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Research Article

A MORPHOMETRIC STUDY OF HUMERAL TORSION IN NORTH INDIAN POPULATION

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ABSTRACT
Torsion is defined as a state of longitudinal twisting of shaft of long bones along its long axis. In humerus, it is expressed by angle of humeral torsion which is defined as the angle between the longest axis of the proximal and distal humeral articular surfaces. In lower mammals, it is little more than 90º. In man, due to lateral rotation of the proximal end of humerus, it has been increased to about 164º. The present study was conducted on 100 adult humeri of known sex (M: 50; F: 50) obtained from the Department of Anatomy, Government Medical College, Amritsar. The angle of humeral torsion was measured by a method described by Krahl and Evans (1945). The mean angle of torsion in males was found to be 159.68±10.78º & 154.76±9.89º on right & left sides respectively. In females the corresponding values were 150.24±10.01º and 155.36±8.65º. The angle was slightly higher in males as compared with females and the difference was statistically significant only on right side. Comparing sidewise, the angle found to be slightly higher on left side as compared to right side and the difference was statistically insignificant. Torsion has been considered as a factor in the etiology of recurrent anterior dislocation of shoulder. More is the angle of humeral torsion, higher is the risk of recurrent anterior dislocation of shoulder. Knowledge of torsion angle helps surgeons to understand the problems involved in treating malunited fractures and severe arthritic deformity of the joint.

Keywords: *Humerus, Torsion, Angle, Articular Surfaces, Shoulder Dislocation*

INTRODUCTION
The form and morphometric parameters of the humerus have always invoked a keen interest not only to the anatomists but also to the clinicians, anthropologists and forensic experts. A structural and formatted analysis of the proximal humerus facilitate precise placement of the humeral stem in shoulder arthroplasty. Recently introduced designs for prosthetic replacement of the proximal part of the humerus have emphasized on the importance of accurate recreation of its normal 3 dimensional anatomy. Though the parameters like angle of humeral torsion have been studied, there is varied opinion regarding their origin and cause. The present study intends to establish the morphometric criterion of humeral torsion in North Indians, as it is known to be influenced by cultural, environmental and racial factors (Robertson *et al.,* 2000). Torsion is defined as a state of longitudinal twisting or spiraling of shaft of long bones along its long axis. This apparent twisting of the shaft of the humerus bone is expressed by angle of humeral torsion[23] which is defined as the angle between the longest axis of the proximal and distal humeral articular surface. In lower mammals, this angle is found to be little more than 90º. In man, however, the upper end of the humerus appears to have been rotated laterally. So that the angle between the two axes has been increased to about 164º. This is found to increase with age up to maturity and is greater in males than females. It is also greater in adults than children ranges from 135º to 165º or more in the male. It is greater in man than in anthropoids (Patel *et al.,* 2012). In man, the biological necessity of torsion results from development of upper extremities as prehensile appendages functioning frontally to trunk axis thereby assisting in maintenance of upright posture (Shah *et al.,* 2006).

MATERIALS AND METHODS
The present study was conducted over a period of 3 years from June 2008 to June 2011 after getting approval from the institutional ethical committee. The material for the study comprised of 100 dried adult

humeri of known sex (M: 50; F: 50), obtained from the Department of Anatomy, Government Medical College, Amritsar. These humeri were free of any gross abnormality & labelled from 1-100 with suffix M(Male) or F(Female). The angle of humeral torsion was measured by a method described by Krahl and Evans (1945). The mechanical axis of the head was taken as the line joining the two points namely centre of the articular surface of head where transverse diameter of articular surface is maximum and at the greater tuberosity. A pin was struck with plasticin along the line of these two points.

For the distal end axis, a point was marked on the anterior surface of capitulum along the centre of its vertical diameter. Similarly 2nd point was marked on trochlea. A pin was stuck with plasticin along the line of these two points. The angle formed by the crossing of these two reference lines was then measured with the parallelograph. This angle was called the Torsion angle.

To draw and measure such an angle, a bone was taken along with the pins demarcating the axes at the two ends. It was placed in an osteophore which holds it rigidly in a vertical position. It is a retort stand, equipped with a heavy iron clamp capable of movement in several directions. This apparatus including the vertically placed bone with pins was placed upon a large sheet of paper.

The parallelograph consists essentially of a vertical rod, arising from the centre of an iron tripod paralleled by a rod of a smaller caliber arising from one leg of the tripod base. The larger rod bears two freely movable sockets controlled by binding screws each bearing a horizontal steel needle. To project a given line, the point of the upper needle was placed in contact successively with two points on the pin defining the axis to be projected, while the lower needle recorded the points by making slight punctures in the paper beneath. The two axes were drawn by joining the points with ruler and the angle between the two axes was measured with a protractor (See Figure below).

Fig. showing
Parallelograph and osteophore with a fixed humerous bone.
AB and CD are the axis of the two ends demarcated by pins fixed with plasticin.

RESULTS AND DISCUSSION

Results

Data was compiled and statistically analyzed. Various statistical results calculated were:

1. Mean with standard deviation.
2. Standard error of mean.
3. 95% confidence interval
4. Student's T test.

Stress was laid upon the differences with respect to sex and side and whether these were statistically significant or not.

In the present study, the mean angle of torsion in males was found to be 159.68±10.78º on right side while on left side it was found to be 154.76±9.89º. In female the corresponding values were 150.24±10.01º and 155.36±8.65º.

Comparing between two sexes, the angle was slightly higher in males as compared with females and the difference was statistically significant on right side whereas it was statistically non significant on left side while on comparing sidewise, the angle of humeral torsion found to be slightly higher on left side as compared to right side and the difference was statistically insignificant (See Table 1).

Table 1: Statistical Results Of Angle Of Humeral Torsion In Present Study

Sex	Side	No.	Mean±Sd (degree)	SEM	Range (degree)	95% C.I Lower	95% C.I Upper
M	R	25	159.68±10.78	2.16	134-176	155.45	163.91
M	L	25	154.76±9.89	1.98	140-173	150.55	158.64
F	R	25	150.24±10.01	2.00	135-174	146.34	154.17
F	L	25	155.36±8.65	1.73	140-170	151.97	158.75
MR vs ML			t = 1.681		p = 0.099		NS
FR vs FL			t = -1.935		p = 0.059		NS
RM vs RF			t = 3.207		p = 0.002		S
LM vs LF			t = -0.228		p = 0.820		NS

Discussion

Torsion & rotation are two different phenomenons. The angle made by crossing of the two axes of the two opposite ends, when measured obtusely includes 90 degree rotation, which the entire upper limb undergoes during its development in the embryo (Shah *et al.*, 2006).

A comparison of torsion angle reported by different workers show that there is a considerable racial variation. Mehta and Chaturvedi, 1971 undertook a illustrated study of the angle of humeral torsion on 200 human normal adult humeri from different regions of Rajasthan. The torsion angle was greater on the right than on the left side. Shah *et al.,* (2006) conducted a study of angle of the humeral torsion on 500 normal adult human humeri and found the average angle of the humeral torsion to be 67.57º. They concluded that the variations in means of angle of torsion & large number of bones go hand in hand.

As shown in table 2, torsion angle in the present study was closer to that in Gujarati (Shah *et al.,* 2006), rajasthani (Mehta and Chaturvedi, 1971) populations**,** Indian tribes (Mathew *et al.,* 1893) & Germans (Fuchs *et al.,* 1991). However in all these studies the humeral torsion was slightly higher on right side as compared to left side. But in present study we found torsion to be slightly more on left side as compared to right side (difference was statistically nonsignificant). This was toeing in line with the results of Krahl & Evans (1945) who conducted the study on American Negroes and Broca (1881) who did an extensive study on 600 humeri of various races.

Similar results have also been reported by other European workers. These findings suggest that there is a hereditary racial trait as suggested by Briffault (1927). In present study, the torsion was found to be more in females as compared to males. This may be due to the fact that the Indian males have more powerful musculature as compared to females leading to increased midshaft circumference of the humerus and as concluded by Mehta & Chaturvedi (1971), the torsion angle is directly propotional to the circumference of the shaft so the torsion is more in males in present study.

Ontogeny: In human humerus bone, the ontogenetic or secondary torsion is superimposed upon the primary torsion. Muscular forces produced the torsion at the level of the proximal epiphyseal cartilage prior to bony fusion at that level. Forces involved are attributable to lateral & medial rotator muscles inserting proximal & distal to the epiphyseal line of the humerus respectively. Studies with humeri from fetal to adult stages showed that torsion occurs at the proximal epiphyseal level and not in the humeral shaft which only appears to be twisted. Torsion angle increased until the time of closure of the proximal epiphyseal line in both the sexes occurring somewhat earlier in the female.

Thus it was concluded that ontogenetic or secondary torsion occurs at the level of the proximal epiphyseal cartilage of the humerus as long as the cartilage persists (Krahl, 1976).

Phylogeny

Humeral torsion first appears in labyrinthodonts of the Permocarboniferous period and is found in all later terrestrial tetrapods. It begins as an evolutionary or hereditary primary torsion which probably arose in the transformation of the rhipidistian pectoral fin into a foreleg (Evan & Krahl, 1945). Evidence from studies of paleontology, osteology, mycology, embryology and the course of nerves of the arm of man convinced us that humeral torsion occurred in a medial sense relative to the humeral head. Phylogenetic survey done

by Krahl suggested that the torsion angle increases progressively from the crossopterygian fishes through recent mammals to man.

Humeral torsion is greater in African apes than in other anthropods, owing to parasaggital use of the forelimbs during knuckle-walking in combination with a trunk designed to support a laterally facing scapula (Larson, 1988).

Table 2: Showing the Comparison study of Angle of Humeral Torsion

Authors	Series	Torsion angle (degrees)
Mathews *et al.,* (1893)	Salado-indians	159
Mathews *et al.,* (1893)	Indian tribes	153
Krahl & Evans (1945)	Whites	164.4
Krahl & Evans (1945)	American blacks	162.6
Kate (1969)	Indians (central)	145
Mehta & Chaturvedi (1971)	Indians (Rajasthan)	158.5
Fuchs *et al.,* (1991)	Germans	152.8
Robertson *et al.,* (2000)	Americans	161
Shah *et al.,* (2006)	Indians (Gujarat)	157.57
Patel (2012)	Indians (Gujarat)	160.0
Present study	Indians (north)	155.01

Clinical Significance

Torsion of humeral head has been considered as a factor in the aetiology of recurrent anterior dislocation of shoulder. More is the angle of humeral torsion, higher is the risk of recurrent anterior dislocation of shoulder. Torsion angle may also help surgeons to understand the problems involved in treating manumitted fractures and severe arthritic deformity of the joint (Symenoides, 1995).

Conclusion

It is very difficult to give a constant angle of humeral torsion as the range of distribution is very wide. There was no significant difference in mean values of humeral torsion on right & left side in both sexes except for right humerus where the difference was found to be statistical significant in both sexes.

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