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Reliability of Two Techniques for Measuring Condylar Asymmetry with X-Rays

Confiabilidad de Dos Técnicas de Medición de Asimetría Condilar con Método Radiográfico

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SUMMARY: Among structural alterations that can be a risk factor for temporomandibular joint disorder (TMD) is condylar asymmetry. In order to measure the condylar asymmetry index in panoramic x-rays quantitatively, two methods have been proposed: those of Habets and Kjellberg. The aim of this study was to determine whether the x-ray method of measuring condylar asymmetries in orthopantomographies presents a minor tendency to error due to slight displacements of the head in the horizontal plane. 30 patients between 18 and 25 years of age were assessed. Each of them underwent three panoramic x-rays in three different positions: orthoradial, and at 5º and 10º horizontal angles. Then the Habets and Kjellberg measurements were taken. Habets' technique did not show any statistically significant differences in the x-rays at 5° and 10° horizontal angles compared to the 0º angle. However, Kjellberg's technique showed statistically significant differences only at the 10° angle compared to the 0º angle. The 10° changes produced linear and ratio variations, but the indices did not vary. It was concluded that both methods provide acceptable clinical information within the limitations of these techniques to obtain data on condylar symmetries or asymmetries of the mandibular body or ramus.

KEY WORDS: Temporomandibular joint; Mandibular condyle; Temporomandibular joint disorders; Facial asymmetry.

INTRODUCTION

Among the structural alterations that can be a risk factor for temporomandibular joint disorder (TMD) is condylar asymmetry (CA) (Silva & Fuentes, 2004). This is defined as the comparison of the vertical condylar height between the condyle on the right and left sides (Sağlam & Sanli, 2004).

Habets *et al.* (1988) reported a greater asymmetry of the vertical condylar height in patients with TMD compared with patients from an asymptomatic group. At the same time, Bezuur *et al*. (1988; 1989) have indicated that 74% of patients with TMD presented a vertical CA greater than 3%, which was in fact greater in patients with TMD of myogenic origin than in those of arthrogenic origin.

CA has been related to an overburdening of the joint surfaces, affecting the tissues that compose them, whether these are soft or hard (Sağlam & Sanli). This overburdening can trigger hyperactivity in the masticatory muscles, which in turn suggests that the pathology could degenerate into osteoarthritis (Sağlam & Sanli). Therefore, being able to detect it is of great importance. To this end, techniques to assess CA have been developed, some of which are based on standardised orthopantogram (OPG) measurements, given the relative simplicity of the technique and the low dose of radiation to which the patient is exposed (Kjellberg *et al.*, 1994).

In order to measure the CA index in OPG quantitatively, various techniques have been proposed, without a consensus to date regarding the reliability and usefulness of such techniques for measuring mandibular asymmetries by means of this type of imaging (Van Eslande *et al.*, 2008). Tronje *et al.* (1981) & Türp *et al*. (1996) differ in their use for measuring both horizontal and vertical dimensions of the condyles and ramus.

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Kambylafkas *et al*. (2006) found the OPG was not very sensitive in the diagnosis of asymmetries in the total mandibular height and a suitable specificity, suggesting OPG can be used to evaluate the posterior mandibular vertical asymmetry, but there may be some sub-diagnoses. It has been described that correctly positioning the head when taking the x-ray renders the reproducibility of the vertical measures and angles acceptable (Larheim *et al*., 1984; Larheim & Svanaes,1986). Welander *et al*. (1974) and Zach *et al*. (1969) have agreed that the magnification factor and radiographic distortion are generally lower in the vertical dimension than in the horizontal. Habets *et al*. describe a technique in OPG, which consists of a relation between the difference of the right and left condylar height with the sum of the right and left condylar height.

It is considered that an index of up to 3% is x-ray magnification; over 6% is considered to be asymmetry. Nevertheless, due to flaws in the projection and positioning, errors occur that do not permit reliable clinical predictions. Türp *et al*. concluded in a study in which the technique of Habets *et al.* was used that the validity of the OPG detection of vertical condylar or ramal asymmetries is low.

In search of a method to determine condylar height with fewer tendencies for the error produced by the variation in the head position in the horizontal plane, Kjellberg *et al*. propose another technique for measuring the condylar asymmetry index. This technique compares the ratios of the condylar height with the total mandibular height or condylar height with the mandibular ramus.

Both methods have been used in previous investigations, reporting variations in the tendency toward the error produced by the head position in the horizontal plane in the cephalostat (Larheim & Svanaes; Bumann & Lotzmann, 2000).

The OPG is the most used and beneficial complementary examination in dentistry. Given the relevance of the results of condylar asymmetry measurements to their application in clinical studies and diagnosis. It is therefore important to verify which of the techniques found in literature tends to show fewer errors resulting from variations up to 10º in the head position in the horizontal plane when taking the x-ray. Due to the fact that small areas of horizontal alignment cannot be excluded completely during OPG imaging, the aim of this study was to determine the influence of horizontal misalignment on the condylar asymmetry index calculated by using the methods of Habets *et al*. and Kjellberg *et al.*

MATERIAL AND METHOD

A cross-sectional study was conducted on a non-probability convenience sample of 30 young adults (12 men, 18 women) between 20 and 23 years of age, who previously signed the informed consent approved by the ethics committee. Three OPGs were taken of each individual in three different positions: orthoradial position (0°), at 5º and 10º horizontal angles. The x-rays were obtained at the Radiology Unit of the dental clinics (CODA) of the Universidad de La Frontera in Temuco, Chile. The orthopantomograph used was a BLUEX PantOs 16 (Assago, Italy, 2001), with a magnification index of 1.30. Konica Minolta (Medical Imaging U.S.A.) films, 15x30 cm in size were used. The radiation that a panoramic x-ray produces is 26 uSv, the equivalent of three retro-alveolar x-rays (White & Pharoah, 2002). The x-rays were taken by one of the unit specialists in radiology. In order to determine the angle in the head position, three positioners were used: two of these with a stop at incisor level with deviations of 5° to the right for one and 10° to the right for the other in relation to the incisal groove.

In each one of the three x-rays obtained from each patient, the condylar asymmetry index was measured with both techniques. This was done using an x-ray viewer, and the following contours were marked on transparent paper on the x-ray film with a pencil: mandibular line, angle, ramus and notch, and condylar process. The measurements were taken on this schematic according to the techniques of Habets *et al*. and Kjellberg *et al.*

Habets' technique. This consists of measuring the vertical height of the right and left condyles on the panoramic x-ray (Fig. 1). A tangent (A) is traced to the most lateral points of the ramus (O1) and the condyle (O2). Then a perpendicular (B) is traced to line A, tangential to the highest point of the condyle. The condylar height (CH) corresponds to the distance measured between the tangent (B) to the most lateral point of the condyle (O1), and the ramal height (RH) corresponds to the measurement that goes from the most lateral point of the ramus to the most lateral point of the condyle (distance between O1 and O2). Thus a condylar asymmetry index (AI) is proposed that is obtained by applying the following formula:

$$\text{Asymmetry index (AI)}_{\text{Habets}} = \frac{\text{right CH} - \text{left CH}}{\text{right CH} + \text{left CH}} \times 100$$

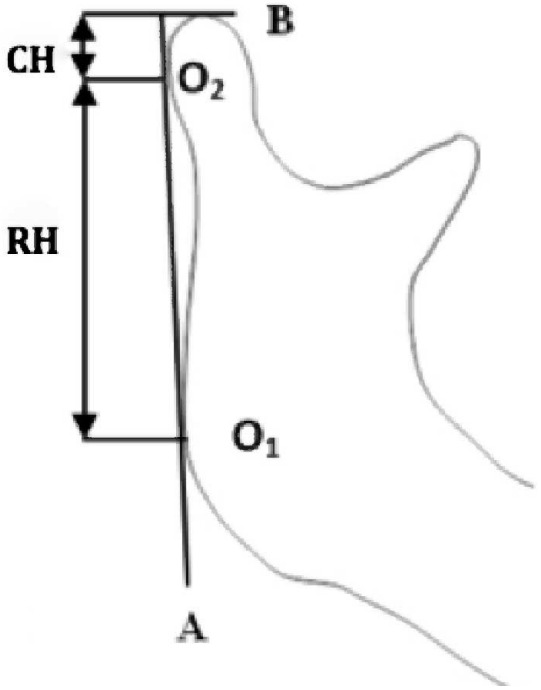

Fig. 1. Habets' technique.

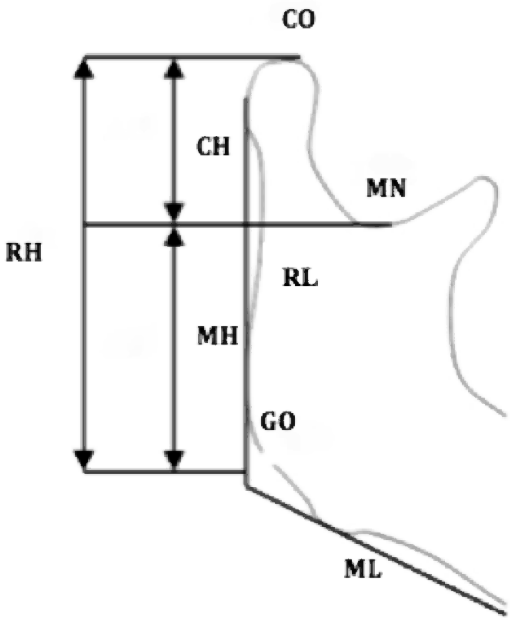

Fig. 2. Kjellberg's technique.

Kjellberg's technique. This technique (Fig. 2) uses the following points of reference: CO (the highest point of the condylar head), MN (mandibular notch, the deepest point between the coronoid process and the condylar process), GO (gonion), the intersection between the ramal line (RL) and the mandibular line (ML) that is tangential to the mandibular margin, RL (tangential to the most posterior points of the condylar process and mandibular angle). These points are transferred to the ramal line (RL) to calculate these measurements in the vertical dimension, thereby defining the condylar height (CH) as the distance that goes from CO to MN measured above the RL, the mandibular height (MH) as the distance between MN and GO, and the ramal height (RH) as the distance that goes from CO to GO. Condylar height is defined relative to the CH/RH ratio. Comparing the quotients from both sides contributes information on the relation of symmetries, instead of a linear measurement to avoid considering the magnification differences. Where A < B is always considered on the same individual, calculated on the same side (right or left) to then establish the comparisons of one side with the other and thereby ascertain the degree symmetry or asymmetry.

Formula for calculating condylar symmetry according to Kjellberg *et al.*

$$\text{Kjellberg Symmetry Index (SI)} = \frac{\left(\frac{CH}{RH_A}\right)}{\left(\frac{CH}{RH_B}\right)} \times 100$$

The methodology used for the investigation was reviewed and approved by the Ethics Committee of the Faculty of Medicine of the Universidad de La Frontera, Temuco, Chile.

A descriptive analysis was performed through averages, standard deviation, minimum and maximum and percentages. For the comparison of the measurements being studied with both techniques at the different angles, a repeated measures regression model (generalized estimating equations (GEE)) was used. The level of significance used was 5%.

RESULTS

The measurements were taken in 30 patients in the three positions: 0°, 5° and 10° degrees in the horizontal plane to the right in relation to the true vertical.

When comparing Habets' measurements in all the patients stratified by sex on the right and left side (right condylar height (RCH) and left condylar height (LCH)), no statistically significant differences were observed when the 0° and 5° angles were compared. By contrast, significant differences were found in all the patients at 0° and 10° only in RCH, the variation being greater at 10°; when stratifying

Table I. Condylar height according to Habets at different head positions.

	Habets measurements			p	
	0°	5°	10°	0° and 5°	0° and 10°
RCH	$\bar{x} \pm sd$	$\bar{x} \pm sd$	$\bar{x} \pm sd$		
Male	7.73±2.03	8.08±1.76	8.71±3.78	0.5915	0.2642
Female	7.92±2.68	8.14±2.41	9.16±3.11	0.5399	0.0094*
Total	7.84±2.41	8.12±2.14	8.98±3.34	0.4218	0.0124*
LCH					
Male	8.20±1.78	9.08±3.07	8.85±2.03	0.2282	0.3551
Female	7.38±2.04	7.93±2.04	7.76±2.07	0.2433	0.3456
Total	7.71±1.95	8.39±2.52	8.20±2.09	0.0943	0.1890

Repeated measures regression model (GEE).

by sex, the significant difference was in women, the variation being greater at 10° (Table I).

When analyzing the individual differences in the measurements on the right and left sides, Table II shows an increase in these at different angles, with only the difference on the right side at 0° and 10° being significant.

The average Habets asymmetry index did not present any variations in the different angles studied, either in the total or stratified by sex (p>0.05) (Table III); however, it did present a wide dispersion. When comparing the individual differences of these measurements at the different angles of the head, an increase at 5° and 10° is observed, but is not statistically significant (Table IV).

Table II. Differences in condylar height according to Habets at different head positions.

Differences	Positive	Negative	Zero	p
RCH				
0° - 5°	11	18	1	0.4973
0° - 10°	12	18	0	0.0449*
LCH				
0° - 5°	10	20	0	0.0978
0° - 10°	12	18	0	0.3820

Wilcoxon signed-rank test.

Table III. Condylar asymmetry index (CAI) according to Habets at different head positions.

	Different head positions			p	
	0°	5°	10°		
CAI Habets	$\bar{x} \pm sd$	$\bar{x} \pm sd$	$\bar{x} \pm sd$	0° and 5°	0° and 10°
Male	-3.36±17.88	-3.99±21.70	3.06±19.18	0.9088	0.9537
Female	2.33±17.20	0.64±15.46	6.93±14.59	0.6869	0.2550
Total	0.057±17.40	-1.21±18.00	2.93±17.01	0.7052	0.3695

Repeated measures regression model.

Table IV. Differences in the Asymmetry Index (AI) according to Habets at different head positions.

Differences	Positive	Negative	Zero	p
0° - 5°	12	18	0	0.8855
0° - 10°	12	18	0	0.3493

Wilcoxon signed-rank test.

When analyzing the measurements RCH, LCH, RRH (right ramal height), and LRH (left ramal height) in all the patients at the different angles of the head according to Kjellberg, no statistically significant differences were observed. When stratifying by sex, significant differences were observed in the men at the 0° and 5° angles in the LRH measurement. No significant differences were found in women (Table V).

The analysis of the differences in the measurements on the right and left sides of the condylar and ramal height are shown in Table 6, where the differences in the RCH were significant when the 0º and 5º angles and the 0º and 10º angles were compared. When comparing the differences in the ramal height significant differences were found when the 0º and 10º angles on the right side were compared (Table VI).

Kjellberg's average symmetry index did not present any variations in the total number of people at the different angles studied (p>0.05); when stratifying by gender only differences were found in men and at the 0° and 5° angles, with an increase being observed in the index at 5° (Table VII). The individual differences in this index show a decrease at 5° and 10°, but like the average, these are not statistically significant (Table VIII).

Table V. Condylar and ramal height (mm) according to Kjellberg *et al.* at different head positions.

	Different head positions			p	
	0°	5°	10°	0° and 5°	0° and 10°
RCH	$\bar{x} \pm sd$	$\bar{x} \pm sd$	$\bar{x} \pm sd$		
Male	22.33±3.25	22.87±2.94	22.47±3.24	0.0546	0.7466
Female	23.20±3.60	23.91±3.58	24.14±3.70	0.2987	0.1261
Total	22.85±3.43	23.49±3.32	23.47±3.56	0.1314	0.1329
LCH					
Male	23.34±3.08	|22.60±2.75	23.43±3.38	0.0971	0.8908
Female	22.74±3.38	22.39±4.34	23.24±2.79	0.7223	0.3266
Total	22.98±3.22	22.47±3.73	23.32±2.98	0.4191	0.4080
RRH					
Male	79.70±5.31	79.95±5.51	79.88±7.21	0.4441	0.8769
Female	71.11±5.84	70.17±6.97	72.54±7.57	0.3266	0.0657
Total	74.55±7.00	74.08±7.99	75.47±8.17	0.4354	0.1639
LRH					
Male	78.50±6.34	77.72±5.88	76.77±6.95	0.0057*	0.0831
Female	70.30±7.21	68.69±7.19	69.47±7.70	0.2475	0.3423
Total	73.58±7.90	72.30±7.98	72.39±8.15	0.1315	0.0730

Repeated measures regression model.

Table VI. Condylar and ramal height (mm) according to Kjellberg *et al.* at different head positions.

Differences	Positive	Negative	Zero	p
RCH				
0° - 5°	10	20	0	0.0175*
0° - 10°	8	22	0	0.0087*
LCH				
0° - 5°	19	11	0	0.1588
0° - 10°	12	18	0	0.5786
RRH				
0° - 5°	13	17	0	0.4528
0° - 10°	7	23	0	0,0117*
LRH				
0° - 5°	21	9	0	0.0545
0° - 10°	20	10	0	0.0822

Wilcoxon signed-rank test.

Table VII. Condylar symmetry index (CSI) according to Kjellberg at different head positions.

	Different head positions			p	
	0°	5°	10°	0° and 5°	0° and10°
CSI Kjellberg	$\bar{x} \pm sd$	$\bar{x} \pm sd$	$\bar{x} \pm sd$		
Male	91.31±7.21	96.15±3.74	90.67±8.17	0.0238*	0.6959
Female	92.63±6.62	86.80±13.47	92.94±7.25	0.0913	0.8163
Total	92.10±6.77	90.54±11.55	92.03±7.58	0.5213	0.9453

Table VIII. Differences in the condylar symmetry index (CSI) according to Kjellberg at different head positions.

Differences	Positive	Negative	Zero	p
0° - 5°	15	13	2	0.8693
0° - 10°	14	13	3	0.8450

Wilcoxon signed-rank test.

DISCUSSION

Condylar asymmetry has been widely used to complement clinical diagnostic tests in patients with TMD (Miller & Bodner, 1997; Miller *et al*., 1998; Sag˘lam, 2003). However, there is currently no consensus with respect to the reliability and utility of the different techniques used to measure mandibular asymmetries (Van Eslande *et al.*, 2008). Tronje *et al*. and Lahreim & Svanaes mention that panoramic x-rays serve to evaluate vertical and non-horizontal measurements as long as the patient is correctly positioned. On this basis, one can see that, in the linear measurements of all the patients studied according to the method of Habets *et al*. (Table I), significant differences were found only in the women when the position of 0º and 10º was compared in the RCH, with the variation of the position defined in the study being to the right. The coincidence in most of the linear measurements is consistent with what has been proposed by Lahreim & Svanaes, who mention that the vertical linear measurements of the panoramic x-rays are reproducible. In the individual differences of the measurements when comparing the different positions of the head, both to the right and left according to the method of Habets *et al.* (Table II), significant differences were observed only on the right side between 0º and 10º. The condylar asymmetry indices according to the method of Habets *et al*. (Tables III and IV) found no significant differences between the different positions of the head. This differs to what was reported by Bumann & Lotzmann, who suggest that it is possible to find differences in the results when the head position is modified. Nevertheless, it must be stressed that a wide disparity was observed in the sample values, suggesting that when it is applied, there may be individual values that give false positives that produce an erroneous diagnosis. This is consistent with Turp *et al.*, who conclude a decreased validity in the detection of vertical condylar or ramal asymmetries in OPGs using the technique of Habets *et al.*

In the linear measurements of the ramal height and condylar height observed in all the patients studied with different head positions facing right as per the method of Kjellberg *et al.* (Table V), significant differences were found only in the men between the 0º and 5º angles of the ramal height on the left side. No significant differences were observed in the women. This tallies with Lahreim & Svanaes in relation to the reproducibility of the vertical linear measurements in panoramic x-rays. With regard to the values observed when comparing the different head positions in the Wilcoxon signed-rank test using the measurements of Kjellberg *et al*. (Table VI), significant differences were found only on the right side, which were detected when comparing the condylar height of the right side between 0º and 5º and 0º and 10º, and when comparing the ramal height between 0º and 10º. The symmetry index of Kjellberg *et al*. presented a narrower disparity in the results than the index of Habets *et al*. When comparing the index between 0º and 5º in the men, statistically significant differences were found, but that difference tended towards symmetry. It is important to stress that, although both methods have been analyzed in previous investigations reporting that errors in the head position in the horizontal plane in the cephalostat would generate variations in the results of the indices (Larheim & Svanaes; Bumann & Lotzmann), the general results observed in this study, when varying at 5º and 10º, show that the linear variations do not influence the results of the indices to any great extent, that the variation found in the index of Kjellberg *et al*., tends towards symmetry and the wider disparity in the values of the indices is in the technique of Habets *et al*.

In conclusions, Kjellberg's technique is easier in terms of identifying the points and measurements and compares both sides based on the CH/RH ratio.

Both techniques show that slight alterations in the position of the head can produce variations in the linear dimensions measured.

In Habets' index there is no variation in the three head positions, but it shows a wide disparity which could lead to false positives.

In Kjellberg's index, the given values show only one difference (Male 0º- 5º), but tends toward symmetry. In addition, the results have a narrower disparity, decreasing the possibility of false positives, which leads to the suggestion that Kjellberg's technique is to be recommended, considering the limitations discussed.

FUENTES, R.; ENGELKE, W.; BUSTOS, L.; OPORTO, G.; BORIE, E.; SANDOVAL, P.; GARAY, I.; BIZAMA, M. & BORQUEZ, P. Confiabilidad de dos técnicas de medición de asimetría condilar con método radiográfico. ***Int. J. Morphol., 29(3)***:694-701, 2011.

RESUMEN: Dentro de las alteraciones estructurales que pueden ser un factor de riesgo de desarrollo de un trastorno temporomandibular (TTM) se menciona a la asimetría condilar. Para realizar la medición cuantitativa del índice de asimetría condilar en radiografías panorámicas se han propuesto dos métodos, Habets y Kjellberg. El objetivo de este estudio fue determinar si el método radiográfico de medición de asimetrías condilares en ortopantomografías que presenta menor tendencia al error por leves desplazamientos de la cabeza en el plano horizontal. Se evaluaron 30 pacientes entre 18 y 25 años de edad. Cada uno de ellos se sometió a tres radiografías panorámicas en tres posiciones distintas: posición ortoradia, 5º y 10º de angulación horizontal. Posteriormente, se realizaron las mediciones de Habets y Kjellberg. La técnica de Habets no mostró diferencias estadísticamente significativas en las radiografías con 5° y 10° de angulación horizontal con respecto al ángulo de 0º. Sin embargo, la técnica de Kjellberg mostró diferencias estadísticamente significativas sólo al ángulo de 10° con respecto al ángulo de 0º. Las alteraciones de 10° produjeron variaciones lineales y de razones, sin embargo no variaron los índices. Se concluye que ambos métodos entregan información clínica aceptable con las limitaciones que estas técnicas tienen para obtener información sobre simetrías o asimetrías condilares de cuerpo o de rama.

PALABRAS CLAVE: Articulación temporomandibular; Cóndilo mandibular; Trastornos temporomandibulares; Asimetría facial.

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