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Correlation between Morphological Variations and Morphometry of Scapula and Suprascapular Notch with Its Clinical Significance in South Indian Population

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ABSTRACT

Introduction: The biological profile is one of the most important things that forensic anthropologists accomplish in their work, which includes determination of age, sex, race and stature. These components aid in identification of an individual in forensic context. Since the beginning of the field of physical anthropology, anthropologists and anatomists have studied human remains in order to provide new and more accurate ways of building the biological profile.
Aim: To compare the metric difference between right and left scapula, calculate scapular index, and to correlate the morphometry between the scapula and the suprascapular notch.
Materials and Method: This study was carried out in 200 dry ossified adult human scapula bones collected from the Department of Anatomy and from the students of 1st year MBBS of Yenepoya Medical College. Study done using vernier calliper and measuring tape. Scapula having gross deformity or any pathological alterations were excluded from the study.
Results and Discussion: Out of 100 right and left scapulae, maximal width and projection length of scapular spine and maximal length of coracoid process were more on the right sided scapula. The superior- transverse diameter of suprascapular notch, maximal depth of suprascapular notch, morphological length and width of scapula and scapular index were more on the left sided scapulae. The mean scapular index of right side scapula was 70.11 and left side was 70.26, which shows that the left scapula is slightly shorter than right. Also there were more scapulae with longer superior transverse diameter of suprascapular notch (STD>MD) with 52% than the scapulae with longer maximal depth of suprascapular notch (MD>STD) 24% and STD=MD was 9%. Absent notches were seen in 15% of scapulae. The superior transverse scapular ligament was completely ossified in 12% of cases. Both right and left scapula shows more of 'U-shaped' suprascapular notch. There was no statistically significant difference between anthropometric measurements of the group with higher maximal depth and the group with higher superior transverse diameter of the suprascapular notch.
Conclusion: The scapular index was more in left scapula, which shows that left scapula is slightly shorter than the right scapula compared to other populations. This may be due to the difference in general built and stature of South Indians compared to other populations. Completely ossified superior transverse scapular ligament can result in entrapment of suprascapular nerve.

Key Words: Scapula, Suprascapular notch, Spine of scapula, Coracoid process.

INTRODUCTION

The scapula (shoulder blade) is a triangular flat bone that lies on the posterolateral aspect of the thorax, overlying

the 2nd to 7th ribs. The convex posterior surface of the scapula is unevenly divided by the spine of the scapula into a small supraspinous fossa and a much larger infraspinous fossa. The concave costal surface of the scapula has a large subscapular fossa. It has costal and dorsal surfaces; superior, lateral and medial borders; inferior, superior and lateral angles and three processes - the spine, the acromion and the coracoid process.

The suprascapular notch is situated in the lateral part of the superior border of the scapula, adjacent to the base of the coracoid process. This notch is converted into a foramen by the superior transverse scapular ligament and serves as a passage for the suprascapular nerve which supplies motor branches to the supraspinatus, infraspinatus and sensory branches to the rotator cuff muscles and the ligamentous structures of the shoulder and the acromion-clavicular joint.

The variations in the suprascapular notch are accompanied by a variation of the superior transverse scapular ligament. These variations have a role to play in suprascapular nerve entrapment. Usually, cases of suprascapular nerve entrapment neuropathy complain of deep and diffuse, poorly localized dull or burning pain in the posterolateral aspect of shoulder, which exaggerate on activity. This pain can be elicited by the palpation over the region of the scapular notch[1]. Injury to the nerve may result in significant rotator cuff dysfunction. Suprascapular nerve entrapment caused by the superior transverse scapular ligament (STSL) causes pain, and limitation of motion in the shoulder. To relieve these symptoms, suprascapular nerve decompression is performed through the resection of superior transverse scapular ligament[2].

There are very few papers in forensic literature in which scapular dimensions have been used for the estimation of living stature. Detailed anatomy and morphometry of the scapula were obtained to provide information for surgical procedures such as hardware fixation, drill hole placement, arthroscopic portal placement and prosthetic positioning[3]. The study of dimensions of suprascapular notch will help the orthopaedicians to correlate suprascapular nerve entrapment syndrome with a specific type of suprascapular notch[4].

Suprascapular nerve entrapment is an acquired neuropathy secondary to compression of the nerve in the bony suprascapular notch[5]. The nerve may be entrapped at suprascapular notch, secondary to narrowed neck, by cyst (ganglion), repetitive strain (volley ball players), thick transverse scapular ligament, fracture of superolateral area of scapula, or at spinoglenoid notch by space occupying lesion such as ganglion or tumor[6]. Lesions of the suprascapular nerve can occur at the supraspinatus notch[7]. They usually present with vague pain radiating across scapula, dull shoulder ache, limitation of shoulder joint movements and wasting of supraspinatus and infraspinatus. Bilateral cases have been reported in weight lifters[7,8].

The size of the suprascapular notch played a role in the predisposition for suprascapular nerve entrapment. In their opinion, a small notch gave a greater chance of a nerve impingement than a large one. The suprascapular notch type, apart from the anatomical interest, may have some clinical significance for suprascapular nerve entrapment [9,10]. The size and shape of the suprascapular notch may be a factor in suprascapular nerve entrapment because narrow suprascapular notch have been found in patients with this syndrome[11-14].

Aims and Objectives

- To compare the metric difference between the right and left scapula.
- To calculate the scapular index.
- To correlate the morphometry between the scapula and the suprascapular notch.

MATERIALS AND METHODS

- 200 dry ossified adult human scapulae bones collected from the Department of

Anatomy and 1st year MBBS students, Yenepoya Medical College, Mangalore.

- Only fully ossified dry adult human scapulae without any deformities were taken for the study. Scapulae showing gross deformity and pathological alterations are rejected as unsuitable. Bones of paediatric size are also excluded from the study.
- MATERIALS / INSTRUMENTS USED were Sliding Vernier Calliper and measuring tape.
- The statistical analysis was done by using T test. P value was taken as significant at 5 percent confidence level ($p \leq 0.05$).

METHODS

Various parameters of scapulae are measured using the vernier callipers and measuring tape and its different shapes and types are morphologically assessed. The bones are classified side wise according to its morphological features. The guidelines for taking parameters are as provide:

1. ***Superior-Transverse diameter of suprascapular notch:*** Maximum distance between superior most edges of the supra scapular notch.
2. ***Maximal depth of suprascapular notch:*** Maximum vertical distance between the deepest point at the base of the supra scapular notch to an imaginary line between the superior edges of the notch.
3. ***Types of suprascapular notch:*** It is classified as; type-I is ill-defined, type-II is 'V'-shaped, type-III is 'U'-shaped, type-IV is completely ossified and type-V is absent notch.
4. ***Morphological length of scapula:*** Distance from superior angle to the inferior angle of Scapula.
5. ***Morphological width of scapula:*** Maximum transverse diameter between the medial border of the scapula, where the spine meets the body of scapula and the anterior lip of glenoid.
6. ***Scapular Index:*** Calculated by the equation:
   $(\boldsymbol{Scapular\ width} \div \boldsymbol{Scapular\ length}) \times \mathbf{100}\ \%$
7. ***Maximal width of scapular spine:*** Distance between the most dorsal point of the crest of spine and the anterior edge.
8. ***Projection length of scapular spine:*** Distance between the spinal axis at the vertebral border to the most distal point of the acromion process.
9. ***Maximal length of coracoid process:*** Distance between the most lateroventral point of the coracoid and the base of the most medial point of the coracoid, often just above the scapular notch.

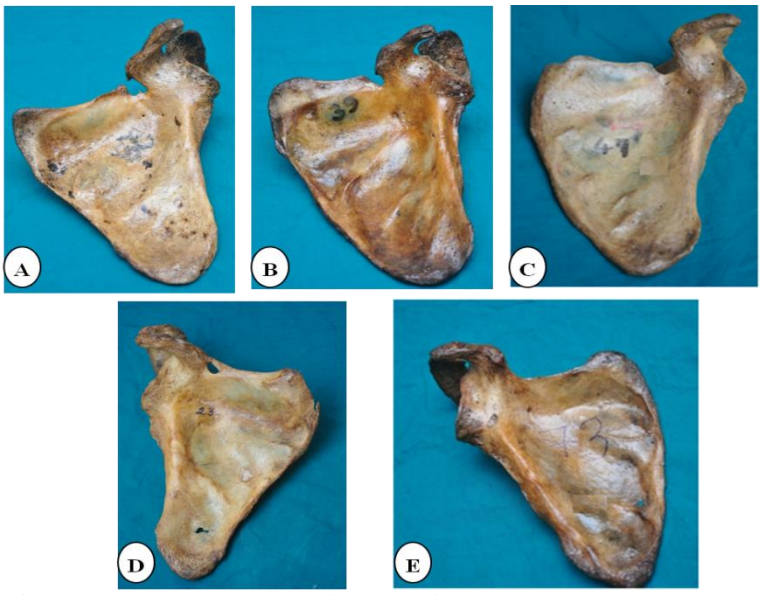


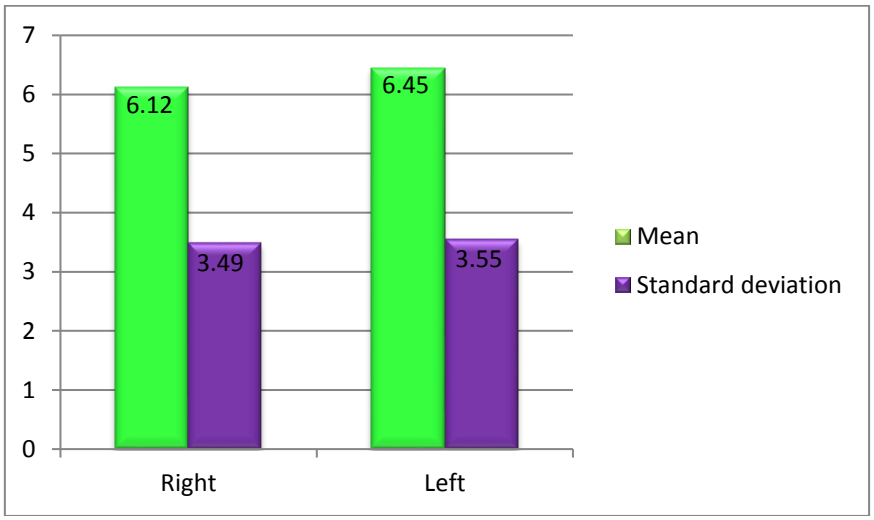
Figure 1: Different types of suprascapular notch: (A) - Ill defined type of suprascapular notch, (B) - 'V'shaped suprascapular notch, (C) - 'U'shaped suprascapular notch, (D) - Completely ossified suprascapular notch, (E) - Absent suprascapular notch.

OBSERVATION AND RESULT

In this study 200 Scapulae were measured for the osteometric differences between right and left sides, out of which 100 were right sided and 100 were left sided bones.

Superior-Transverse diameter of suprascapular notch

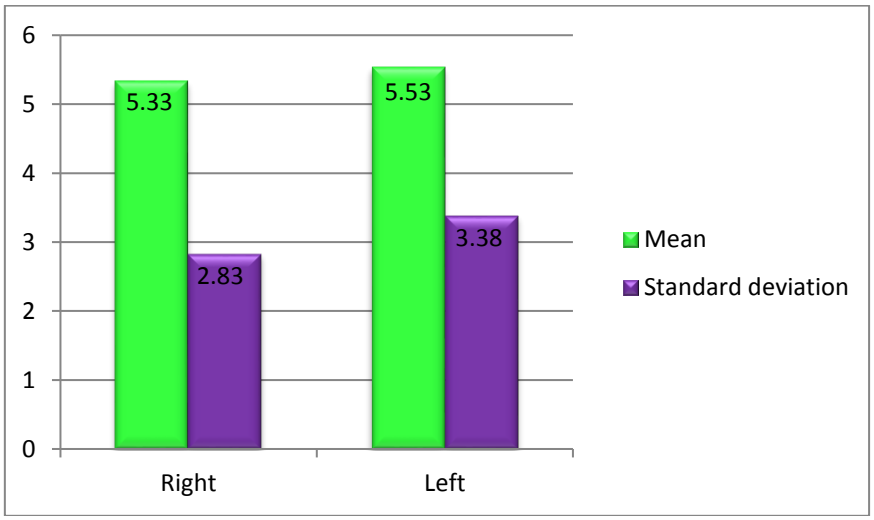
As shown in Graph-1, the maximum superior transverse diameter of the suprascapular notch of right scapulae varied from 0mm to 13mm with an average of 6.12±3.49 and that of left scapulae varied from 0mm to 13mm with an average of 6.45±3.55. The left superior transverse diameter of supra scapular notch is greater than the right side by 0.33mm which is statistically not significant.



Graph 1: Bar graph showing the difference between the right and left superior-transverse diameter of suprascapular notch.

Maximal depth of suprascapular notch

As shown in Graph-2, the maximal depth of the suprascapular notch of right scapulae varied from 0mm to 11mm with an average of 5.33±2.83 and that of left scapulae varied from 0mm to 19mm with an average of 5.53±3.38. The maximal depth of the left suprascapular notch is greater than the right side by 0.2mm which is statistically not significant.

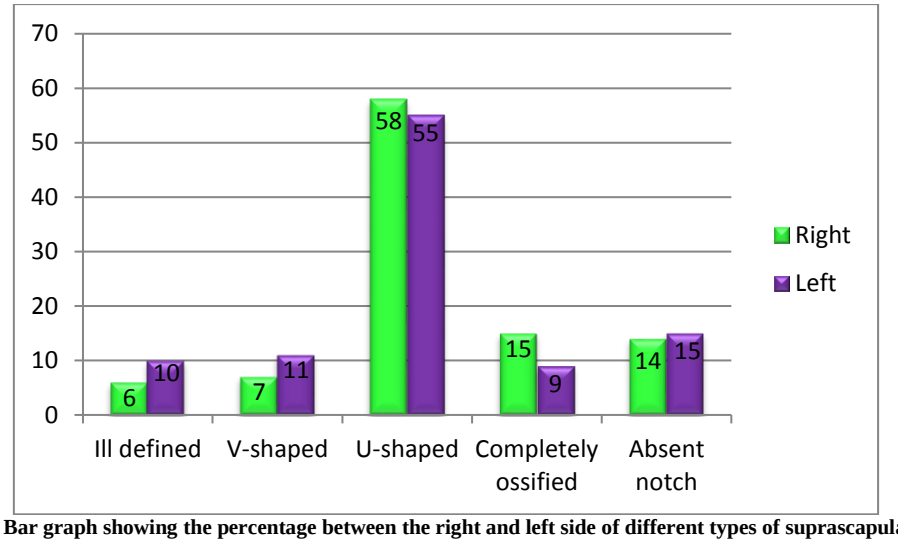


Graph 2: Bar graph showing the difference between the maximal depth of right and left suprascapular notch.

Types of suprascapular notch

As shown in Graph-3, the maximum percentage of different types of suprascapular notch of right sided scapulae varied from 6% in Ill defined type, 7% in V-shaped and 58% in U-shaped, 15% in

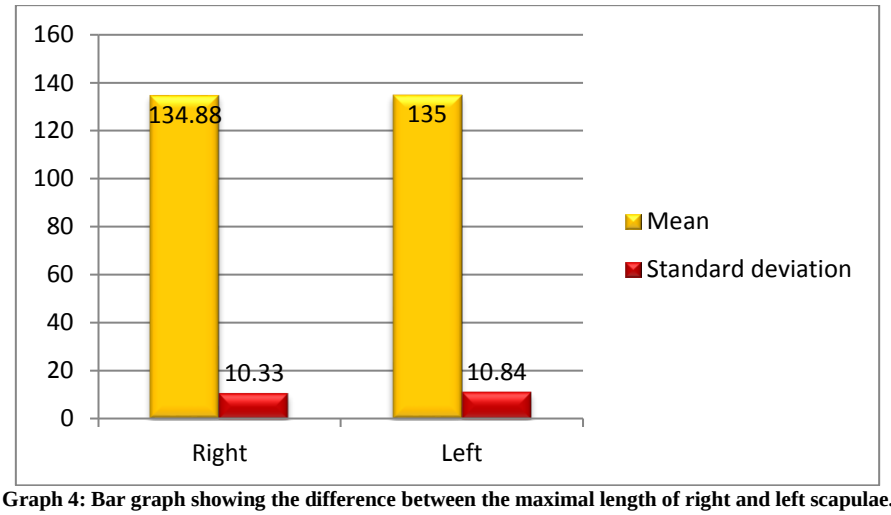
completely ossified and 14% of absent notch and left scapulae varied from 10% in Ill defined, 11% in V-shaped and 55% in U-shaped, 9% in completely ossified and 15% of absent notch. Both the right and left scapulae shows more of 'U'-shaped suprascapular notch.



Graph 3: Bar graph showing the percentage between the right and left side of different types of suprascapular notch.

Morphological length of scapula

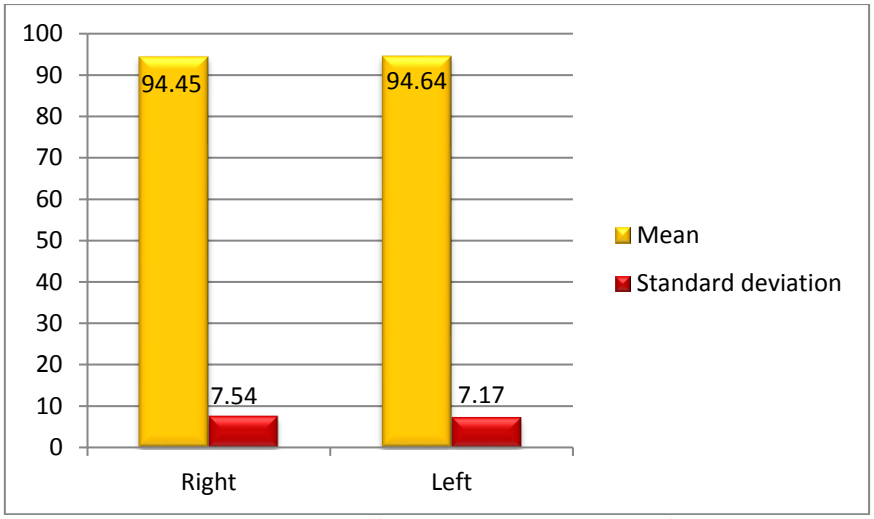
As shown in Graph-4, the maximal length of the right scapulae varied from 111mm to 161mm with an average of 134.88 ±10.33mm. The length of the left scapulae varied from 110 to 165mm with an average 135 ±10.84mm. It has been observed that the right scapulae was shorter than the left scapula by 0.12mm. Although the length of the left scapulae was found to be marginally more than that of the right scapulae, the differences were statistically insignificant.



Graph 4: Bar graph showing the difference between the maximal length of right and left scapulae.

Morphological width of scapula

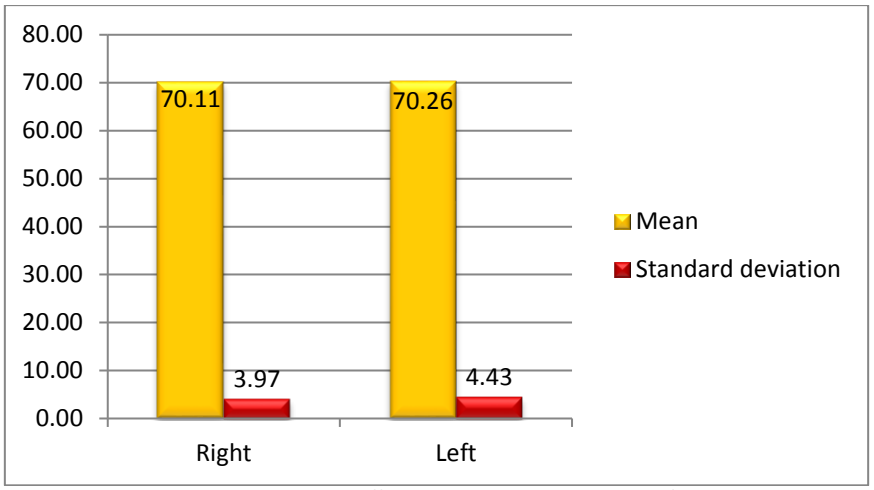
As shown in Graph-5, the breadth of the right scapulae varied from 77mm to 112mm with an average of 94.45 ±7.54mm. The breadth of the left scapulae varied from 81 to 111mm with an average of 94.64 ±7.17mm. It has been observed that the left scapulae is broader than the right scapulae by just 0.19mm, the differences were statistically insignificant.



Graph 5: Bar graph showing the difference between the right and left scapular width.

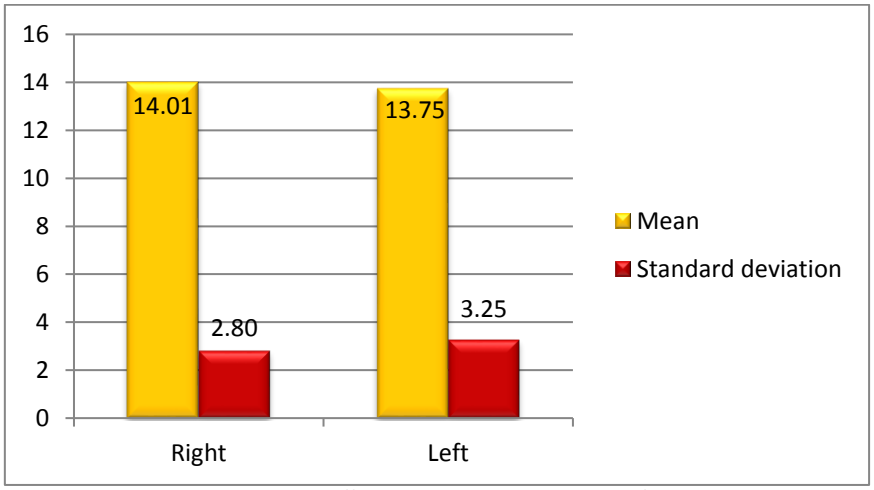
Scapular Index

As shown in Graph-6, the mean of right scapular index was 70.11±3.97 which is lower than the left scapular index 70.26±4.43 by 0.15mm. There is no significant statistical correlation between right and left side of scapulae.



Graph 6: Bar graph showing the difference between the right and left scapular index.

Maximal width of scapular spine

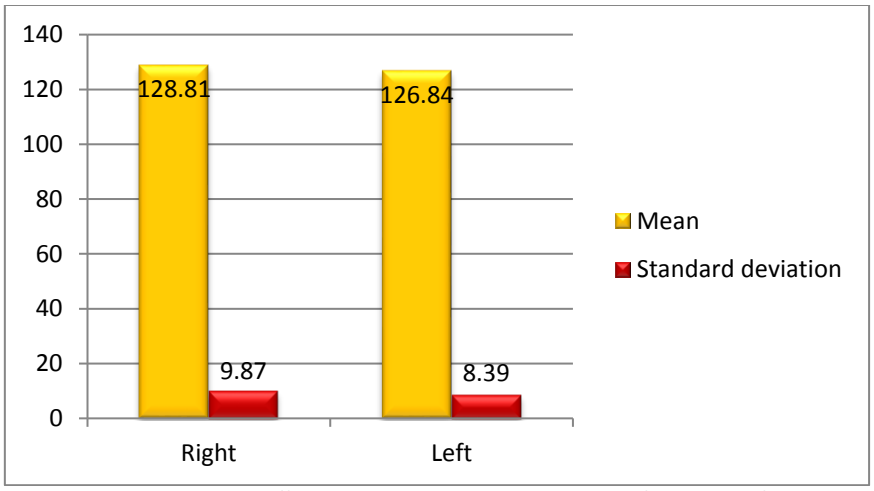


Graph 7: Bar graph showing the difference between the right and left scapular spine width.

Width of right scapular spine varied from 9mm to 27mm with an average of 14.01±2.80mm and that of left scapulae varied from 7mm to 23mm with an average of 13.75±3.25mm as shown in Graph-7. Right scapular spine width was 0.26mm broader than left scapulae which was not statistically significant.

Projection length of scapular spine

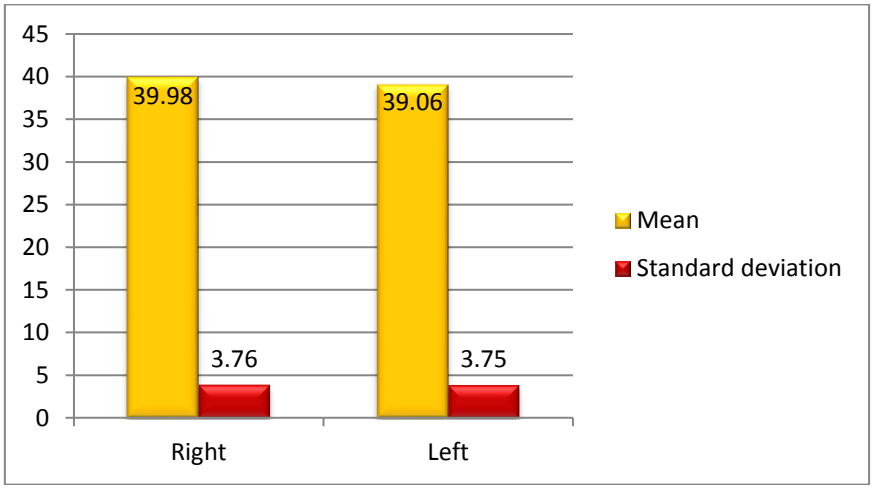
Projection length of right scapular spine varied from 108mm to 150mm with an average of 128.81±9.87mm and that of left scapulae varied from 103mm to 146mm with an average of 126.84±8.39mm as shown in Graph-8. Right scapular spine length was 1.97mm longer than left scapulae which was not statistically significant.



Graph 8: Bar graph showing the difference between the projection length of right and left Scapular spine.

Maximal length of coracoid process

As shown in Graph-9, the maximum length of coracoid process of right scapulae varied from 31mm to 48mm with an average of 39.98±3.76 and left coracoid process length varied from 32mm to 48mm with an average of 39.06±3.75. Right side coracoid process length is 0.92mm longer than left side which is statistically insignificant.



Graph 9: Bar graph showing the difference between the maximum length of coracoid process on right and left side.

DISCUSSION

During the evolution of the upper extremity, the scapula more than any other bone of the shoulder girdle, reflects momentous alterations that have been brought about by increased functional demands of a prehensile limb. Changes in posture provided the stimulus which

initiated the numerous morphologic changes. Impingement of the rotator cuff beneath the coracoacromial arch has been recognized as one of the cause for chronic disability of the shoulder.

In the present study an effort has been made to know about the comparative differences between the right and left scapulae from certain parameters in the south Indian population. Several authors have attempted to determine the side differences in course of their research. This has been performed in a variety of ways, including direct measurement of dry scapulae, measurement of scapulae from fresh or embalmed cadavers, radiographic measurement of scapulae harvested from cadavers and radiographic measurement in living patients. These studies have been performed on different populations. Evaluation and comparison of present data with the previous study reveals several differences as well as similarities.

Morphological length of scapula

In the present study [Graph-4], the average length of right scapulae was 134.88±10.33mm and that of the left scapulae was 135±10.84mm. Though the length of the left scapulae was slightly more, it was statistically insignificant. This shows that the length of left scapulae was slightly longer than that of the right scapulae.

Von Schroeder HP et al measured the average length of the scapulae in Canadians which was 155+/-16mm, compared to the South Indians whose average length of right scapulae was 134.88±10.33mm and that of the left scapulae was 135±10.84mm. This suggested that Canadian scapulae are longer than that of the South Indian population[15].

Gretchen R et al studied the scapular measurements in the Wichita State University, and explained that the maximum length of the scapulae was 162.49±9.65mm, when compared to our study population and was significantly more. Therefore, the Lexington population scapulae are longer compared to the South Indian population[16].

In the present study, the length of scapulae and the maximal depth of suprascapular notch was more on left side. Which shows that humans with longer scapulae will have deeper notches.

Morphological width of scapula

The present observations [Graph-5] showed that the average breadth of the right scapulae was 94.45±7.54mm and the left scapulae was 94.64±7.17mm. Though the left scapulae value was slightly more, it was not statistically significant. This suggested that the left scapulae was slightly broader than right scapulae.

Gretchen R et al studied the maximum breadth of the scapulae which was 106.89±6.16mm. In our study the average breadth of the right scapulae was 94.45±7.54mm and the left scapulae was 94.64±7.17mm. So when compared to the study done by Gretchen R et al in Lexington population, the scapulae of South Indian population was less broader[16].

Also the superior transverse diameter of suprascapular notch was more on left side compared to the right side, which shows that in wider scapulae there can be shallow suprascapular notch.

Projection length of Scapular spine

The average length of right scapular spine was 128.81±9.87mm and the left scapulae was 126.84±8.39mm in the present study [Graph-8]. Though the right scapulae value was slightly more, it was not statistically significant. This suggested that the right scapular spine was slightly longer than left scapular spine.

In the study done by Iordanidis left side spine 132±9.2mm was longer than right side 130±7.4mm which was slightly similar to our study having 128.81±9.87mm on right side and 126.84±8.39mm on left side, which was in accordance with our study[17].

Von Schroeder HP et al measured the length of the spine from the medial edge of scapulae to the lateral edge of acromion

was 134+/-12 mm in Canadian population, which was compared to the South Indians having 128.81±9.87mm on right and 126.84±8.39mm on left scapular spine. This suggests that Canadian scapulae had longer scapular spine than the South Indian population[15]. The study by Gretchen R et al showed higher values as 141.33±7.88mm in the length of spinous process compared to the present study. This suggests that Lexington population scapular spine was longer than our study population[16].

Maximal length of coracoid process

The average length of right coracoid process was 39.98±3.76mm and the left side was 39.06±3.75mm in the present study [Graph-9]. Though the right scapulae value was slightly more, it was not statistically significant. This suggested that the right scapular coracoid process was slightly longer than left scapular coracoid process.

Gretchen R et al studied the length of coracoid process as 46.23±3.47, which was slightly higher when compared to the present study, being right 39.98±3.76mm and the left coracoid process 39.06±3.75mm, which was significantly more than our study population[16].

Coskun N et al in Turkish population, recorded the length of coracoid process which was 39.4±7.9mm, which was almost similar to that of our study population having right side 39.98±3.76mm and the left coracoid process 39.06±3.75mm. In their study, right sided coracoid process was longer than the left side which was in accordance with our study[18].

Scapular index

Scapular index expresses scapular breadth as percentage of scapular height so if scapular index is less means scapulae will be longer, and if scapular index is more, then scapulae is shorter. In the present study [Graph-6], the mean of right scapular index was 70.11±3.97% which was lower than the left scapular index 70.26±4.43%. There was no significant statistical correlation between right and left side. This shows that left scapulae was slightly shorter than right scapulae.

Flower and Garson measured the scapular index of Europeans and Negroes. European scapular index was 65.91% and that of Negroes was 68.16%, which showed that Negroes had shorter scapulae than compared to the Europeans [19]. In present study, right scapular index was 70.11±3.97% and left scapular index 70.26±4.43% which was more than Europeans and Negroid population suggesting that scapulae of South Indian population were shorter than the European and Negroid populations.

Table 1: Comparison of suprascapular notch in the present study with the study conducted by M. Polguj et al in 2011(MD>STD).

Measurements and indices of the scapula	Scapulae with longer maximal depth (MD>STD) than superior transverse diameter			
	M. Polguj et al		Present study	
	Mean (mm)	Standard deviation	Mean (mm)	Standard deviation
Length of glenoid cavity	38.55	3.48	3.577	.3568
Width of glenoid cavity	27.83	2.97	2.485	.2552
Glenoid cavity index (%)	72.3	5.8	69.8544	7.76692
Length of acromion	45.31	6.74	4.621	.7296
Morphological length	155.71	11.49	13.588	1.1343
Morphological width	99.1	7.45	9.488	.7388
Scapular index (%)	63.7	3.5	69.9813	4.30584
Maximal width of scapular spine	43.32	6.26	1.413	.3071
Projection length of scapular spine	132.43	8.97	12.800	.8916
Maximal length of coracoid process	44.6	4.46	4.025	.3762

According to study done by Polguj et al, scapulae with longer maximal depth (MD>STD), projection length of scapular spine, maximal width of scapular spine, length of acromion, maximal length of the coracoid process, length and width of the glenoid cavity were higher than in scapulae with longer superior transverse diameter[20].

In the present study, in 200 scapulae MD>STD was in 48 scapulae. Length of glenoid cavity, width of glenoid cavity, glenoid index, morphological length of scapula, morphological width of scapula and maximal length of coracoid process were higher than in scapulae with longer superior transverse diameter.

Table 2: Comparison of suprascapular notch in the present study with the study conducted by M. Polguj et al in 2011(STD>MD).

Measurements and indices of the scapula	Scapulae with longer maximal depth (STD>MD) than superior transverse diameter			
	M. Polguj et al		Present study	
	Mean (mm)	Standard deviation	Mean (mm)	Standard deviation
Length of glenoid cavity	38.09	2.97	3.476	.3086
Width of glenoid cavity	27.52	2.36	2.410	.2355
Glenoid cavity index (%)	72.4	5.3	69.5142	6.07430
Length of acromion	44.33	5.26	4.694	.6337
Morphological length	156.4	11.75	13.489	1.0285
Morphological width	100.84	6.52	9.435	.7134
Scapular index (%)	64.76	3.15	70.0428	3.84743
Maximal width of scapular spine	42.48	5.26	1.391	.3079
Projection length of scapular spine	134.36	8.17	12.841	.9426
Maximal length of coracoid process	43.47	3.73	3.955	.3874

According to the study done by Polguj et al, scapulae with longer superior transverse diameter (STD>MD), morphological length, morphological width, width-length index and glenoid cavity index were higher than in bones with longer maximal depth[20].

According to the present study, in 200 bones 104 scapulae showed longer STD (STD>MD), length of acromion process, projection length of spine and scapular index were higher than in bones with longer maximal depth.

Types of suprascapular notch

In the present study [Table/Graph-3] [Fig.-1], the maximum percentage of different types of suprascapular notch of right sided scapulae varied from 6% in Ill defined type, 7% in V-shaped, 58% in U-shaped and 15% were completely ossified and left side scapulae varied 20 from 10% in Ill defined, 11% in V-shaped, 55% in U-shaped and completely ossified were 9%. Which shows that both right and left scapulae shows more of 'U-shaped' suprascapular notch. Also absence of suprascapular notch in right sided scapulae was seen in 14% and in left was 15%.

Gargi Soni et al done a study in Malaysian population and concluded that 58% were U-shaped, 7% were V-shaped, 14% of completely ossified notch and 2% of absent notch, which was almost same as our study[21].

Complete ossification of suprascapular notch was seen in 7.3% in a study done by Natsis et al in German population. A study done by Ritika Sharma in North Indians shows 4% on the right side and 6% on left side with complete ossification of suprascapular notch in 100 scapulae[4,22].

A Study done by Rangachary et al in American population shows that 8% of absent notch, 28% in a study done by Wang et al in Chinese population and 15.46% in an Indian study done by Md. Jawed Akhtar. This shows that absent notch were common in Indian population[5,23,24].

CONCLUSION

The observations in the present study were:

The following parameters were more on right side compared to the left side

- Maximal width of scapular spine
- Projection length of scapular spine
- Maximal length of coracoid process

The following parameters were more on left side compared to right side

- Superior-Transverse diameter of suprascapular notch
- Maximal depth of suprascapular notch
- Morphological length of scapula
- Morphological width of scapula

- Scapular Index

The mean of scapular index of right sided scapulae was 70.11 and left side scapulae was 70.26. The scapular index shows that right scapulae was longer than the left scapulae. Also, there were more scapulae with longer superior transverse diameter of suprascapular notch (STD>MD) with 52% than scapulae with longer maximal depth of suprascapular notch (MD>STD) of 24%. And also STD=MD was present in 9% of scapulae. There was no statistically significant difference between anthropometric measurements of the group with higher maximal depth and the group with higher superior transverse diameter of the suprascapular notch.

The suprascapular notch was completely ossified in 12% of cases to form suprascapular foramen by the transverse scapular ligament which can result in suprascapular nerve entrapment syndrome and absence of suprascapular notch was seen in 14.5% of cases. Both right and left sided scapulae showed more of 'U'- shaped suprascapular notch.

The knowledge of normal anatomical features and morphometry of scapula are pre- requisites for the complete understanding of the functions of the shoulder joint. It is also useful in rotator cuff rupture, suprascapular nerve entrapment, and in surgical procedures like shoulder arthroplasty and joint fractures. Most common complications of surgeries include glenoid loosening, limitation of functions, etc. which needs a revision surgery. The acromion process plays a significant part in the formation as well as in offering stability to the shoulder joint. Measurements of the scapula and acromion process are vital because these may be involved in various shoulder girdle pathologies. This study would be useful for surgeons while working on the shoulder joint.

About the types and shapes of acromion process, we were able to classify both the right and left scapulae, which shows more of curved type and quadrangular shaped acromion process. The different shapes of acromion may also play important role in impingement syndrome.

This type of variations of acromion process should be kept in mind during surgery around the shoulder joint. It may also help anthropologists during their study on evolution of acromia. According to the shape of glenoid cavity, the maximum percentage of different shapes of glenoid cavity shows more of pear shaped in both right and left scapulae.

The clinical importance of this study rests on the contributory consequence of the shape of the anterior third of the acromion process in relation to the impingement syndrome as well as to rotator cuff tear. It is believed that rotator cuff lesions are observed mostly in the hooked acromia (62-66% of the cases of rotator cuff tear involve the type III acromion process)[25,26].

This relationship is explained by the decrease in the sizes of the subacromial space in hooked acromia, which more frequently leads to impingement of the rotator cuff[27].

Precise, knowledge of the range of various scapular parameters may be of great help for the orthopaedicians, prosthetists, radiologists and clinicians for better understanding of the shoulder joint and other lesions like impingement syndrome, glenohumeral arthritis, suprascapular nerve neuropathy, etc., and also in the diagnosis of congenital shoulder dysplasia. The study of different parameters of scapula may be of great help for the anthropologists also during the study on evolution of the bipedal gait. Thus, the present study would have great importance to anthropologists, orthopaedicians and the clinicians.

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