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Morphometric study of torsion of humerus and its applications in total shoulder arthroplasty

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***Abstract*---**Background: Being the most common bone to osteoporotic fracture after the hip and distal radius, the surgical importance of the proximal humerus has gained much interest. Shoulder joint replacement has become very common option for many clinical conditions like arthritis, fracture of proximal humerus etc in last few decades. Although the fractures can be treated non surgically, the surgical correction has gained popularity. Restoration of the normal anatomy of the shoulder is extremely important to avoid future complications in shoulder arthroplasty. The angles at the proximal humerus are crucial in selecting the appropriate prostheses. The objective of the study is to have a region specific data on the torsion of head of humerus. Material and methods: Angle of torsion of 300 unpaired humeri collected from various medical colleges of Western part of India were analysed. Observation: The average torsion of humerus was 63.89±14.97. The P value of 0.483 showed statistically non-significant difference between the left and right humeri. Conclusion: The success of Total Shoulder Arthroplasty (TSA) depends on the satisfaction of the patient. Population specific prosthesis increases patient satisfaction and decreases post operative complications. The data of the current study can surely contribute in the process of manufacturing prostheses for local population.

***Keywords*---**Humerus, Torsion, Shoulder Arthroplasty, Dislocation, Prosthesis, Total Shoulder Arthroplasty.

Introduction

The term 'Torsion' means the action of twisting or the state of being twisted, especially of one end of an object relative to the other. The longitudinal twisting of shaft of long bones along its long axis results in an angulation between the upper and lower epiphyses [1].Torsion of long bones about their long axes has been recognized and described by anatomists for several years. As a result of this twisting or torsion, the articular axis of one end lies in a plane different from that of the other end. The two axes when superimposed on one another, an angle called the angle of torsion is formed[2].

In lower mammals the head of the humerus is directed backwards to articulate with the forward facing glenoid cavity of the scapula[3]. The angle of humeral torsion is slightly more than 90 in lower mammals[1]. Modification of upper extremities as prehensile appendages and assisting in the maintenance of an upright posture in humans resulted in the humeral torsion [4]. This lateral rotation of the head of humerus makes the angle increase to about 164 in humans, which increases with age[5].

The angle of torsion is measured at the intersection of two lines: one at the proximal end, that evenly bisects the articular surface of the head, and the other being the transepicondylar line distally (Fig. 1). In the clinical literature, this angle is referred to as humeral retroversion (as measured in the opposing direction).[6] The terms torsion and retroversion simply represent different assumptions about the neutral position of this angle [7]. The use of alternative terms has led to some confusion in the literature[8].

There are two aspects of humeral torsion: - Primary and Secondary. Primary torsion happens during embryonic development and secondary torsion is the results of muscular pull [4]. Researchers have varied opinion regarding the origin and cause of torsion of humerus. Factors like race, lifestyle, physical activity etc. has a direct effect on the development of torsion of humerus[9].

Various methods have been employed. Investigators have used instruments like torsiometer, Parallelograph, radiological studies like X- Rays and CT [7,10 ,11,12,13] to measure the humeral torsion. The objective of the study is to have a specific data on the normal morphometry of torsion of humerus in Western Indian population.

Materials and Methods

The cross-sectional analytical study was done on 300 dry humeri (150 right and 150 left) of unknown age and gender collected from various medical colleges of North India during a period of 2.6 Years (June 2019-2021 December). Dried and well-preserved humeri of any damage or abnormality were included in the study. Damaged or those bones with arthritic abnormality were excluded from the study. Angle of humeral torsion was measured by a method used by Motagi M et al. the axes of upper and lower ends were marked using some reference points on the head of humerus [9]. The axis of the upper end was marked by making two points on the head of humerus. The first point (P1**)** at the junction between the upper

and middle impressions of the greater tuberosity and the second point (P2) at center of the articular surface of head where the transverse diameter of is maximum (Fig 2 & 3).After marking the points, the humerus was placed on a flat horizontal surface and an end-on digital photograph of the articular surface of the head was taken. The images were analyzed using geometry tool software Geogebra. (https://www.math10.com/en/geometry/geogebra/geogebra.html) (Fig 4). The line joining the center of the two points to represents the upper end axis and a horizontal line through the second point to indicate the axis of lower end.The angle of humeral torsion was measured.

Statistical analysis

The results were tabulated and analysed by SPSS Software for Windows version 18.0 (SPSS Inc., Chicago, IL,USA).The mean and standard deviation (SD) was calculated. Unpaired student's 't' test was used to compare the means and *p* value of less than 0.05 was considered as statistically significant.

Results

The mean value of humeral torsion was 63.89±14.97° It was 64.49±14.04° and 63.28±15.83° and on right and left and sides respectively (Table 1). The P value of 0.483 showed statistically non-significant difference between the left and right humeri.

Table 1
Statistical results of torsion of right and left humerus

	N	Mean ±S.D.	t-value	p-value
Left Humerus	150	63.28 ±15.83°	0.70	0.483
Right Humerus	150	64.49 ±14.04°		

Discussion

Measurement of humeral torsion is clinically important because it enables surgeons to make justifiable assumptions and make inferences about the position of the glenohumeral joint in relation to range of shoulder mobility, particularly the rotational range of motion[2]. It is also of surgically important to understand the variations in the retroversion of humeral head among the individuals undergoing surgeries and the ways in which this parameter might be manipulated to surgical advantage. Recent biomechanical studies suggest that humeral retroversion could have a significant bearing on shoulder function and shoulder injuries [5].

Measurement of humeral torsion is crucial in placing the prosthesis in TSA. Understanding the individual variations in retroversion is important before performing any surgical procedures. Various studies suggest that humeral retroversion could have a significant bearing on shoulder function and shoulder injuries. [14]. Humeral torsion is highly variable in human beings. Torsion values have been shown to differ between different populations and sexes[1,4,7]. Several pieces of literature available from different parts of the world give a clear idea of its variations. As per the literature, the world wide mean torsion reported on dry

bones vary from 48.5° to 74.4°.[7,15]. Standard textbooks mention the average humeral torsion as 74° [16], however, angle of humeral torsion depends on several factors like race, the type of activities involving the upper extremity etc. The highest average degree of torsion is reported ever in is the White race [7] The angle of humeral torsion is found lower in the populations participating in high levels of strenuous activity and increased in less active subjects.[71]

Torsion also varies ontogenetically, which steadily increases during postnatal growth by an average of 23.4° until the completion of skeletal growth [17]. Much of this change in torsion seems to occur at the proximal humerus, which is one of the last bones in the body to fuse: only 20% of individuals have achieved fusion by 18 years of age[18]

The literature shows variations among the average torsion of the humerus. Maximum value of mean torsion torsion ever reported is 107°[11] and minimum was 35°[10]. The mean torsion of the present study showed similarity with the findings of Pati S, Shah RK, Patel S [2,4,5]. The results of the present study is compared with previous study in Table 2

Arya RS et al. observed comparably lower values in torsion of humerus.[19] Tellioğlu et al. in the Turkish population observed lesser torsion angle using MRI. They didn't notice any significant difference in men and women [20]. A study by Edelson on 336 dry humeri known to originate from black Americans, white Americans, Bedouins of the Negev Desert, natives of New Mexico, Alaskan Eskimos and North China observed a range of –8° to 74° torsion angle. They assumed that differences in the torsion angle may be due to the differences in social, genetic structures and physical activities[21].

The present study showed a statistically non-significant difference between the left and right humeri. Similar results were reported by Shah RK et al in the Gujrati population. [4] Similar observations have been made by Kate et, al. [22]. They stated that 87% of the adult torsion is completed at birth by various intrinsic factors. Greater torsion on the right side has been reported by Debevoise et al [23] Krahl & Evans on Caucasians [24] Patel S [5] and Mehta and Chaturvedi [10] similar to the present study. Authors like Motagi M [9] Kate [22] and Krahl and Evans study on American blacks [24] et al. reported a greater AHT on the left side. The disparities in the bilateral differences probably due to the limb dominance.

Angle of humeral torsion is found lower in the populations participating in high levels of strenuous activity and increased in less active subjects [25].Recent biomechanical studies suggest that humeral retroversion could have a significant bearing on shoulder function and shoulder injuries [14]. Researchers like Debevoise et al , Syndmonides et al, and Kronberg et al, [23,26,27] observed a positive relationship between increased humeral torsion and recurrent anterior dislocation of the shoulder (RADS). They reported a significant increase in the angle of humeral torsion in patients with RADS as compared to normal persons. Kronberg et al suggested that greater torsion of the humeral head might predispose the anterior dislocation of the humeral head in the abducted and external rotated shoulder.[27] Shah RK et al observed that the lesser incidence of

recurrent anterior dislocation in Indians may be due to the lower degree of torsion. [4]

Limitations

The humeri used in the present study were of unknown age and sex. The exact origin of the bones were nor known and were unpaired. A detailed analysis could have been possible if this data were available. A functional correlation could have been done if the type of occupation and the pattern of limb dominance were known.

Conclusion

The present study aimed at making a baseline data on the torsion of humeral head among Indians. The average torsion of humerus was 63.89±14.97.The study showed statistically non-significant difference between the left and right humeri. The study will be of use anthropologists to understand racial variations of humeral torsion. The Measurement of humeral torsion is clinically important because it enables orthopaedic surgeons to plan and implement surgical procedures related to the proximal epiphysis of humerus. Selection of appropriate prosthesis is crucial in performing arthroplasty. Use of population specific implants increases the success of arthroplasty and reduces the post operative complications. The implant manufactures can make use of this regional data for making implants exclusively for Indians rather than using western implants.

Author	Year	Population	Torsion
Present study	2021	Western India	63.89°±14.97° Right=64.49°±14.04 Left=63.28°±15.83
Patil S et al. [2]	2016	New Delhi	64.57°±7.56° Right=66.84°±9.69° Left=63.31°±9.50°
Kaur M et al. [1]	2015	North India	Right Male-159.68°±10.78°. Female 150.24°±10.01° Left Male 54.76°±9.89°. Female 155.36°±8.65°
Arya R S et al. [19]	2015	Madhya Pradesh	32.97°±10.862° Right=34.90° ±11.582° Left=31.04°± 9.753°
Patel S et al. [5]	2012	Gujrat	70.02° Right=70.94° Left=68.94°
SS Dare et al. [14]	2012	Uganda	56.61±9.57° Right=54.67±9.46° Left= 58.55±8.54°
M Motagi et al. [9]	2011	South India	59.65°±10.97° Right=57.85°± 9.80°

			Left=61.83°±11.93°
Tellioğlu et al. [20]	2010	Turkish	Total- 19.5° Female - 21.5° Male 18 18.5°
Shah RK et al. [4]	2006	Ahmedabad	67.57°± 9.99° Right=67.84°±10.49 Left=67.31° ± 9.50°

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Figures

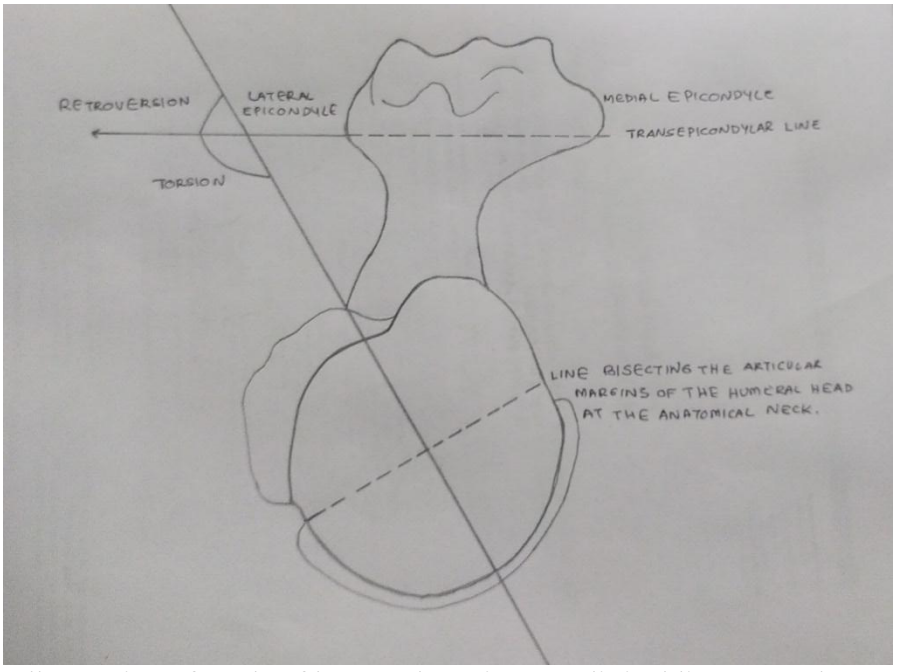

Fig 1- Illustration of angle of humeral torsion. In clinical literature the same is refferred as humeral retroversion

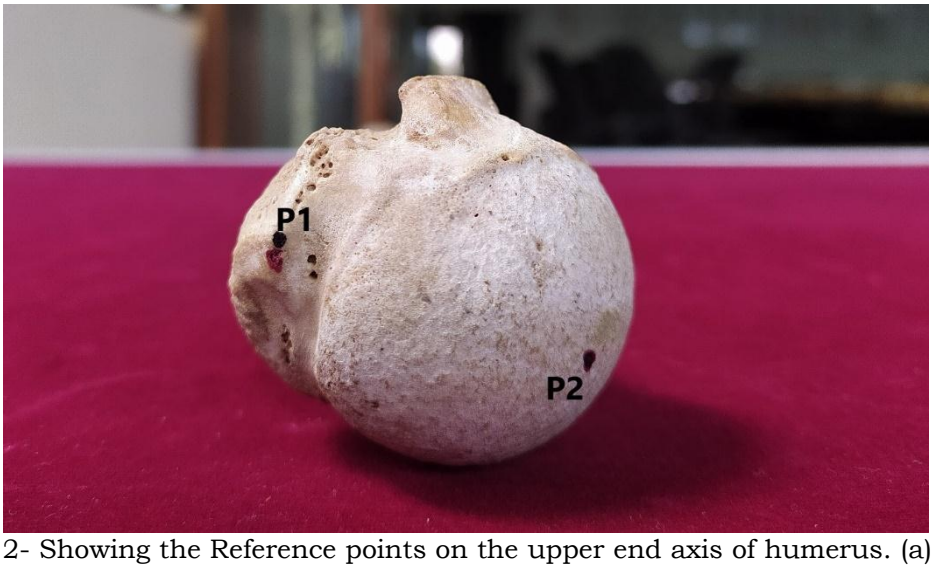

Fig. 2- Showing the Reference points on the upper end axis of humerus. (a) P1: the junction between the upper and middle impressions of the greater tuberosity of the humerus (b) P2: center of the articular surface of head where the transverse diameter of is maximum

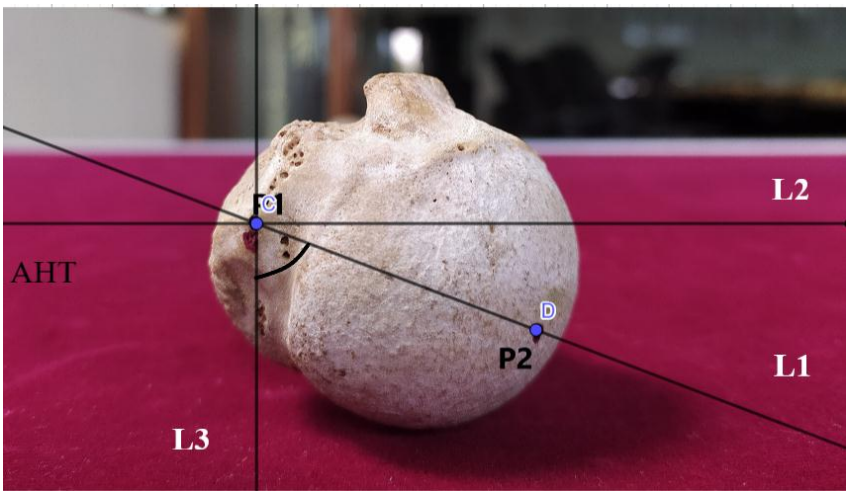

Fig. 3 : Head of humerus showing the axes; L1- axis of upper end, L2 – axis of lower end. AHT- Angle of Humeral Torsion.

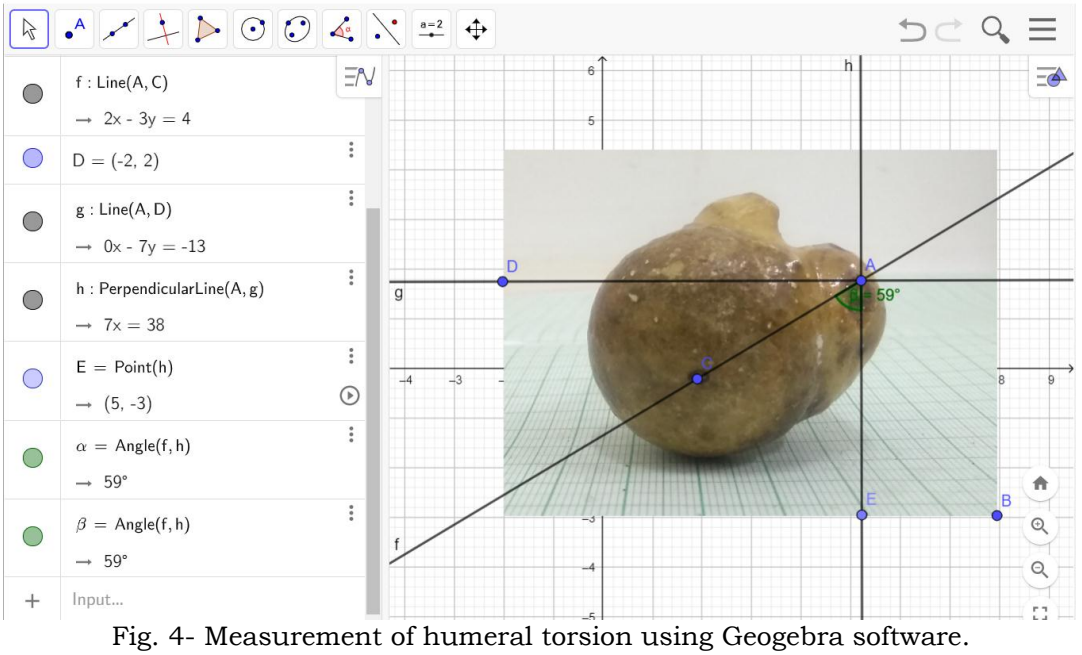

Fig. 4- Measurement of humeral torsion using Geogebra software.