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ORIGINAL PAPER

Morphometric Study of Suprascapular Notch and Its Safe Zone in Indian Population

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ABSTRACT

Objectives: *The suprascapular notch is located on the lateral part of the superior border of the scapula. The anatomical variation of the notch is considered as one of the causes of suprascapular nerve entrapment. In the present study, we tried to evaluate the morphology and morphometry of the suprascapular notch of Indian human dry scapulae and to compare it with scapula morphometry, which is essential to understand and treat different causes of suprascapular nerve entrapment and to obtain a safe zone, which would be useful to avoid iatrogenic nerve lesion during open arthroscopic surgeries and help in designing implants for the shoulder joint.*

Methods: *This is an observational study, with a total of 200 human dry scapulae being observed, examined and studied in detail. The type of suprascapular notch was noted as per the description given by Rengachary et al. Digital Vernier Caliper was used for classical osteometric measurements of suprascapular notch parameters, posterior limit and posterosuperior limit of safe zone along with length and width of scapulae. A statistical data analysis was done.*

Results: *Out of the 200,scapulae examined by us, 172 (86%) showed the presence of suprascapular notch, while nine (4.5%) showed partial ossification and 19 (9.5%) complete ossification. Six types of suprascapular notches were observed: type I,51 (25.5%); type II 45 (22.5%); type III 64 (32%); type IV 11 (5.5%); type V 9 (4.5%), and type VI 20 (10%). Type III notch was more prevalent. The study showed a moderate positive linear correlation between the width of the scapula and the safe zone of type III notch, respectively.*

Conclusion: *Anatomical knowledge about the types of suprascapular notch and measurements is very helpful in the diagnosis and management of cases with shoulder pain due to suprascapular nerve entrapment and also while administering suprascapular nerve blocks for surgeries involving the shoulder region. Safe zone distances are very important for avoiding iatrogenic suprascapular nerve injuries during shoulder surgical procedures.*

Keywords: suprascapular nerve entrapment, suprascapular notch, scapula, safe zone.

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INTRODUCTION

The scapula is a thin bone placed on,the posterolateral aspect of the thoracic cage overlying, the 2nd-7th ribs. The suprascapular notch (SSN) is located on the superior border of the scapula at the anterolateral aspect just medial to the base of coracoid process (1). The SSN is bridged by the superior transverse scapular ligament (STSL); during the process of evolution, SSN is bridged by bone rather than ligament in some lower animals (2). The suprascapular nerve (SN) is a branch from the upper trunk of the brachial plexus; it passes successively through the suprascapular notch below the STSL and then through the spinoglenoid notch. The SN is prone to iatrogenic injury at these two notches due to its proximity to the operative field during shoulder surgeries. Suprascapular nerve injuries have become increasingly recognized as a cause of shoulder pain and dysfunction. In 1959, Kopell and Thompson (3) reported that compression of the SN caused suprascapular nerve entrapment. The STSL sometimes gets ossified and converts the SSN into a bony foramen, through which the SN travels. The safe zone is defined as an area within which iatrogenic injury to the SN is likely to be avoided. The smaller the size of the notch, the greater the chances of nerve entrapment and injury. The morphometry of SSN is important because it is a crucial landmark of SN during various surgical interventions; it is the main site of SN entrapment and it helps to measure the safe zone, which is useful for clinicians in safe advancement during shoulder surgery.

In the present study, notches are classified based on the description of Rengachary *et al* (4), since it is a simple, reproducible and objective method. De Mulder *et al* (5) and Warner *et al* (6) described the safe zone and stated that the distance between the SSN and the margin of the glenoid cavity was critical during open surgical procedures required for opening of the posterior shoulder region.

A number of variations occur in the shape of SSN from a discrete notch to "J" shape, "V" shape, and "U" shape. Classification of SSN has been done by various authors in different populations on the basis of vertical length, transverse diameter and shape of the notch. Rengachary *et al* (4) classified the SSN into six types based on the shape of the notch and ossification of STSL. Ticker *et al* (7) and Bayramolu *et al* (8) modified the classification of Rengachary and included only U-shaped and V-shaped notches, and the notch with ossification of the STSL. Natsis *et al* (9) and Michael Polguj *et al* (10) established a new method of classifying SSN morphology by using specific geometrical parameters.

The main objective of the present study is to evaluate anatomical knowledge on different types of SSN and their morphometry. This is very helpful in diagnosis and management of SN entrapment and safe zone, which is of surgical importance in avoiding iatrogenic SN injuries while administering SN blocks for surgical interventions involving the shoulder region. ❑

MATERIAL AND METHOD

The present observational study was carried out in the Department of Anatomy, Gandhi Medical College, secunderabad, Telangana, after obtaining the permission of institutional Ethical Committee. This study involved a detailed work on 200 Indian human dry scapulae of unknown sex and origin, in which SSN morphology and ossification of STSL was observed. Morphometric classical osteometric measurements of SSN, safe zone and scapulae were done using Digital Vernier Caliper and recorded in millimetres. The data obtained was analysed statistically using SPSS version 19 on Windows format. In the present study, the suprascapular notch was classified according to Rengachary's method (Figure 1).

The SSNs of each scapula were measured for the following details (Figures 2 and 3): 1) superior transverse diameter (STD) – the horizontal distance between superior corners of the SSN on the superior border of the scapula; 2) middle transverse diameter (MTD) – the horizontal distance between the opposite walls of the SSN at a mid-point of the MD and perpendicular to it; 3) maximum depth (MD) – the maximum value of the longitudinal measurements taken in the vertical plane from an imaginary line between the superior corners of the notch to the deepest point of the suprascapular notch; and 4) the safe zone, which has two safe limits: A) posterior limit (M1) – the distance between the deepest point of the SSN and the supraglenoid tubercle; and B) posterosuperior limit (M2) – the distance between the medial wall of the spinoglenoid notch at the base of scapular spine and the posterior rim of the glenoid cavity.

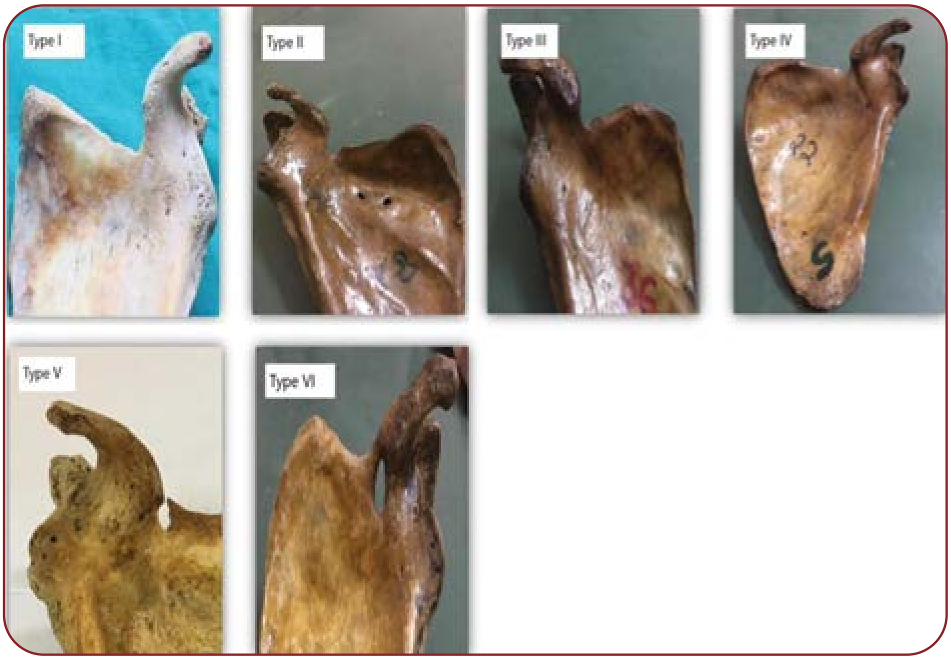

FIGURE 1. Types of suprascapular notch based on Rengachary classification

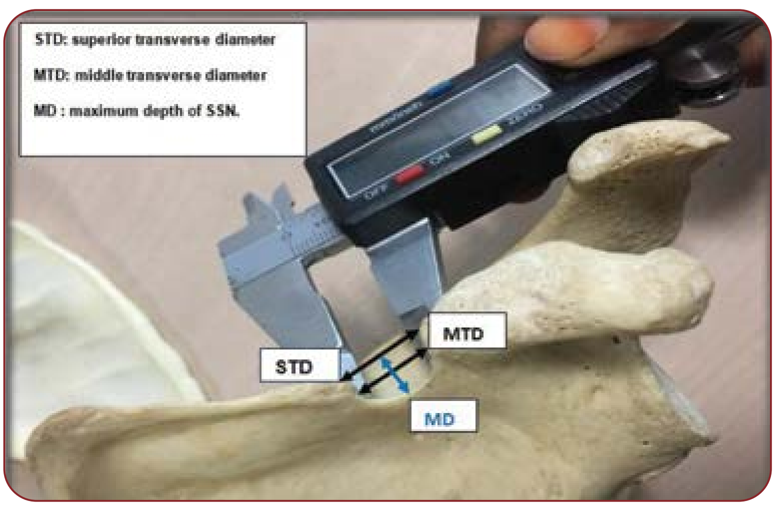

FIGURE 2. Dimensions of suprascapular notch showing the method of measurement. STD: superior transverse diameter; MTD: middle transverse diameter; MD: maximum depth

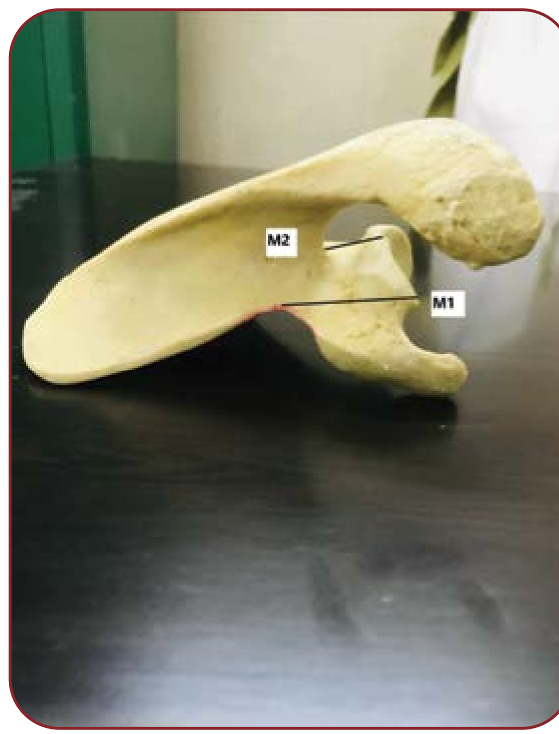

FIGURE 3. Safe zone measurements. M1: posterior limit of safe zone; M2: posterosuperior limit of the safe zone

Each scapula was measured for the following details (Figure 4): 1) maximum scapular length (M3) – the distance from the superior angle to the inferior angle of scapula; and 2) maximum scapular width (M4) – the maximum transverse diameter between the medial border of the scapula, where the spine meets the body of the scapula, to the anterior lip of the glenoid. ❑

RESULTS

In the present study, a total of 200 scapulae were analysed, out of which 106 were right sided and 94 left sided, 172 (86%) showed the presence of SSN, while nine (4.5%) showed partial ossification and 19 (9.5%) complete ossification. Among the various types of SSN, type III was the most prevalent (32.0%), followed by type I (25.5%), type II (22.5%), type VI (10%), type IV (5.5%) and type V (4.5%) (Table 1). Superior transverse diameter (STD) and middle trans-

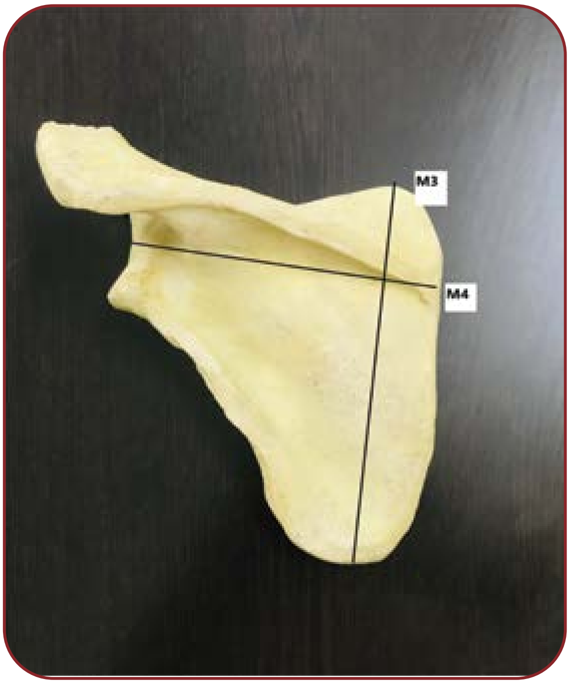

FIGURE 4. Measurements of scapula. M3: maximum scapular length; M4: maximum scapular width

verse diameter (MTD) showed a highly significant p-value <0.01 for various types of SSN based on Rengachary classification. The mean±standard deviation of each parameter of SSN is shown in Table 2. In scapulae where the notch was absent and in those with a type I and type VI, measurements were not recorded. STD and MTD of type III notch had greater dimensions, while type V had the least. Types III and II had maximum depth (MD) and type IV, the least. From the above-mentioned observations, it is inferred that type III notch has greater transverse diameter and maximum depth making the notch wide, so the chance of nerve entrapment is lower when compared with type IV, which has narrow dimensions, so there are higher chances of nerve entrapment. Based on morphological appearances, U shaped notches were commonly observed (39.3%), followed by V (31.6%) and J shaped (28.1%) notch, respectively.

The mean distance of the posterior limit (M1) of the safe zone between the SSN and supraglenoid tubercle is 30.51±2.71 mm, with type I SSN displaying the greatest diameter and type V,

TABLE 1. Various types of SSN and its frequencies based on Rengachary classification

S. No	Type	Right n (%)	Left n (%)	Total n (%)
1.	Type I	26(13.0)	29 (14.5)	55 (27.5)
2.	Type II	25 (12.5)	20 (10.0)	45 (22.5)
3.	Type III	31 (15.5)	29 (14.5)	60 (30)
4.	Type IV	8 (4.0)	3 (1.5)	11 (5.5)
5.	Type V	7 (3.5)	2 (1.0)	9 (4.5)
6.	Type VI	9 (4.5)	11 (5.5)	20 (10)
	TOTAL	106 (53)	94 (47)	200 (100) = N

TABLE 2. Mean ± standard deviation of various parameters of SSN

Type of notch (Rengachary classification)	STD	MTD	MD
Type I	-	-	-
Type II	9.22 ± 2.58	5.94 ± 1.74	6.35 ± 2.12
Type III	9.69 ± 2.53	7.46 ± 2.11	8.04 ± 2.56
Type IV	6.31 ± 1.27	4.05 ± 1	5.92 ± 8.1
Type V	6.04 ± 3.02	4.72 ± 1.43	8.36 ± 2.66
Type VI	-	-	-
p-value	<0.01**	<0.01**	0.02*

**correlation is highly significant when p-value <0.01; STD: superior transverse diameter; MTD: middle transverse diameter; MD: maximum depth

TABLE 3. Mean and standard deviation of posterior limit (M1) and posterosuperior limit (M2) of safe zone

Type of notch	M1 (mean ± standard deviation)	M2 (mean± standard deviation)
Type I	30.51 ± 2.71	15.75 ± 2.37
Type II	30.08 ± 3.24	15.77 ± 2.17
Type III	29.61 ± 3.24	15.96 ± 2.63
Type IV	29.33 ± 2.62	14.95 ± 1.45
Type V	28.26 ± 2.72	14.77 ± 1.03
Type VI	28.29 ± 2.71	16.16 ± 2.32

TABLE 4. Correlation between width of scapula (M4) with parameters of type III SSN and safe zone

Parameters of type III notch	M4		Result
	r-value	p-value	
M1	0.63	<0.0001	Moderate positive linear relationship
M2	0.38	=0.0017	Moderate positive linear relationship
STD	0.30	=0.015	Weak positive linear relation ship
MTD	0.05	=0.015	Negligible linear relationship

M1: distance between the deepest point of the SSN and the supra glenoid tubercle; M2: the distance between the medial wall of the spinoglenoid notch at the base of scapular spine and the posterior rim of the glenoid cavity; M4: width of scapula; STD: superior transverse diameter; MTD: middle transverse diameter

TABLE 5. Correlation between length of scapula (M3) with maximum depth (MD)of type III SSN

Parameters of type III notch	MD	
M3	r-value	p-value
	-0.264	0.83

M3: length of scapula; MD: maximum depth

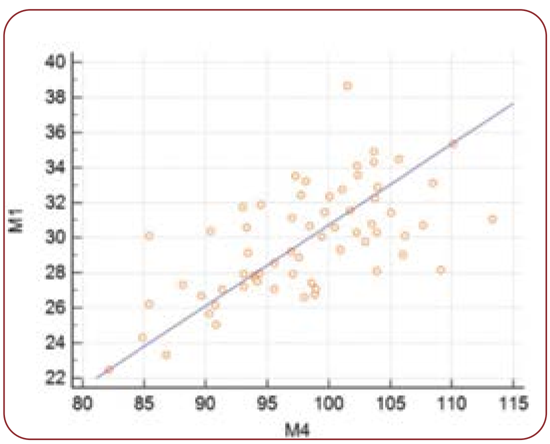

FIGURE 5. Correlation between M1 and M4 of type III notch. M1: posterior limit of safe zone; M4: width of scapula

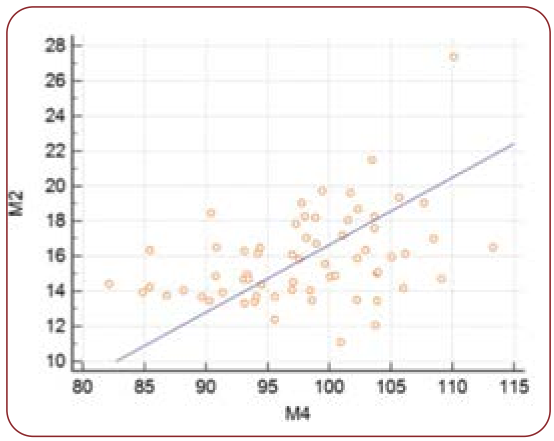

FIGURE 6. Correlation between M2 and M4 of type III notch. M2: posterosuperior limit of safe zone; M4: width of scapula

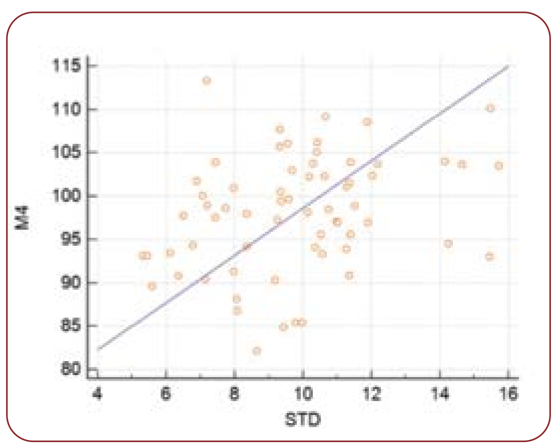

FIGURE 7. Correlation between M4 and STD of type III. M4: width of scapula; STD: superior transverse diameter of suprascapular notch

the least. The mean distance posterosuperior limit (M2) of safe zone between the posterior rim of the glenoid cavity and the medial wall of spinoglenoid notch at the scapular spine is 16.16 ±2.32 mm, with type VI SSN showing the greatest diameter and type V, the least. Measurements of 'safe zone' distances in various types of notches are shown in Table 3.

In this study, type III notch is most prevalent. We individually correlate the width of scapula (M4) with STD, MD, M1 and M2 of type III SSN (Table 4), and the length of scapula (M3) with MD of type III SSN (Table 5). A moderate positive linear correlation was seen between the width of scapula (M4) and safe zone (M1 and M2), respectively (Figures 5 and 6). A weak positive linear correlation was seen between the

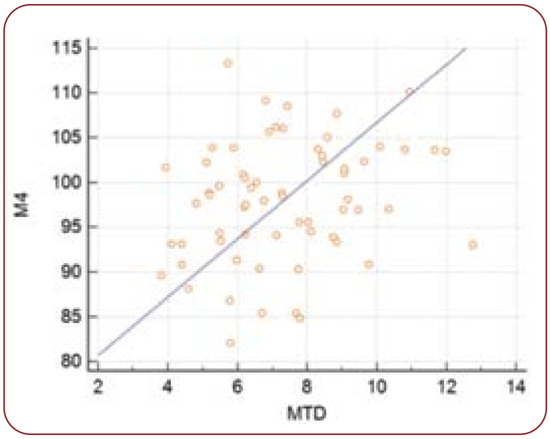

FIGURE 7. Correlation between M4 and MTD of type III. M4: width of scapula; MTD: middle transverse diameter of suprascapular notch

width of scapula (M4) and STD of SSN (Figure 7), and a negligible correlation was seen with MTD of SSN (Figure 8). However, a negative correlation was found between the length of scapula and maximum depth (MD) of type III SSN. The Pearson correlation indexes between safe zone (M1 and M2) and the dimensions of type III SNN (width and depth) are shown in Table 4. ❑

DISCUSSION

The SSN is an anatomical structure of great clinical importance because it is a probable site of SN compression. Suprascapular nerve entrapment is an acquired neuropathy secondary to nerve compression in the bony SSN more than spinoglenoid notch (11). The suprascapular nerve may be also injured during various surgical procedures such as blind drilling during arthroscopic Bankart surgery, labrum repair in the rotatory cuff tear of shoulder joint and decompression of suprascapular entrapment due to proximity of the nerve to the operative field (12). De Mulder *et al* and Warner *et al* (3) described that the distance between the SSN and the margin of the glenoid cavity was critical during open surgical procedures. The supraglenoid tubercle, posterior margin of the glenoid cavity and base of the scapular spine are used as landmarks during surgical interventions and its critical distance is used to provide a rough idea for safe advancement during surgeries in shoulder region and to avoid complications. Various authors classified SSN in different populations on the basis of notch parameters and shape (4, 17, 13).

In their study, Rengachary *et al* (4) reported six types of suprascapular notches: type I – the entire superior border of the scapula shows a wide depression from the medial superior angle to the base of the coracoid process; type II – a wide and blunt V-shaped notch; type III – symmetrical U-shaped notch with parallel margins; type IV – a small V-shaped notch; type V – similar to type III with the medial part of the ligament ossified; and type VI – with the ligament completely ossified and forming a foramen.

In the present study, we classified suprascapular notches based on Rengachary system. We found that type III SSN was the most prevalent (32%), which was in accordance with the studies of Rengachary *et al* (4), Sinkeet *et al* (13), Natsis *et al* (14), and Muralidhar *et al* (15), followed by type I (25.5%), type II (22.5%), type VI (10%), type IV (5.5%) and type V (4.5%). STD and MTD of type III notch is greater than that of the other notches, that of type V notch being the least. The maximum depth of type III and type II notches is greater than the other types of notches, while that of type IV notch is the least (Table 3). Thus, we could conclude that type III notch had a greater transverse diameter and depth, while type IV had the least depth and diameters, making the notch very narrow and hence, predisposing to SN injuries. Also, types V and VI notches, with partial and completely ossified superior transverse scapular ligament respectively, are more prone for suprascapular nerve entrapment. Also, the distance between the notch and posterior glenoid rim of safe zone is less in type IV notch, minimizing the safe zone for suprascapular surgery.

The size and shape of SSN plays an important part in predisposition of SN entrapment, assuming that the narrow notch provides more chances of nerve entrapment than the wider notch. A V-shaped notch would be more likely associated with nerve entrapment (11). In the present study, we found a moderate positive linear relationship between the posterior limit of safe zone in type III notch and width of scapula; also, a weak positive linear relationship was observed between STD of type III and M4 width of scapula, and a negative linear relationship between maximum depth (MD) of type III and M3 length of scapula, similarly to the study conducted by Polguji *et al* (5). It is assumed that wide scapulae may have wide SSN and longer scapulae may have deeper SSN.

According to Sinkeet *et al* (13), SN entrapment neuropathy is associated with SSN morphology and revealed three morphological variations (U, V and J). In the present study, we found that, among all notches, 39.3% were U shaped, 1.6% J shaped, and 28.1% V shaped, which was in accordance with the studies of Ticker *et al* (7) and Sinkeet *et al* (13).

A safe zone has been described to avoid injuries during surgical procedures, based on the critical distance within which they can be done safely (4). It has been reported that 2.3 cm from the glenoid rim at the level of the superior rim of the glenoid and 1.4 cm from the posterior rim of the glenoid at the level of the base of the scapular spine were safe (16). In this study, the mean distances are 2.9 and 1.6 cm, respectively, and in few scapulae, the corresponding distances were less than the mentioned safe zones, as commonly noted in type II, followed by type IV. Thus, extra caution is needed in carrying out shoulder procedures in the mentioned types of SSN. ❑

CONCLUSION

The present study provides values of morphometric measurements of suprascapular notch along with safe zone, which is essential for clinicians in making proper diagnosis like clinical screening in high risk populations by specialists in sport medicine, orthopaedics, radiology and general surgery, as well as surgical interventions using either open- or endoscopic techniques, coupled with histopathological studies on suprascapular nerve. It is also a helpful approach in designing implants for shoulder joint in India. This study is used in further investigations for the management of suprascapular nerve entrapment and provides additional data to the existing literature. ❑

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