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Original Research Article

An osteological study of measurement of safe zone to prevent iatrogenic suprascapular nerve injury and its correlation with type of suprascapular notch

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ABSTRACT

Background: Suprascapular nerve injury is commonly recognized as a cause of post-operative shoulder pain and rotator muscle dysfunction. The nerve may be injured during open or arthroscopic shoulder surgeries, due to its proximity to the operative field, particularly at the suprascapular and spinoglenoid notches. 'Safe zone' is defined as an area within which iatrogenic injury to the suprascapular nerve is likely to be avoided and it presents definitive limits. Aims of study were to identify morphometric variations of suprascapular notch (SSN), to measure distances from commonly used surgical landmarks to the possible course of suprascapular nerve so as to identify safe zone and to correlate safe zone with the type of suprascapular notch (SSN).
Methods: Total 200 dry human scapulae were obtained from Anatomy departments of three medical colleges of south Gujarat. Using digital vernier caliper, for each SSN, maximal depth (MD) and superior transverse diameters (STD) were measured and SSN classified into five types. The distances of suprascapular nerve from common surgical landmarks were measured as 'AB'; 'CD' and 'BD' to obtain safe zone. These distances were correlated with dimension of notch. Results of the present study were compared with previous studies in different populations.
Results: The suprascapular notch was classified into five types of which Type III (MD <STD) predominate (46.5%). The mean measurements of 'safe zone' distances vary with type of notch and correlate with notch dimensions.
Conclusions: The precise knowledge of morphology in the shoulder girdle region (especially, variations of SSN) is particularly essential to avoid iatrogenic nerve injuries during shoulder surgeries. The measurements of 'safe zone' help clinicians for safe advancement during surgeries. The safe zone varies with the type of suprascapular notch.

Keywords: Iatrogenic injury, Safe zone, Suprascapular nerve, Suprascapular notch

INTRODUCTION

The suprascapular nerve (SN) (C5, C6) is a branch from the upper trunk of brachial plexus.

It supplies motor branches to the supraspinatus and infraspinatus muscles and sensory branches to rotator cuff muscles and ligaments of the shoulder and acromioclavicular joints.[1-5] In its course, the nerve passes backward below the clavicle and disappears beneath the anterior border of trapezius.

It passes successively through the suprascapular notch below the superior transverse scapular ligament (STSL) and then through spinoglenoid notch beneath spinoglenoid ligament.[6-9] The nerve is prone to iatrogenic injury at these two notches due to its proximity to the operative field.

The supra scapular nerve may be injured during various surgical procedures such as blind drilling during arthroscopic Bankart and SLAP repair, advancement of rotator cuff during the repair of massive retracted rotator cuff tears arthroscopic anterior or double interval slide and also during decompression of suprascapular nerve entrapment.[10-17]

The nerve injury is common due to its proximity to the operative field. Mansat et al reported a nerve injury rate of 1.1% following rotator cuff repair.[17] Zanotti et al reported iatrogenic nerve palsy in 10 % patients following mobilization and repair of a massive tear of rotator cuff.[13,18] McIIveen et al reported not a single case of complete improvement in the iatrogenically injured cases.[9]

The suprascapular notch (SSN) is a depression in the lateral part of the superior border of the scapula. It is bridged by the superior transverse scapular ligament (STSL). The suprascapular nerve passes through the opening below the ligament, while suprascapular vessels pass above the ligament.[19] The morphometry of suprascapular notch is important because**:** (1) It is an important landmark for the suprascapular nerve during various shoulder operations. (2) Morphometric variations of the notch affect the measurement of safe zone. (3) It is the main site of compression of the suprascapular nerve.

Safe Zone is defined as an area within which iatrogenic injury to the suprascapular nerve is likely to be avoided.[15,16,20-24] The safe zone presents certain safe limits: (1) The posterior limit is represented as the distance measured from the supraglenoid tubercle to the deepest point of the suprascapular notch. (2) The posterosuperior limit is represented as the distance measured from the midline of the posterior glenoid rim to the base of the scapular spine. (3) The distance between base of scapular spine and deepest point of the suprascapular notch.[23,24]

The precise knowledge of morphology in the parascapular/shoulder girdle region (especially, variations of SSN) is particularly essential to avoid iatrogenic nerve injuries during surgeries. The measurements of 'safe zone' help clinicians for safe advancement during surgeries. The safe zone varies with the type of suprascapular notch. Several studies have been carried out to obtain a safe zone for operative procedures so as to avoid iatrogenic nerve lesions. The present study is based on the specific geometrical measurements of parameters of the SSN and measurements to find the safe zone to avoid iatrogenic nerve injury during surgery and also to find correlation between 'safe zone' and notch type.

METHODS

A total of 200 dry human scapulae of unknown age and sex were collected from the departments of Anatomy of (1) SMIMER Medical College, Surat, (2) Government Medical College, Surat and (3) GMERS Medical College, Valsad after obtaining permission from the heads of the concerned departments. Scapulae broken particularly in the study area were excluded. All the measurements were taken by classical osteometry using sliding digital vernier caliper (resolution up to 0.01 mm). Two types of measurements were taken.

Measurement of dimensions of suprascaular notch

Two dimensions were defined and measured for each suprascapular notch: (1) Maximal 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. (2) Superior transverse diameter (STD): the maximum value of the horizontal measurements taken in the horizontal plane between the corners of the SSN on the superior border of the scapula (Figure 1a). Based on above measurements, the Suprascapular notches were classified into five types (based on Polguj M 25). Type I: MD greater than STD; Type II: MD equal to STD; Type III: STD greater than MD; Type IV: A bony suprascapular foramen and Type V: A discrete suprascapular notch.

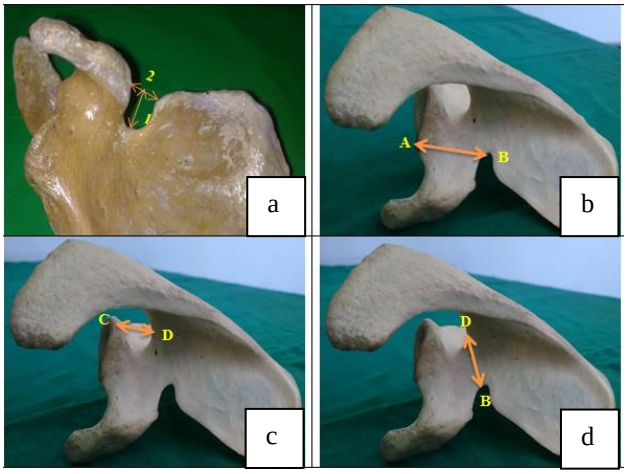

Figure 1: Dimensions of suprascapular notch and 'safe zone' distances; 1a: showing 1 →MD and 2→ STD; 1b: showing 'AB' distance; 1c: showing 'CD' distance; 1d: showing 'BD' distance.

Measurement of 'Safe zone' distance

To measure distance of suprascapular nerve, along its course, from commonly used surgical landmarks certain points were considered. 'A' is a point on the most superior part of the supraglenoid tubercle; 'B' is a point on the deepest part of the suprascapular notch; 'C' is a point at the middle of the posterior rim of the glenoid cavity and 'D' is a point at the middle of the base of spine of scapula.

In the scapulae having suprascapular foramen instead of notch (i.e. Type IV), a point on the lower margin of the

foramen is considered as point 'B' while in the scapulae having no notches (i.e. Type V), a point just medial to the root of the coracoid process was considered as point 'B'. The distances between abovementioned points were measured as 'AB' distance; 'CD' distance and 'BD' distance (Figure 1b-d).

Statistical analysis

Continuous variables were expressed by mean and standard deviation. Categorical variable were expressed in percentage. To find out the mean difference in between two independent groups independent 't' test applied and to determine the relation in between two independent continuous variable Pearson`s correlation technique applied. To find out the mean difference for more than two continuous variables ANOVA test has been used.

To know the relation between different groups multiple comparison test (Post hoc test - Turky's test) is applied. Level of significance is considered 95 %. All statistical analysis is done by SPSS 20 and Open EPI software.

The photographs were taken, using a digital camera (Sony 13.0 Mega pixels) and they were documented.

RESULTS

The suprascapular notches (SSN) were classified into five types, of which Type III predominate. Relative proportion of each notch type is shown in Table 1.

Table 1: Distrbution of different types of SSN (based on Polguj's classification).[25]

Type of SSN	Description	Total	Percentage
Type - I	MD > STD	32	16
Type - II	MD = STD = MTD	11	5.5
Type - III	MD < STD	93	46.5
Type - IV	Bony suprascapular foramen	12	06
Type - V	Descrete notch	52	26
	Total	200	100

(Where MD - maximum depth and STD - superior transverse diameter of SSN)

The measurements of 'safe zone' distances in all types of notches were collected and mean, standard deviation and range calculated for each distance and notch type. The results are shown in Table 2.

Table 2: Measurements of distances 'AB', 'CD' and 'BD'.

Type of SSN	Parameter	'AB' distance (mm)	'CD' distance (mm)	'BD' distance (mm)
Type I	Mean	28.23	15.39	22.48
	Std. Deviation	1.83	1.17	0.85
	Range	24.4 – 31.5	12.5 – 18.5	21.1 – 24.1
Type II	Mean	28.82	15.94	22.21
	Std. Deviation	1.41	0.8	0.87
	Range	25.8 – 34.3	14.8 – 17.7	21.2 – 23.5
Type III	Mean	28.42	15.08	22.83
	Std. Deviation	1.83	1.13	0.84
	Range	24.3 – 34.9	12.4 – 19.6	21.1 – 24.8
Type IV	Mean	26.62	15.61	22.9
	Std. Deviation	0.97	1.38	0.86
	Range	25.8 – 28.6	12.3 – 18.4	21.8 – 24.4
Type V	Mean	27.78	15.23	23.80
	Std. Deviation	0.85	0.98	0.69
	Range	26.1 – 29.4	12.4 – 16.9	21.9 – 24.9

(Where 'AB': distance between the supraglenoid tubercle and the deepest point of the SSN; 'CD': distance between posterior rim of the glenoid fossa and base of the scapular spine and 'BD': distance between base of the scapular spine and the deepest point of the SSN)

For AB distance

Highest mean value has been observed for Type II followed by Type III, Type I, Type V and least for Type IV. Lowest variation has been observed for type V. The difference in the mean value of AB between all five types is statistically significant. (p value - 0.001). When mean value of AB is compared for two types (Post Hoc test for multiple comparisons) significant difference is found between Type I and Type IV (p value - 0.022) and also between Type II and Type IV (p value - 0.0001).

For CD distance

Highest mean value has been observed for Type II followed by Type IV, Type I, Type V and least for Type

III. Lowest variation has been observed for Type II. The difference in the mean value of CD between all five types is not statistically significant.

For BD distance

Highest mean value has been observed for Type V followed by Type IV, Type III, Type I and least for Type II. Lowest variation has been observed for Type V. The difference in the mean value of BD between all five types is statistically significant. (p value - 0.0001). When mean value of BD is compared for two types (Post Hoc test for multiple comparisons) significant difference is found between Type I and Type V (p value - 0.0001), between Type II and Type V (p value - 0.0001) and between Type III and Type V (p value – 0.0001).

Table 3: Correlation between depth of notch (MD) with 'AB' and 'BD' distances in Types I, II and III SSN.

Type of SSN	Parameters	'r' value	'p' value
Type I	MD & AB	0.359	0.044 *
	MD & BD	- 0.240	0.186
Type II	MD & AB	0.181	0.593
	MD & BD	0.178	0.602
Type III	MD & AB	0.234	0.024 *
	MD & BD	0.099	0.343

Where r–Pearson's correlation coefficient, 'p'<0.05 - significant difference

As the deepest point of the notch is considered in measuring distances 'AB' and 'BD', correlation of these distances was checked with depth of notch in Types I, II and III SSN. These are shown in Table 3.

Correlation between MD and AB

A weak positive correlation found between depth of notch (MD) and AB distance in Type I, Type II and Type III. Correlation is statistically significant in Type I ('p'value-0.044) and also in Type III ('p' value-0.024).

Correlation between MD and BD

A weak negative correlation found between depth of notch (MD) and BD distance in Type I, while a weak positive correlation found between the same parameters in Type II and Type III. Correlation is statistically not significant in any type.

DISCUSSION

The suprascapular nerve may be injured during various surgical procedures (as mentioned in the introduction) due to proximity of the nerve to operative field. The supraglenoid tubercle, posterior margin of the glenoid cavity and base of the scapular spine are used as landmarks during surgeries.

Table 4: Studies concerned with measurement of 'safe zone' in different populations of the world.

Study by	Population	No. of scapula	'Safe zone' distances measured
Amal Mehdy et al[26]	Egyptian	132	distance which corresponds with 'BD' of present study
Shivaleela et al[27]	Tumkur, Karnataka (Indian)	110	distances which correspond with 'AB' and 'CD' of present study
Sinkeet et al[28]	Kenyan	138	distances which correspond with 'AB' and 'CD' of present study
Vyas K et al[29]	Middle Gujarat (Indian)	300	distances which correspond with 'AB' and 'CD' of present study
Wang H et al[30]	Chinese	295	distances which correspond with 'AB', 'CD' and 'BD' of present study
Present study	South Gujarat (Indian)	200	'AB', 'CD' and 'BD'

Table 5: Mean AB distance (in mm) in different studies of the world.

Type of SSN	Description of SSN	Shivaleela et al[27]	Sinkeet et al[28]	Vyas K et al[29]	Wang H et al[30]	Present study
Type I	MD>STD	31.45	27.35	27.52	31.59	28.23
Type II	MD=STD	30.62	30.16	27.10	33.09	28.82
Type III	MD<STD	31.51	29.03	27.44	33.33	28.42
Type IV	Bony foramen	30.0	29.14	28.75	29.77	26.62
Type V	Absent notch	31.62	29.15	28.33	37.48	27.78

Table 6: Mean CD distance (in mm) in different studies of the world.

Type of SSN	Description of SSN	Shivaleela et al[27]	Sinkeet et al[28]	Vyas K et al[29]	Wang H et al[30]	Present study
Type I	MD > STD	15.75	16.5	15.61	16.28	15.39
Type II	MD = STD	16.80	16.2	15.56	16.43	15.94
Type III	MD < STD	15.30	17.2	15.61	16.36	15.08
Type IV	Bony foramen	15.90	16.0	16.99	17.27	15.61
Type V	Absent notch	15.23	14.5	15.96	16.89	15.23

The relative distance of the suprascapular nerve from these landmarks as it passes through the suprascapular notch and spinoglenoid notch has been measured to provide rough idea for safe advancement during surgeries and to avoid complications. Several authors have tried to measure one or more of the abovementioned distances in their studies. Some of them have also classified suprascapular notches into different types and also correlated safe zone distances with scapular dimensions. A list of such studies, the population in which conducted, sample size and parameters included in the studies are shown in Table 4.

Table 7: Mean BD distance (in mm) in different studies of the world.

Type of SSN	Description	Amal Mehdy et al[26]	Wang H et al[30]	Present study
Type I	MD > STD	21.06	20.13	22.48
Type II	MD = STD	-	-	22.21
Type III	MD < STD	22.03	20.80	22.83
Type IV	Bony foramen	20.0	17.70	22.90
Type V	Absent notch	24.75	20.64	23.80

The mean value of safe zone distances varies with type of suprascapular notch in each of the above mentioned studies. Different studies revealed variable results. A Comparative analysis of results of such studies with the present study for distances 'AB', 'CD' and 'BD' is shown in Tables 5-7 respectively.

Correlation between dimensions of notch and safe distance in various studies

Amal Mehdy et al found a highly significant negative correlation between depth of the notch and distance BD in types II and III scapular notches and no other statistically significant correlations between measured parameters of safe distance with the dimensions of suprascapular notches.[26]

Shivaleela et al, Sinkeet et al, Vyas K et al and Wang H et al reported no significant correlation between dimensions of notch and safe distances 'AB', 'CD' and 'BD'.[27-30] Also there was no significant difference of measured parameters between various types. In present study a weak positive correlation found between depth of notch (MD) and AB distance in Type I, Type II and Type III. The correlation is statistically significant in Type I ('p'value-0.044) and also in Type III ('p' value-0.024). A weak negative correlation found between depth of notch (MD) and BD distance in Type I, while a weak positive correlation found between the same parameters in Type II and type III. However correlation was statistically not significant in any type.

CONCLUSION

It can be concluded from the present study that measurement of safe zone vary with the type of notch and has variable correlation with dimensions of notch. The morphological variations of suprascapular notch must be considered to avoid iatrogenic suprascapular nerve injury. The data regarding the safe zone helps the clinicians in the preoperative evaluation of patients and also during surgery to make a decision about the safe advancement in the operative field. Since the present study was performed with a limited number of scapulae, more cadaveric, radiological and clinical studies need to be done.

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