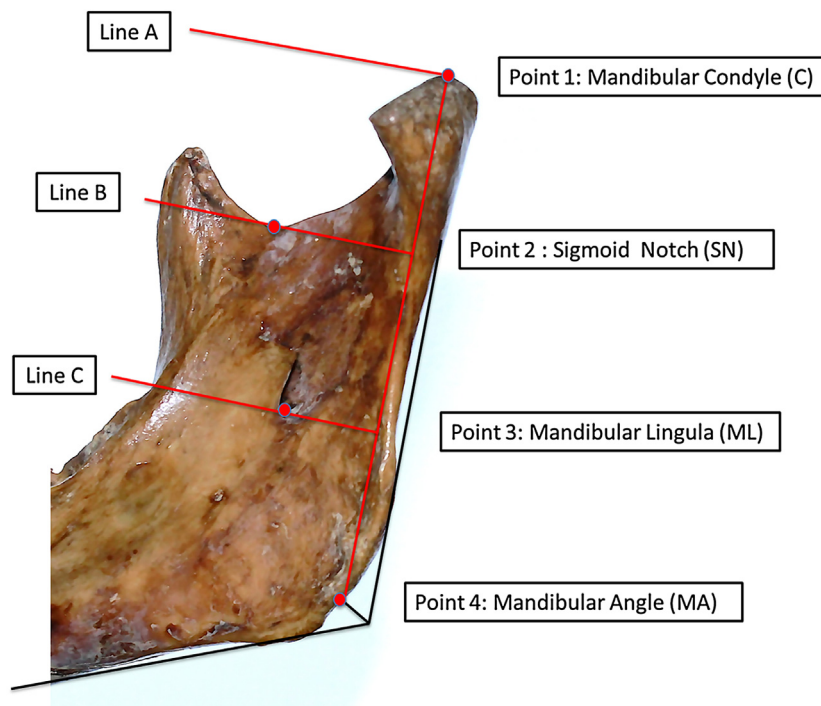

Fig. 1. Outline of the protocol for determining the length of the mandibular condyle. Point 1: upper point of mandibular condyle (C). Point 2: Sigmoid notch (lowest point of the depression in the sigmoid notch) (SN). Point 3: Base of the mandibular lingula (ML). Point 4: Mandibular angle (formed by the bisector of the parotid edge and the basilar edge) (MA). Line A: Line perpendicular to plane formed by points 1−4 at point 1 (condyle). Line B: Line perpendicular to plane formed by points 1−4 at point 2 (SN). Line C: Line perpendicular to plane formed by points 1−4 at point 3 (ML).

Fig. 2. Cephalometric points on cone beam computed tomography (CBCT).

length on both sides, measured from the mandibular SN.

A cephalometric tracing of the mandibular ramus and condyle on both sides was done on the CBCT to determine their lengths according to a protocol established for this study.

Cephalometric points and measurement protocol

The cephalometric points and measurement protocol (Figs. 1, 2) were as follows:

Point 1: Mandibular condyle (C): uppermost point of the mandibular condyle's convexity.

Point 2: Sigmoid notch (SN): lowest point of the sigmoidal notch's concavity.

Point 3: Mandibular lingula (ML): base of the mandibular lingula with relation to the mandibular foramen.

Point 4: Mandibular angle (MA): bisector formed by an angle of the tangent to the parotid edge and the tangent to the basilar edge.

With these four points identified, a connection plane is drawn from point 1 to point 4, which determines the length of the mandibular ramus. Then three lines are drawn perpendicularly to this plane, passing through points 1, 2, and 3, which are lines A, B, and C, respectively.

Once the four cephalometric points have been identified, the following measurements on both ramus sides were done and classified as the affected condyle (AC) and normal condyle (NC) measurements (Fig. 2).

- Ramus height: Distance from point C to MA
- Condylar height from SN: Distance from line C to SN

- Condylar height from ML: Distance from C to ML

The program Stata v 13.1 was used to analyze the results, applying a paired *t* test to compare results within a same group of patients. When more than two variables were compared, a Bonferroni-adjusted *P* value was used.

This study was approved by the Hospital del Salvador ethics board. Patient consent was not required.

Results

This research included 20 patients (15 females, 5 males) with an average age of 21.6 (standard deviation [SD] 5.71) years (Table 1).

The average of all the differences of ramus heights (D.1) was 7.97; the average of all the differences in condylar heights measured from ML (D.2) was 7.16 mm, and measured from the SN (D.3) was 4.89 mm (Table 2)

There was no significant difference between D.1 (difference between affected condyle from C to MA with normal condyle from C to MA) and D.2 (difference between affected condyle from C to ML with normal condyle from C to ML) (*P* = 0.818) (Table 3).

There was a significant difference between D.1 (difference between affected

Table 1. Distribution of study groups according to age and gender.

Gender	Average age (y)	Standard deviation	95% Confidence interval	*P*-value
Female (*n* = 15)	20.73	5.49	17.68–23.77	0.2507
Male (*n* = 5)	24.2	6.18	16.52–31.87	
Total (*n* = 20)	21.6	5.71		

Table 2. Patients with Active Unilateral Condylar Hyperplasia.

Patient	Age (y)	Gender	AC_MA	NC_MA	D.1	AC_ML	NC_ML	D.2	AC_SN	NC_SN	D.3
1	18	F	67.7	59.2	8.5	48.7	37.2	11.5	24.8	17.7	7.1
2	14	F	58.3	56.4	1.9	39.2	35.2	4	20.8	16.2	4.6
3	20	F	63.1	45.5	17.6	40.1	28.6	11.5	23.7	16.3	7.4
4	15	F	60	56.6	3.4	37.8	33	4.8	27.6	24.8	2.8
5	16	F	56.8	52.4	4.4	35.7	31.1	4.6	19.6	17.7	1.9
6	30	M	68.1	65.4	2.7	42.2	36.8	5.4	23.8	19.5	4.3
7	27	F	58.7	46	12.7	40.6	26.4	14.2	20.5	10.8	9.7
8	28	M	69.4	65.8	3.6	43.4	41.4	2	22	20.8	1.2
9	30	F	64	56.5	7.5	42.2	36	6.2	27	20.4	6.6
10	14	M	70.3	64.7	5.6	45.8	37.5	8.3	22.9	19.6	3.3
11	18	F	65	59.3	5.7	42.1	36.7	5.4	26.5	21.8	4.7
12	24	M	64.2	58.9	5.3	39.6	37.6	2	21.8	18.3	3.5
13	33	F	65.3	52.4	12.9	42.1	30	12.1	25.1	16.6	8.5
14	21	F	53.9	52.2	1.7	37.2	31.8	5.4	22.2	20.1	2.1
15	19	F	64.5	56.2	8.3	45.5	35.8	9.7	25.8	17.1	8.7
16	17	F	61.2	57.5	3.7	38.8	36.6	2.2	21.4	23.8	−2.4
17	24	F	68.7	54.3	14.4	41.6	33.4	8.2	24.6	19.8	4.8
18	19	F	58.3	41.6	16.7	37.7	26.2	11.5	18.9	12.9	6
19	25	M	65.7	53.5	12.2	43	34.3	8.7	23.9	16.8	7.1
20	20	F	55.9	45.4	10.5	34.8	29.3	5.5	22	16.2	5.8
X	21, 6				7.97			7.16			4.89

AC, affected condyle; F, female; M, male; MA, mandibular angle; ML, mandibular lingula; NC, normal condyle; SN, sigmoid notch. D.1, difference between AC to MA with NC to MA; D.2, difference between AC to ML with NC to ML; D.3, difference between AC to SN with NC to SN.

Table 3. Description of the average of differences in three variables, with confidence intervals and t- and *P*-values.

Variable	Mean difference	95% Confidence interval		Standard difference	t	df	Bonferroni adjusted *P*-Value
		Lower limit	Upper limit				
D1 D2	0.805	−2.297	0.687	3.187	−1.130	19.000	0.818
D1 D3	3.080	−4.843	−1.317	3.766	−3.658	19.000	0.005
D2 D3	2.275	−3.264	−1.286	2.112	−4.817	19.000	0.0005

condyle from C to MA with normal non-
dyle from C to MA) and D.3 (difference
between affected condyle from C to SN
with normal condyle from C to SN)
($P = 0.005$) (Table 3).

Finally, there was a significant differ-
ence between D.2 (difference between
affected condyle from C to ML with nor-
mal condyle from C to ML) and D.3
(difference between affected condyle from
C to SN with normal condyle from C to
SN) ($P = 0.0005$) (Table 3).

Discussion

The purpose of this study was to determine
how the condylar unit should be measured
in patients with AUCH.

CBCT is a means of radiographic ex-
amination that is used in various areas of
dentistry. It produces three-dimensional
high-definition and contrast images of
dental and maxillary structures. In addi-
tion, in evaluating the hard tissues of the
maxillofacial region, it is gradually repla-
cing medical helical computed tomogra-
phy because it produces images of
adequate quality that are associated with
low doses of radiation exposure[12–14].

You et al. and Park et al. reported that
the mandibular body begins at the mental
foramen and extends to the mandibular
foramen, which suggests that the start of
the condylar unit is from the ML to the
condylar head[7,8].

In this series of patients with AUCH, it
can be observed that, as in other publica-
tions, it was more frequent in females
(75%)[9–11]. In regard to average differ-
ences, there were no significant differ-
ences when comparing D1 with D2
($P = 0.818$). However, there was a signifi-
cant difference when comparing D1 with
D3 ($P = 0.005$) and also when comparing
D2 with D3 ($P = 0.0005$).

The changes in the length of condylar
unit on the affected side altered the posi-
tion of the SN, moving it to a more cranial
position; therefore, if the condylar unit is
measured using the SN in AUCH, it is
possible that no differences will be found
in length due to a change of position of the
SN, when there really is a difference[15,16].

Therefore, if the condylar unit is mea-
sured from SN in a patient with AUCH, it
could appear like a normal condyle be-

cause SN has moved upward, leading to an
incorrect diagnosis.

The ML is a reliable and easy point to
identify on panoramic radiographs; there-
fore it can be used with conventional
radiology also.

In summary, according to this research,
it can be concluded that the ML is the
lowest point of the condylar skeletal unit
and is therefore a stable parameter that is
useful for making measurements in
patients with condylar hyperplasia. Thus,
it ought to be considered as the reference
point for measuring condylar height, con-
tributing to diagnosis and the planning of
treatment. In contrast, the NS is not a
stable parameter in patients with asymme-
try due to condylar hyperplasia, so it can-
not be used to measure the condylar unit.

Funding

None

Competing Interests

None

Ethical Approval

This study was approved by the Hospital
del Salvador ethics board

Patient Consent

Not required

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