Original Research Article

A CT scan anatomical study correlating between the retroversion of the humeral head and the orientation of the inter-tubercular sulcus

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Abstract

The shoulder socket is called the *glenoid fossa*. This socket is shallow and is part of the *scapula* (shoulder blade). The surface of the humeral head and the inside of the fossa are covered with *articular cartilage*. The glenohumeral joint consists of an articulation between the scapula and humerus. Retroversion angle of humeral head (or retrotorsion angle, RA) is an important parameter in total shoulder arthroplasty and is one of these important reference factors which can influence the outcomes of total shoulder arthroplasty. This study was undertaken to evaluate the correlation between retroversion angle of humeral head and position of intertubercular sulcus. The present study is a prospective one which was conducted in the Department of Radiodiagnosis and Imaging at Government Medical College and Hospital, Srinagar. The 60 dry adult humeri were analyzed by multiplanar computed tomography (CT). CT data were transferred to a workstation (Silicon Grafics; Sunnyvale, CA) for multiplanar CT-reformation. The mean retroversion angle of the humeral head in relation of the transe-picondylar axis was 12.3 degree. The mean ITS orientation was 40.7 degree. The Pearson correlation coefficient between the retroversion of the humeral head and the ITS orientation was -0.37. There was an inverse correlation between the retroversion of the humeral head and the ITS orientation. This variation is due to several factors, including the definition of humeral head retroversion, different methods of measurement, ranges of normal values, and accuracy of anatomic landmarks to guide determination of anatomic retroversion. Humeral head retroversion is generally defined with respect to the plane of the humeral head articular surface proximally; distally, however,

the reference axis has been debated, including the transepicondylar axis, trochlear tangent axis and forearm axis. The study concludes that there is a reverse correlation between the retroversion of the humeral head and the orientation of the intertubercular sulcus.

Key words

CT scan, Anatomical study, Retroversion, Humeral head, Inter-tubercular sulcus.

Introduction

Shoulder motion requires the coordinated effort of muscles, tendons, ligaments, and bones primarily across the glenohumeral joint and scapulothoracic articulation. The shoulder joint is a ball-and-socket joint. The ball portion of the joint is called the *humeral head*. The humeral head is the uppermost part of the humerus, or upper arm bone. The shoulder socket is called the *glenoid fossa*. This socket is shallow and is part of the *scapula* (shoulder blade). The surface of the humeral head and the inside of the fossa are covered with *articular cartilage*. The glenohumeral joint consists of an articulation between the scapula and humerus [1]. The humeral head lies within the glenoid fossa, a cavity that is lined by the glenoid labrum. The shallow nature of the glenoid fossa lends the glenohumeral joint an increased range of motion while providing little stability. Articular cartilage is a tough, slick material that allows the surfaces to slide against one another with very little friction. The cartilage is about one-quarter of an inch thick in most large weight-bearing joints, but a bit thinner in the shoulder, which normally doesn't support much weight. This anatomy of the proximal head of the humerus has been described in numerous studies [1].

Retroversion angle of humeral head (or retrotorsion angle, RA) is an important parameter in total shoulder arthroplasty [2] and is one of these important reference factors which can influence the outcomes of total shoulder arthroplasty [3]. The retroversion of the humeral head and the orientation of the intertubercular sulcus are two bony features of the proximal humerus that may be considered in the pathogenesis of chronic anterior shoulder instability [4, 5]. The aim of our work was to add possibly critical information to the knowledge on humeral head anatomy, which might help in orthopedic surgery. In addition to addressing methodological issues such as how to determine the retroversion of the humeral head by CT scan, we propose new, practically relevant measures such as the orientation of the intertubercular sulcus, using an easy method. This study was undertaken to evaluate the correlation between retroversion angle of humeral head and position of intertubercular sulcus.

Materials and methods

The present study was a prospective one which was conducted in the Department of Radiodiagnosis and Imaging at Government Medical College and Hospital, Srinagar from January 2017 to January 2018. The study was done on dry humeri which were collected from various museums and other places in college.

60 dried adult humeral specimens (intact specimen, no fractures and pathological damage), of these, left lateral in 10 cases, right lateral in 10 cases, male or female all inclusive, specimens. The 60 dry adult humeri were analyzed by multiplanar computed tomography (CT). CT data were transferred to a workstation (Silicon Grafics; Sunnyvale, CA) for multiplanar CT-reformation. The measurements obtained by CT-reformation were recorded by an independent radiologist. The following way was used for collection of data, the humeral head axis was defined as that perpendicular to the anatomical neck taken to the periphery of the articular cartilage. However, this study was performed on dry bones so subchondral plate was used instead of the articular cartilage as the landmark. The subchondral bone plate which consists of two mineralized layers, which together form a single

unit separating the articular cartilage from the bone marrow [6]. There is a discrete band of mineralized cartilage on the articular side of the plate of the line of contact between plate and cartilage, which is well visualized on CT scan. The transepicondylar axis was defined by a line joining the most medial and the most lateral extremities of the distal humerus. The angle of humeral retroversion is the angle between the humeral head axis and the transepicondylar axis. We measured the ITS width on a horizontal CT-reformation in a plane passing by the greater and lesser tubercles and the intertubercular sulcus. The line perpendicular at the intertubercular line is the ITS axis. Intertubercular sulcus orientation was defined by the angle between the intertubercular sulcus axis and the humeral head axis. The correlation between humeral head retroversion and the intertubercular sulcus orientation was analyzed using Pearson correlation coefficient.

Statistical analysis was conducted using SPSS for Windows. Statistical analysis on the obtained data with the Statistics 17.0 package and analyzed the correlation between distance D data from three different slices of the proxymal humerus, position angle of intertubercular sulcus (PA) and retroversion angle of humeral head, and to verify if the difference(s) had any statistical significance, $P < 0.05$ as difference with statistical significance.

Results

The results in form of mean and median values were presented in **Table - 1**. Data for readings of 60 dry adult humeri were tabulated. The mean retroversion angle of the humeral head in relation of the transepicondylar axis was 12.3 degree. The mean ITS orientation was 40.7 degree. The Pearson correlation coefficient between the retroversion of the humeral head and the ITS orientation was -0.37 (95 % confidence interval = [-0.974; -0.11] and p = 0.005). There was an inverse correlation between the retroversion of the humeral head and the ITS orientation (**Table - 1**).

Measurements by two independent musculoskeletal radiologists, with 6 and 20 years of experience, were recorded for each humerus. No significant intraobserver variability or interobserver variability was found using ANOVA test with a significance level at 0.05.

Table - 1: Pearson correlation coefficient between the retroversion of the humeral head and the ITS orientation.

In Degree	N	Mean (SD)	Median	Min	Max
Retroversion humeral head	60	123 ± 7.9	10 [7; 17.5]	2	45
ITS orientation	60	40.7 ± 13	40 [30; 50]	14	70

Discussion

Currently, there are many monographs on total shoulder arthroplasty in which the authors all recommended the maintenance of a posterior inclination angle varying from 30° to 40° or from 20° to 35° when performing an osteotomy and placing a prosthesis of head of humerus. However, it has been confirmed in anatomical studies that there is considerable variation in retroversion angle of humeral head in the general population.

In the present study mean humeral retroversion angle of 12.31 degree confirms other anatomical studies, which found mean normal values that were quite variable, from 9 degree to 40 degree [5, 7]. This variation is due to several factors, including the definition of humeral head retroversion, different methods of measurement, ranges of normal values, and accuracy of anatomic landmarks to guide determination of anatomic retroversion. Humeral head retroversion is generally defined with respect to the plane of the humeral head articular surface

proximally; distally, however, the reference axis has been debated, including the transepicondylar axis [7, 8], trochlear tangent axis [9, 10] and forearm axis [9]. Methods of measurement have included direct anatomic. [11] radiographic [4], ultrasound [12], computed tomography scan [7, 8], MRI [5], and computer-assisted methods [13]. Boileau, et al. [14] showed that the radiographic method overestimated the humeral head retroversion relative to the computer- assisted method. However, there was no difference between humeral head retroversion obtained by the CT scan method, the direct method, and the computer-assisted method.

In our study, the mean ITS orientation was 40.7. We defined ITS orientation as the angle between the intertubercular sulcus axis and the humeral head axis. Rockwood, et al. [15] found a mean ITS orientation of 45. Many authors studied the anatomy of the intertubercular sulcus [13, 16], and some tried to define the relation with the humeral head retroversion [5, 7]. Doyle and Burks [5] measured the distance from the biceps groove to a line perpendicular to the midpoint of the humeral articular surface. Then they studied the relation between the biceps distance and the retroversion angle of the humeral head. They found that the biceps distance average was 11.8 mm, whereas retroversion average was 26.8. They concluded that placing the fin of a humeral head implant 12 mm posterior to the biceps groove reproduces normal anatomy better than the use of an arbitrary standard of 30,40 retroversion.

Based on the difference in correlation coefficient between the position angles of intertubercular sulcus and retroversion angles of humeral head at different levels, we found the beginning of intertubercular sulcus as the most reliable reference mark, which was followed by surgical neck of intertubercular sulcus. These findings suggested that in total shoulder arthroplasty, in addition to the entry of intertubercular sulcus, the surgical neck of humerus can also be used as a reference mark in positioning.

Cassagnaud, et al. [7] measured the intertubercular sulcus and transepicondylar axis creating the angle of lateralization of the intertubercular sulcus. This method requires choosing four CT sections and superimposing them on a single plane. The average values of lateralization of the intertubercular sulcus were between 115 and 122. Our method of measurement seems easier, logical and reproducible. Furthermore, we found an inverse correlation between the retroversion of the humeral head and the ITS orientation. The more the retroversion of the humeral head increases, the more the ITS orientation angle decreases. This inverse correlation highlights the intervention of the tendon of the long head of the biceps in the mechanism of the retroversion of the humeral head. The biceps brachii muscle is generally considered to be a supinator of the forearm and a flexor of the elbow. However, the biceps crosses the glenohumeral joint and the elbow. As it passes to its insertion in the supraglenoid region, the tendon of the long head of the biceps occupies an intra-articular position in the shoulder. Some authors demonstrated that the long head of the biceps may function to stabilize the glenohumeral joint [17, 18]. It has been suggested that using the bicipital groove as a landmark for placing the prosthesis might reproduce normal anatomy [19]. Indeed, the anatomy of the proximal humerus was highly variable for medial offset, tuberosity offset, and retrotorsion [20]. Yet, the practically relevant variance was minimal for the inclination of the humeral head, the head radius–height ratio, and the distance between the bicipital groove to the equator [20]. These findings have pertinent implications for prosthetic design and implantation. Our study is the first that shows an inverse correlation between the humeral head retroversion and the intertubercular sulcus orientation. This anatomical datum could help in the design of humeral head prostheses. However, several limitations may be considered inherent to the materials and methods. The anthropometric angle measurements were made using CT scan imaging. Thus, our data were not directly obtained from cadaver dissection, but from

multiplanar CT- eformation. However, CT scan imaging facilitated precise and reproducible drawing of the axis and angles. Another limitation is the low number of humeri: another study including a higher number of humeri could confirm this reverse correlation and find a better coefficient of correlation, closer to -1. Finally, this is an anthropometric study but such measurements could be easily realized for patients who undergo shoulder CT scan before prosthesis, by making an additional low-dose section on the epicondyle, after the authorization of patients and ethics committees.

Conclusion

The measurements of humeral retroversion and the intertubercular sulcus orientation by the CT method are easy to realize and in agreement with the data of the literature. There is a reverse correlation between the retroversion of the humeral head and the orientation of the intertubercular sulcus. To the best of our knowledge, this is the first study to describe this correlation. These additional anatomical data might improve knowledge of the humeral head anatomy and be helpful for orthopedic surgery.

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