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Can We Use the Contralateral Glenoid Cavity as a Reference for the Measurement of Glenoid Cavity Bone Loss in Anterior Shoulder Instability?. A Comparative Analysis of 3D CT Measurements in Healthy Subjects

¿Podemos utilizar la Cavidad Glenoidea Contralateral como Referencia para la Medición de la Pérdida Ósea de la Cavidad Glenoidea en la Inestabilidad del Hombro Anterior?. Un Análisis Comparativo de Mediciones 3D TC en Sujetos Sanos

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KOSE, O.; CANBORA, M. K.; KOSEOGLU, H.; KILICOGLU, G.; TURAN, A.; YUKSEL, Y. & ACAR, B. Can we use the contralateral glenoid cavity as a reference for the measurement of glenoid cavity bone loss in anterior shoulder instability?. A comparative analysis of 3D CT measurements in healthy subjects. *Int. J. Morphol., 36(4)*:1202-1205, 2018.

SUMMARY: The purpose of this study was to compare the glenoid cavity measurements in healthy subjects. 100 adult subjects without shoulder pathology who had pulmonary computed tomography for any reason, were included in the study. Lung CT images were three-dimensionally rendered and glenoid cavity enface images were obtained. On these images, the glenoid cavity superior-inferior long axis and anterior-posterior equator, as well as the equatorial anterior and posterior radii, were measured. Dominant and non-dominant glenoid cavity measurements were compared using the t-test in dependent groups. The long axis of the dominant glenoid cavity was 38.15 ± 3.5 mm, whereas it was 37.87 ± 3.3 mm on the non-dominant side ($p = 0.068$). The mean width of the glenoid cavity was 28.60 ± 3.3 mm in dominant glenoids cavities and 28.00 ± 2.9 mm in the non-dominant side ($p = 0.0001$). The equatorial anterior and posterior radii were significantly different between the two sides ($p = 0.010$, $p = 0.001$, respectively). The ratio of length to equator was different between the two sides ($p = 0.012$). The difference in equatorial lengths was 0.98 ± 0.8 mm (range, 0-4.2 mm). The mean difference between the long axis of the glenoid cavity was 1.2 ± 0.9 mm (range 0-4.6 mm). The equator on 69 individuals was larger on the dominant side. Glenoid cavity long axis was larger on the dominant side of 61 individuals. Glenoids cavities are not equal and not symmetrical to each other or influenced by hand dominancy. Measurements based on the assumption that both glenoids cavities are equal may be misleading.

KEY WORDS: Anterior shoulder dislocation, Shoulder instability; Bone loss; Surgery.

INTRODUCTION

Anterior shoulder dislocation is the most common joint dislocation that may result in shoulder instability and recurrent dislocations (Wasserstein *et al*., 2016). Anterior shoulder dislocations not only lead to soft tissue injuries such as labrum, joint capsule and rotator cuff tears, but also sometimes to glenoid cavity bone losses. In particular, in patients presenting with chronic recurrent dislocation, there is a higher possibility of bone loss. In a study by Griffith *et al*. (2008), 41 % bone loss was determined after the first shoulder dislocation and 86 % after recurrent dislocations.

Surgical management of anterior shoulder instability can be performed primarily with two methods. The first method is to perform soft tissue repair only and the other is reconstruction of the glenoid cavity bone loss (if present). When deciding on anterior instability surgery and in the selection of the most appropriate surgical method for each individual patient, prior knowledge of the glenoid cavity bone loss and measurements are vitally important (Garcia *et al*., 2015). It has been reported that in repairs directed only at the soft tissues, ignoring the bone loss, failure rates are high (Burkhart *et al*., 2000).

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Although there are different views on the threshold amount of bone loss to switch from soft tissue procedures to bone reconstructions, it is widely accepted that glenoid cavity bone loss should be addressed in case of >20 % loss on the glenoid cavity joint surface (Mologne *et al*., 2007; Provencher *et al*., 2010). Various methods have been reported for the measurement of glenoid cavity bone loss. Some of these methods assume that both glenoids cavities are exactly equal like mirror images of each other, thus calculations of the bone loss are based on the comparative measurements of the healthy glenoid cavity (Provencher *et al*.).

The hypothesis of this study was that the two glenoid cavities joint surfaces are not equal. The aim of the study was to compare the measurements of glenoid cavity joint surfaces in healthy subjects and to determine whether or not the contralateral side can be used as reference for the injured glenoid cavity bone.

MATERIAL AND METHOD

A retrospective review was performed on adult patients (>18 years) whom multi-slice pulmonary computed tomography (CT) were taken between January 2017 and June 2017 for any reason from the picture archiving and communication systems (PACS). A total of 100 patients, comprising 50 males and 50 females, were randomly selected for inclusion in the study. All these selected patients were contacted by telephone and were requested to complete a questionnaire about the demographic data of the patients, age, gender and dominant side. Any patients with a previous shoulder fracture or dislocation, a history of previous shoulder surgery, or congenital malformation that could affect glenoid cavity measurements, were excluded from the study. Approval for the study was granted by the Local Ethics Committee and it was conducted in accordance with the principles of the Declaration of Helsinki.

3-Dimensional CT measurements. Radiological measurements were made by rendering the multi-slice helical pulmonary CT images into 3D format. All the measurements were performed twice by the same investigator and the average value was used in the final analysis. On the '3D enface' images of the glenoidcavity, the glenoid cavity superior-inferior length (12 o'clock – 6 o'clock) was measured. The glenoid cavity anterior-posterior equator (the widest diameter) was measured. The point at which the superior-inferior length crossed the equatorial plane was accepted as the center. The equatorial anterior and posterior radii were measured again (Fig. 1). The measurements of the dominant and non-dominant side were recorded separately (Fig. 2).

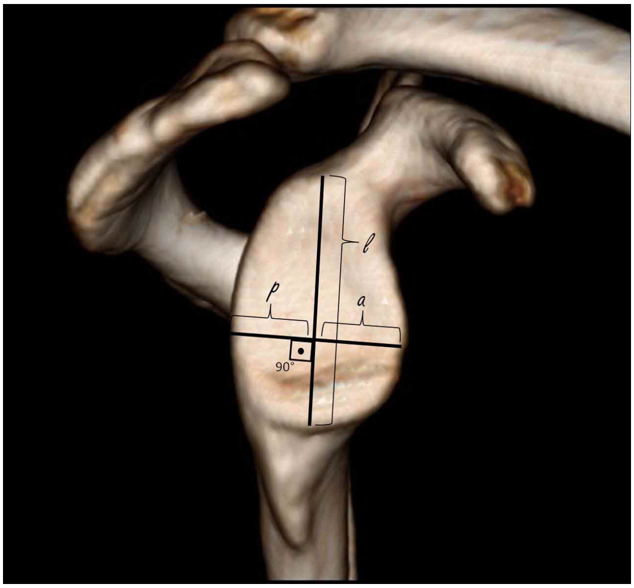

Fig. 1. Glenoid 3D Enface Image. The glenoid superior-inferior length is indicated by the letter 'l'. The glenoid equator was drawn as the widest edge vertical to the glenoid long axis. The radius remaining behind the equator is indicated by the letter 'p' (posterior) and the area in front with the letter 'a' (anterior).

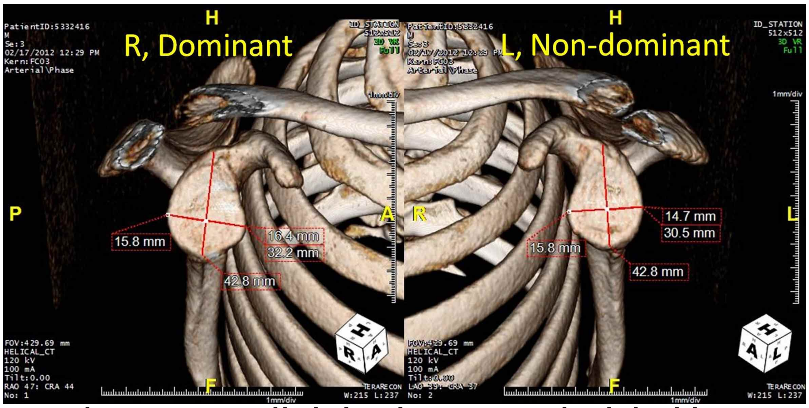

Fig. 2. The measurements of both glenoids in a patient with right-hand dominance.

Statistical analysis. Continuous and categorical data were presented with descriptive statistics as mean ± standard deviation (SD), range, and frequency and percentage values. Continuous variables in dependent groups were analyzed using the t-test. A value of $p<0.05$ was accepted as statistically significant.

RESULTS

The measurements were performed on a total of 100 subjects (50 males, and 50 females) with a mean age of 47.11±15.22 years (range, 18-83 years). The right side was determined as dominant in 81 subjects. Analysis was made as a comparison of the dominant and non-dominant sides. The mean length of the long axis of the glenoid cavity was determined as 38.15±3.5 mm on the dominant side and 37.87±3.3 mm on the non-dominant side (p = 0.068). The mean width of the glenoid cavity (equator) was measured as 28.60±3.3 mm on the dominant side and as 28.00±2.9 mm on the non-dominant side (p = 0.0001). A statistically significant difference was determined between the two sides in respect of the anterior and posterior radii of the equator (p=0.010, p=0.001, respectively). The length-equator ratio was significantly different between the two sides (p=0.12). The mean difference between the equator lengths was 0.98 ± 0.8 mm (range, 0-4.2 mm). The mean difference between the glenoid cavity long axis of both sides was 1.2±0.9 mm (range, 0-4.6 mm). The equator was found to be larger on the dominant side in 69 subjects. The glenoid cavity long axis was found to be larger on the dominant side in 61 subjects. All the glenoid cavity measurements are presented in Table I.

DISCUSSION

This study examined whether or not glenoid cavity dimensions were equal in healthy individuals and whether or not these dimensions varied in accordance to hand dominancy. Results of this study demonstrated a significant difference in the dimensions of the paired glenoids cavities in each individual. Although the glenoid cavity long axes were similar, transverse axes, in other words equator of the glenoid cavity, and anterior and posterior radii were significantly different. These differences reached up to 4.6 mm in the long axis and 4.2 mm in the maximum width. Glenoid cavity bone loss measurements based on the assumption of equality of both glenoids cavities may be misleading, and the hand dominancy should be taken into consideration.

In the radiological calculation of glenoid cavity bone loss, various imaging methods can be used. At initial evaluation, usually plain shoulder radiographs are ordered as they are inexpensive and readily available. The West Point radiograph is a variation of a shoulder axillary radiograph and is useful in the evaluation of bone loss as there is a projection in the anterior-posterior plane of the glenoid cavity joint surface (Rokous *et al*., 1972). However, even if an appropriate technique is used, it is insufficient for the quantitative evaluation of the amount of glenoid cavity bone loss. It has been shown that mathematical calculation of glenoid cavity bone loss which reflects the reality can be performed on 3D enface images (Kwon *et al*., 2005).

As the glenoid cavity joint surface resembles a pear shape, measurement is extremely difficult. However, in a cadaver study by Huysmans *et al*. (2006), it was suggested that the glenoid cavity inferior surface is a complete circle. From this starting point, Baudi *et al*. (2005) developed a method, which they named "Pico", in honor of the Italian philosopher, Pico della Mirandola. In this method, the lost surface area is calculated by superimposing the 2D image of the healthy side glenoid cavity on to the image of the injured side. As this method is made on 2D cross-sectional images, if the images have not been taken correctly, they can give incorrect results. Chuang *et al*. (2008) modified this method by applying it on 3D enface images. The Pico method applied on 3D images is currently accepted as the gold standard. However, in all these methods, the appearance of both glenoids cavities is accepted as the same. The healthy side is used as the reference in the calculation of bone loss. The results obtained in the current study are in conflict with this accepted concept.

This study had some limitations and some strong aspects. Pulmonary CT was used to create the shoulder 3D enface images instead of specific shoulder CT. However, both shoulders are taken at the same time in a single CT image; thus measurements were not affected by magnification. As the patients were not examined personally but were only scanned on the basis of a telephone enquiry,

Table I. A summary of all the measurements and comparisons.

	Dominant side	*Non-dominant side*	*P value*
lenoid long axis(mm ± SD)	38.15±3.5	37.87±3.3	*0.068*
quator (mm ± SD)	28.60±3.3	28.00±2.9	*0.0001*
quator anterior radius (mm ± SD)	14.07±1.5	14.32±1.5	*0.010*
quator posterior radius (mm ± SD)	14.39±1.6	13.67±1.6	*0.001*
ɔng axis-equator ratio	1.3±0.08	1.35±0.07	*0.012*

there were doubts that they were completely healthy in respect of the shoulder. Another limitation of the study could be considered to be the low number of patients. Finally, as the measurements were made by a single person, there could have been mistakes made, but to minimize potential errors, the measurements were taken twice and the average was used in the analysis.

In conclusion, the results of this study demonstrated that both glenoids cavities are not completely equal and symmetrical. Glenoid cavity size is affected by hand dominance. In bone loss measurements made assuming that both glenoids cavities are equal, there may be mistakes. There is a need for the development of methods not only of glenoid cavity bone loss, but also of the relationship of the humeral head and glenoid cavity joint surface, which could contribute to the calculation in the radiological evaluation of glenohumeral stability.

KOSE, O.; CANBORA, M. K.; KOSEOGLU, H.; KILICOGLU, G.; TURAN, A.; YUKSEL, Y. & ACAR, B. ¿Podemos utilizar la cavidad glenoidea contralateral como referencia para la medición de la pérdida ósea de la cavidad glenoidea en la inestabilidad del hombro anterior?. Un análisis comparativo de mediciones 3D TC en sujetos sanos. *Int. J. Morphol., 36(4)*:1202-1205, 2018.

RESUMEN: El propósito de este estudio fue comparar las mediciones de las cavidades glenoideas en sujetos sanos. Se incluyeron en el estudio 100 sujetos adultos sin patología de hombro que tenían tomografía computarizada pulmonar. Las imágenes de CT de pulmón se representaron tridimensionalmente y se obtuvieron imágenes de la faceta de la cavidad glenoidea. En estas imágenes, se midieron el eje largo glenoideo superior e inferior y el ecuador anteroposterior, así como los radios ecuatoriales anterior y posterior. Las mediciones de las cavidades glenoideas dominantes y no dominantes se compararon usando la prueba t en grupos dependientes. El eje largo de la cavidad glenoidea dominante fue 38,15 ± 3,5 mm, mientras que fue 37,87 ± 3,3 mm en el lado no dominante (p = 0,068). El ancho medio de la cavidad glenoidea fue de 28,60 ± 3,3 mm en las glenoides dominantes y de 28,00 ± 2,9 mm en el lado no dominante (p=0,0001). Los radios ecuatoriales anterior y posterior fueron significativamente diferentes entre los dos lados (p=0,010; p=0,001, respectivamente). La relación de longitud al ecuador fue diferente entre los dos lados (p=0,012). La diferencia en las longitudes ecuatoriales fue de 0,98 ± 0,8 mm (rango, 0-4,2 mm). La diferencia media entre el eje largo de la cavidad glenoidea fue de 1,2 ± 0,9 mm (rango 0-4,6 mm). El ecuador en 69 individuos era más grande en el lado dominante. En 61 individuos el eje largo de cavidad glenoidea fue más grande en el lado dominante . Las cavidad glenoideas no son iguales ni simétricas entre sí ni están influenciadas por la dominancia de la mano. Las mediciones basadas en la suposición de que ambas cavidades glenoideas son iguales pueden ser engañosas.

PALABRAS CLAVE: Dislocación del hombro anterior; Inestabilidad del hombro; Pérdida de hueso; Cirugía.

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