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Angle of Humeral Torsion: Comparative Analysis with Length and Mid-Shaft Circumference

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Abstract

The humeral torsion angle is a bony twist of the head of the humerus formed between the proximal and distal articular axis of the humerus, which is essentially significant to measure as it depends on biological activity. The present study was conducted with the aim to document anthropometric variables so as to provide a frame for prosthesis design of humeral components in arthroplasty. A total of 50 dry, normal adult human humeri were obtained from the Department of Anatomy in Nobel Medical College and teaching hospital to measure the angle of torsion, length, and mid-shaft circumference of each bone. The measurement of the angle of humeral torsion was performed by the Kingsley Olmsted method, whereas length and mid-shaft were measured with measuring tape. The data analysis was done in SPSS version 17 to correlate and compare the means. The average (mean± SD) angle of torsion for 50 unpaired dry humeri of both sides was compared and found to be statistically significant (p= 0.004, Right= 66.24± 8.67°, Left= 59.56± 6.7°). Mid-shaft circumference was positively correlated with the angle of torsion and was statistically significant (p=0.012, r= 0.351). The study concludes that mid-shaft circumference was found to be more with a large angle of humeral torsion, but there was no significant correlation with the length of the humeral shaft.

Keywords*: Arthroplasty, Humeral torsion, Humerus, Kingsley Olmsted, Mid-shaft, Prosthesis.*

Introduction

The development of the upper extremity in humans as appendages known as the humerus and the bony twist of the humeral head formed between the proximal and distal articular axis is known as humeral torsion. The angle of humeral torsion (AHT) is measured at the intersection of two lines: one that evenly bisects the articular surface of the humeral head proximally and the second being the trans-epicondylar line distally [1, 2].

The study revealed that the angle of humeral torsion essentially depends on biological activity [3]. Documents report the variations in the AHT depending on the type of usage of the upper limb in sporting activities [4]. Humeral torsion is generally lower in the populations participating in more strenuous activity and increased in less active subjects [5].

Different aspects of humeral torsion have been studied by several workers in different parts of the world. Studies show that humeral torsion may be primary or secondary torsion. Primary torsion present in the embryo is determined by developmental patterns and is a characteristic of various species. Secondary torsion is an outcome of the pull of muscular forces and functions etc. The external and internal rotators of the shoulder and arm region exert their force on the shaft of the humerus, which is responsible for the addition of secondary torsion [6]. An increase in thickness of the shaft of the humerus and altered humeral torsion was observed in professional baseball pitchers [7].

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The humeral torsion has been extensively studied in cases of Recurrent Anterior Dislocation of the Shoulder (RADS). The increase in the angle of humeral torsion is associated with an increase in RADS. Even minimal force can lead to dislocation in such cases compared to normal subjects [8]. So, the circumference of the shaft is also important in the measurement of the angle of humeral torsion. Clinical importance in the study of the angle of the humerus is extensive, and it has a wide range of applications for the improvement of orthopedic surgeries outcome [9].

Background

Humoral torsion and the comparative analysis between angle and length as well as circumference have not been well documented in the Nepalese population. This anthropometric analysis has application in clinical interventions.

The present study is a descriptive analysis of the angle of humeral torsion in dry bone and to determine the correlation of the angle of humerus with the length and mid-shaft circumference.

Material and Methods

This is a cross-sectional study carried out at the Department of Anatomy, Nobel Medical College & Teaching Hospital, and Research Center, Biratnagar, Nepal, from August 2020 to January 2021. Adult dry unpaired humeri of Nepalese origin of either sex available at the department of Anatomy were used for this study.

A total of 50 dry humeri, well preserved and undamaged, were segregated. All the segregated humeri of unknown gender were separated as right and left-sided, based on standardized anatomical criteria. These bones, collected from cadavers used by the anatomy department, belonged to adults of Nepalese origin. The equal number of both-sided humeri, 25 right-sided and 25 left-sided, were collected and included in this study.

The length and mid-shaft circumference of each dry humerus was measured with the help of measuring tape with the conventional method of measurement. In order to reduce the error, the process of measurement was repeated, and the average value was recorded.

Measurement of angle of humeral torsion was performed by the Kingsley Olmsted method [10]. The method measures the torsion angle by placing the specimen at the edge of a horizontal surface so that humerus head rests on the surface. Measurement includes two axes, the upper-end axis was passing through the center of the head of the humerus, extending from a point where the transverse diameter is maximum to the center point on the greater tuberosity of the humerus. The lower end axis was taken as the line passing between the centers of two epicondyles (lateral and medial epicondyle) of the humerus. The horizontal limb of a goniometer was fixed at the edge of the experimental table. The vertical limb of the goniometer was held parallel along the upper-end axis of the head and neck of the humerus. The horizontal surface represents the lower-end axis against which angle is measured with the upper-end axis of the head and neck of the humerus. The angle subtended was recorded in degree.

The investigator of our team randomly selected 50 bones for anthropometric measurement, and the value was recorded. The procedure of measurement and recording of observed values were repeated for Intra- and inter-observer reliability.

Statistical Data Analysis

The means and standard deviation (SD) of the angle of humeral torsion, length, and mid-shaft circumference for all 50 dry humeri from the right and left sides were calculated. The independent sample t-test was used to check for significant differences ($p<0.05$) between the right and left AHT. Pearson correlation analysis was done for the AHT with shaft length and mid-shaft circumference.

Figure 1. Measuring Length of Humeral Shaft

Figure 2. Measuring Mid-shaft Circumference

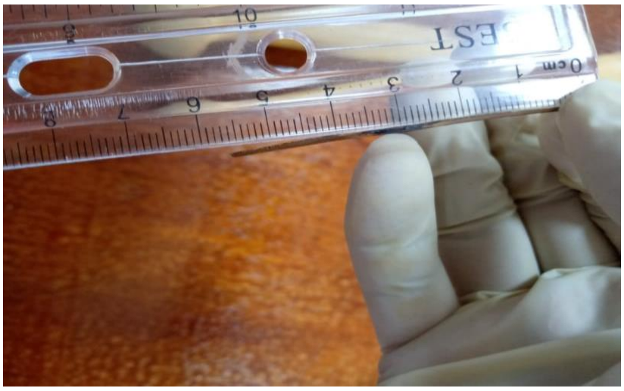

Figure 3. Measuring Mid-shaft Circumference

Figure 4. Measuring Angle of Humeral Torsion

Results

A total of 50 dry unpaired humeri obtained from the Anatomy Lab of Nobel Medical College and Teaching Hospital were measured for the angle of torsion, length, and midshaft-circumference separated as right and left-sided humeri.

Table 1 shows the average (mean± SD) angle of torsion for 50 dry humeri angle of torsion, 66.24±8.67° and 59.56±6.7° for right and left sides, respectively. Lengths were 28.56±1.73 cm and 28.16±1.49 cm for the right and left sides, respectively. Mid-shaft circumferences were 6.44 ±0.88 cm and 6.32± 0.77 cm for the right and left sides, respectively.

Table 2 shows the mean difference of anthropometric variables between the right and left humerus. Assuming the equal variance, the angle of humeral torsion shows a significant difference ($p = 0.004$), whereas the mean difference for length and mid-shaft circumference of the humerus were statistically non-significant.

Table 3 showed the Pearson correlation of angle of torsion with length and mid-shaft circumference, respectively, including all the right and left humeri (N=50). Although mid-shaft circumference and length were positively correlated with the angle of torsion, the mid-shaft circumference was statistically significant ($p=0.012$, $r= 0.351$), but the correlation with length was non-significant.

Table 1. Descriptive Anthropometric Variables of Humeral Bone

Variables	**No. of Samples**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
AR	25	50.00	78.00	66.24	8.67
RL	25	26.00	31.00	28.56	1.73
RMC	25	5.00	7.50	6.44	0.88
AL	25	44.00	68.00	59.56	6.70
LL	25	25.00	30.00	28.16	1.49
LMC	25	5.00	7.00	6.32	0.77

AR - angle of torsion for right sided humerus.
RL - Length of right humerus.
RMC - Right mid-shaft circumference.
AL - angle of torsion for left sided humerus.
LL - Length of left humerus.
LMC - Left mid-shaft circumference.

Table 2. Comparative Analysis of Right and Left sided Variables of Humeral Bone

Variables (Equal variance assumed)		**No of samples (N)**	**Sig (2-tailed)**	**Mean differ.**	**St Err. Diff.**	**95% Confidence Interval of the Difference**	
						Lower	**Upper**
Angle	AR	25	0.004	6.68	2.19	2.27	11.08
	AL	25					
Length	RL	25	0.386	0.40	0.45	-0.51	1.31
	LL	25					
Circumference	RMC	25	0.624	0.11	0.23	-0.35	0.58
	LMC	25					

AR - angle of torsion for right sided humerus.
RL - Length of right humerus.
RMC - Right mid-shaft circumference.
AL - angle of torsion for left sided humerus.
LL - Length of left humerus.
LMC - Left mid-shaft circumference.

Table 3. Correlation of Angle of Torsion with Length and Mid-shaft Circumference

Independent variables(N=50)	Dependent Variable (Right and left)	Correlation (r)	Sig. (2-tailed)
Angle of humeral torsion	Length of shaft (N=50)	0.169	0.241
	Mid-shaft Circumference (N=50)	0.351	0.012

*Correlation is significant at $p < 0.05$ level (2-tailed)

Discussion

The present study evaluates the normal humeral angle of torsion with dry humeri collected in the Anatomy laboratory of Nobel Medical College and Research center. It is a descriptive and comparative study of the anthropometric variable of unpaired right and left adult humeri of unknown sex obtained from a cadaver.

Descriptive analysis of angle of torsion, length, and mid-shaft circumference in the present study shows 66.24±8.67° and 59.56±6.7°, 28.56±1.73 cm and 28.16±1.49 cm and 6.44 ±0.88 cm and 6.32± 0.77 cm in the right and left humerus respectively. Similar finding for the angle of humeral torsion has been reported at 66.84° ± 9.69° on the right side, whereas 63.31 ± 9.50° on the left side in a study population of Indian origin. The humeral mid-shaft circumference in the same population was 5.79 cm and 5.63 cm on the right and left sides, respectively, which were quite comparable with the present study (Rt= 6.44 ±0.88 cm and Lt= 6.32± 0.77 cm). The humeral length was 31.6 ± 2.21 cm and 30.33 ± 1.87 cm from the right and left sides, comparatively similar to the present study 28.56±1.73 cm in the right and 28.16±1.49 cm in the left [11].

In one of the studies by SS Dare et al., the angle of torsion was recorded as 54.54 ±0.69 and 58.71±0.66 degrees on the right and left side, respectively, in the male humerus. Similarly, 55.47±1.59 and 57.56±1.96 degrees on the right and left female humerus. The angle of torsion in the present study is quite close to the above finding. The difference can be explained due to population variation as humeral torsion is generally lower in the populations participating in more strenuous activity and increased in less active subjects (9).

On comparing the mid-shaft circumference with the angle of humeral torsion, a weak negative correlation on both sides was seen. Comparing the length with the angle of humeral torsion, the coefficient correlation showed a weak negative relationship on the right side and a weak positive relationship on the left side. So, we concluded that there is no relationship between length with the angle of humeral torsion. No statistical difference was seen in angles between right and left humeri (p>0.001). Though our study has a significant positive correlation between circumference and angle of humeral torsion, it has no significant correlation between length and angle of torsion though it has positive relation [11].

Comparing throwing and non-throwing arms of base-ball players**;** AHT of the throwing arm was documented to be more in right-handers than left-handers and was statistically significant (77° vs. 81°; P < .001). The present study has similarities as the mean angle of humeral torsion of right-sided humeri was significantly more compared to the left side [12].

Conclusion

Normative data related to the humeral anthropometric variables; angle of torsion, length, and mid-shaft circumference were obtained in the present study, which has an implementation in a surgical intervention like; the open reduction and internal fixation in the clinical practice of orthopedic surgeons. The study documents the significant correlation between angles of humeral torsion with a mid-shaft circumference, which could be valuable information for Orthopedist in the planning of various surgeries along with prognostic evaluation of surgical conditions among populations of Asian origin.

Future Relevance

This study has documented the humeral angle, length, and mid-shaft circumference in Nepalese, which was found to be quite similar to Indian studies. Thus, not only the population-specific studies for anthropometric variation but also the radiographic evaluation can be expanded as supportive research in the future.

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