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Morphometry of suprascapular notch in Egyptian dry scapulae and its correlation with measurements of suprascapular nerve safe zone for clinical consideration

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SUMMARY

The suprascapular notch is bridged by a superior transverse scapular ligament (STSL) and serves as a passage for the suprascapular nerve. The purpose of this study was to group suprascapular notches (SSN) and provide data on the association of the safe zone distances of the suprascapular nerve. Sixty-five Egyptian dried scapulae were classified into five groups; measurement of dimensions of SSN and measurement of safe zone for the suprascapular nerve were taken. The collected data were analyzed and the correlated parameters in the prevalent types of notches were done.

Scapulae were classified into five groups of which the most prevalent groups were Type III (47.63%) followed by Type I (40%). The mean measurements of 'safe zone' distances vary according to the type of notch and correlate with notch dimensions. The present work displayed the anatomical variants of SSN and analyzed the measurement of safe zone distances to help the clinicians to manage different pathological conditions of the shoulder, in order to avoid iatrogenic injury.

Key words: Egyptian Scapula – Safe zone – Suprascapular nerve – Suprascapular notch

INTRODUCTION

The supra scapular notch is a depression situated in the lateral part of the superior border of the scapula, adjacent to the base of the coracoid process. The SSN is bridged by a STSL. The ligament may ossify partially or completely to convert SSN into suprascapular foramen (SSF), which serves as a passage for the suprascapular nerve, whereas the suprascapular vessels pass above the ligament (Moore et al., 2013).

The suprascapular nerve is a mixed nerve that originates from the brachial plexus' superior trunk containing roots from C5 and C6. It enters the supraspinous fossa through the SSN. It then runs deep to the supraspinatus and curves around the spinoglenoid notch to reach the infraspinous fossa. The nerve is prone to iatrogenic injury at these two notches due to its proximity to the operative field. It innervates the shoulder joint, acromioclavicular joint, supraspinatus and infraspinatus muscles, which are components of the rotator cuff (Vorster et al., 2008; Molony et al., 2011).

SNES is an acquired neuropathy in which the nerve is compressed along its course, most commonly at the SSN. It was first described by Kopell and Thompson (1959). It may occur following blunt trauma, rotator cuff tear, ganglion cysts (Hazrati et al., 2003), repetitive traction injury in overhead athletes like volleyball, baseball, tennis players (Khan et al., 2001), suprascapular veins varicose enlargement at the spinoglenoid notch (Van Meir et al., 2011), and also variations in SSN morphology where nerve space is limited by bony and ligamentous constraints (Bayramoğlu et al., 2003).

The clinical manifestations of this neuropathy include deep, dull and diffuse pain of the posterior and lateral aspects of the shoulder, weakened abduction and rotation of the upper extremity in the glenohumeral joint. All these symptoms are based

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on progressive atrophy of the supraspinatus and infraspinatus muscles (Gosk et al., 2007). Males are more likely to suffer from the SNES than females (Boykin et al., 2011), mainly in patients under 35 years of age (Zehetgruber et al., 2002).

Morphological variations of the SSN are very important clinically because:

(1) the size of the notch has been identified as one of the causes of SNES. The smaller the size of the notch, the greater the chance of nerve entrapment (Moore et al., 2013).

(2) the measurements of the safe zone depend on these variations.

Safe Zone is defined as an area within which it is possible to avoid iatrogenic lesions of the suprascapular nerve. The measurements of the safe zone are critical during open surgical procedures (Gumina et al., 2011).

Very scant data are available in the adult Egyptian population on anatomical variations of SSN. Mahdy and Shehab (2013), Ali and Hassanein (2015) classified SSN based on Natsis et al. (2007) and Wang et al. (2011) classification. The purpose of this study was to:

1) group SSN in adult Egyptian scapulae using specific geometric parameters based on the classification system defined by Polguj et al. (2013).

2) provide data on the association of the safe zone distances of the SSN. Knowing the SSN anatomical variations is important for a better understanding of the entrapment syndrome and to improve the safety of arthroscopic nerve decompression.

MATERIALS AND METHODS

The present study was carried out on sixty five completely ossified Egyptian dried scapulae of unknown age and sexes were collected from:

1) Department of Anatomy, Faculty of Medicine, Minia University.

2) Department of Anatomy, Faculty of Physiotherapy, Deraya University.

In the selected specimens the exclusion criterion was the presence of injuries which made measurement collection impossible in the study area. For example scapulae with broken superior border, deformity, pathology and previous scapular sur-

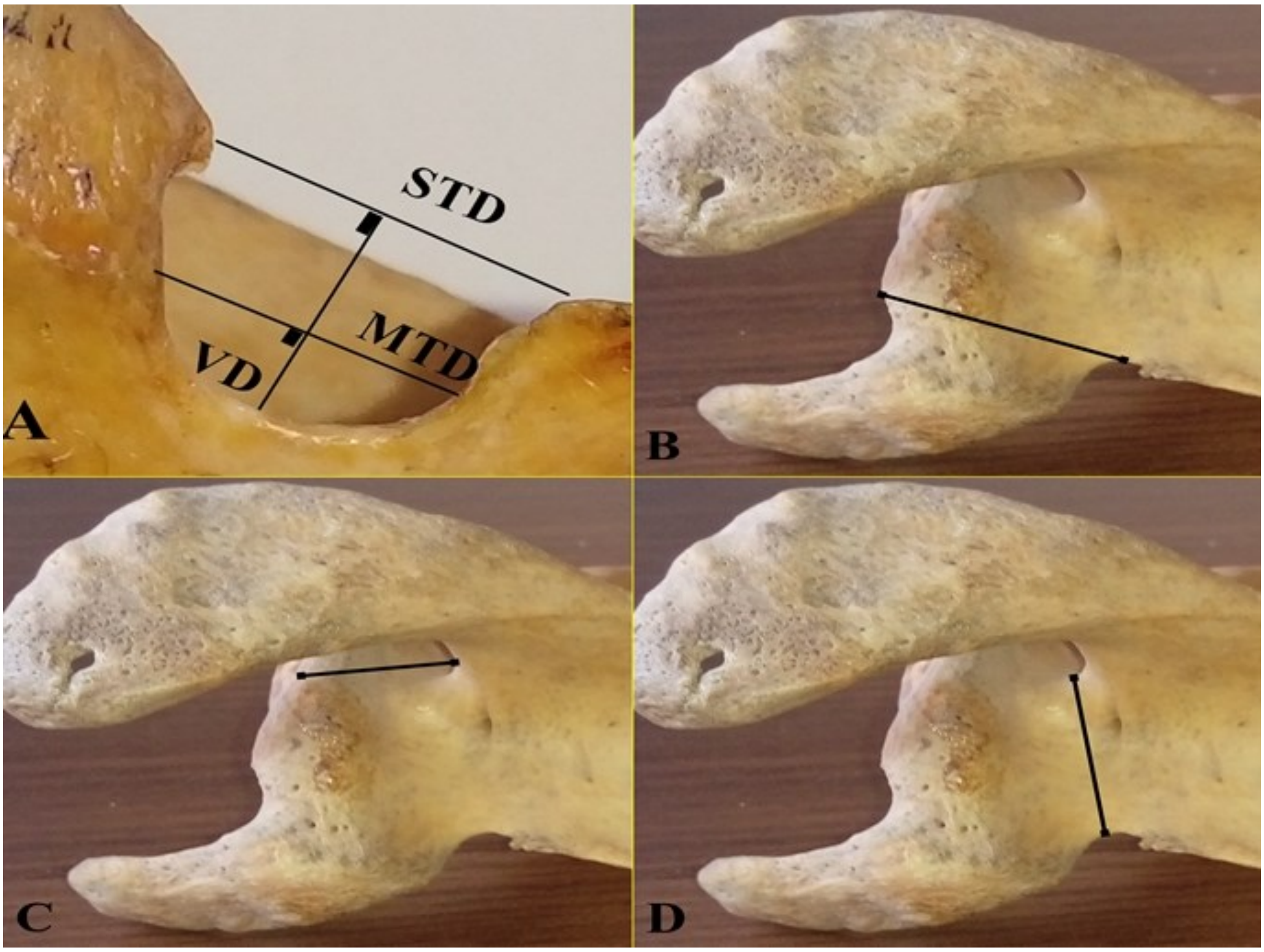

Fig 1. Photographs of dry human scapulae showing measurements of SSN and ‘safe zone’ distances. **A:** superior transverse diameter (STD), middle transverse diameter (MTD) and vertical diameter (VD) perpendicular to STD & MTD; **B:** distance (in mm) between the deepest point of the SSN and the supraglenoid tubercle; **C:** distance (in mm) between the spinoglenoid notch and the middle of the posterior rim of the glenoid cavity; **D:** distance (in mm) between the deepest part of the SSN and the spinoglenoid notch.

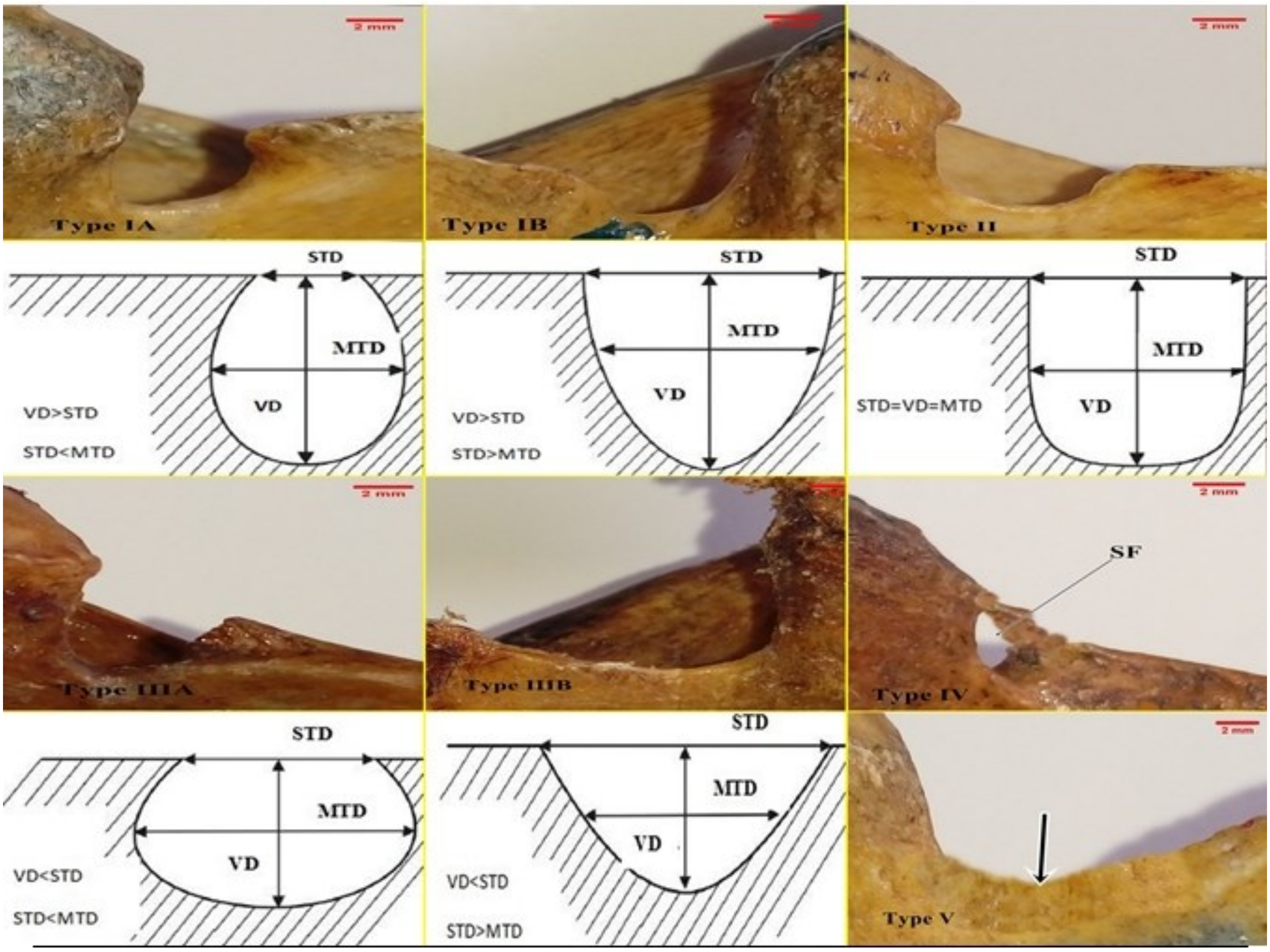

Fig 2. Photographs and diagrams of the ventral surfaces of dry human scapulae showing: Type I SSN with (Type IA and Type IB) diameters where the vertical diameter (VD) is longer than the superior transverse diameter (STD) in both types and the middle transverse diameter (MTD) is longer than the superior transverse diameter (STD) in type IA while it is shorter than it in type IB.

Type II SSN with equal diameters; the vertical diameter (VD), the superior transverse diameter (STD) and the middle transverse diameter (MTD).

Type III SSN with (Type IIIA and Type IIIB) diameters where the vertical diameter (VD) is shorter than the superior transverse diameter (STD) in both types and the middle transverse diameter (MTD) is longer than the superior transverse diameter (STD) in type IIIA while it is shorter than it in type IIIB.

Type IV and type V SSNs with the presence of a scapular foramen (SF) on its superior border in type IV and absence of a SSN on its superior border (arrow) in type V.

gery.

The research procedures were approved by the Research Ethics Committee, Faculty of Medicine, Minia University.

The scapulae with a distinct SSN (Fig. 2) were classified on the basis of gross examination and measurements (Fig. 1) in five groups according to the classification of Polguj et al. (2013).

A photographic method was used for measurements to avoid errors. The scapula was carried on an adjustable clamp at a fixed distance from the camera with a metric scale taped onto it to allow a measurement reference (Wang et al., 2011). Photographs were taken with a digital camera (Canon, 20 Megapixels). The digital images were processed using the image analyzer (image J) and two types of measurements were taken (Fig. 1):

1) Measurement of dimensions of the suprascapular notch (Fig. 1A):

The diameters of SSN were measured in the most prevalent groups using an imaginary line joining the two superior corners of the notch.

a) The vertical diameter (VD) was taken as the maximal length of SSN starting from the imaginary line and perpendicular to it to the deepest point of the SSN and not necessarily parallel to the vertical axis of the body.

b) The Superior Transverse Diameter (STD): The maximum horizontal distance between the superior corners of the notch.

c) The Middle Transverse Diameter (MTD): The maximum horizontal distance between the margins of the notch, perpendicular to the midpoint of the vertical diameter.

The scapulae with absent notch and those with a

SSF were excluded from the morphometric study, because it was not possible to collect the SSN dimensions as described. A photograph representing each type was documented using a digital camera and its percentage was calculated, recorded and tabulated.

2) Measurement of 'Safe zone for the suprascapular nerve' distance

To measure the distance of suprascapular nerve, along with its course in the most prevalent groups:

a) The distance between the deepest point of the SSN and the supraglenoid tubercle (Fig. 1B).

b) The distance between the spinoglenoid notch and the middle of the posterior rim of the glenoid cavity (Fig. 1C).

c) The distance between the deepest part of the SSN and the spinoglenoid notch (Fig. 1D).

Each measurement was made by two medical Colleges (skilled in anthropometric measurements and shoulder disorders) and the mean of the values was taken. The collected data were studied, analyzed and presented in tables. Analysis of the correlated parameters in the prevalent types of notches was done.

Methods of statistical analysis:

Data were collected, revised and analyzed by using SPSS statistical package version 20. The following had been done:

Descriptive statistics:

For quantitative data: range, mean (X~) and standard deviation (SD).

For qualitative data: number (n) and percentage (%).

Analytical statistics: Bivariate Pearson correlation analysis for association analysis.

Probability (p) was considered: Non-significant if ≥ 0.05; Significant if < 0.05; Highly significant if < 0.01; Very highly significant if <0.001.

Grade of Pearson's correlation coefficient: 0.00 to 0.24: weak or no association; 0.25 to 0.49: fair association; 0.50 to 0.74: moderate association; 0.75+: strong association.

RESULTS

By gross examination and comparing the measured vertical and transverse diameters of the SSN, scapulae were classified into five groups according to the classification of Polguj et al. (2013) of which the most prevalent groups were Type III followed by Type I accounting for 47.63% and 40%, respectively.

In the studied scapulae, 1.54% only had type-II, 7.69% revealed the absence of a SSN (Type V) and 3.08% displayed a SSF (Type IV). These findings were summarized in Table 1.

Quantitative measurements of the most prevalent types; Type I and III SSNs were taken and tabulated. The scapulae with type-I were again subclassified into two subtypes; type- IA (15.38%) and type-IB (24.61%) SSN; the vertical diameter (VD) was longer than the superior transverse diameter (STD) in both types, and the middle transverse diameter (MTD) was longer than the superior transverse diameter (STD) in type IA, while it was shorter than it in type IB (Fig. 2 &Table 1). Type-I SSN had a mean VD of 8.7 ± 1.43mm & a mean STD of 5.79 ± 0.98 mm and a mean MTD of 3.69 ±0.97 mm (Table 2).

The analysis of the scapulae with type II SSN showed equal diameters; the VD, the STD and the MTD (Fig. 2).

The scapulae with type-III were again subclassified into two subtypes; type-IIIA (21.53%) and type -IIIB (26.15%) SSN where the VD was shorter than the STD in both types and the MTD was longer than the STD in type-IIIA while it was shorter than it was in type-IIIB (Fig. 2 & Table 1). Type-III SSN had a mean VD of 5.86 ± 1.27mm & a mean STD of 8.56 ± 1.80 mm and a mean MTD of 6.46 ± 1.79 mm (Table 2).

Diameters of types IV and V SSNs could not be measured because type V had an absent notch and type IV had a completely formed bony SSF (Fig. 2).

The measurements of the distance between the SSN and supraglenoid tubercle varied with the type of notch; the highest mean value had been detected for Type I, followed by Type III. The difference was statistically significant (Table 3).

Also, the mean value of the distance between the spinoglenoid notch and the posterior rim of the

Table 1. Distribution of different types of SSN (based on Polguj's classification).

Type of SSN	Description	Total	Percentage
Type - IA	VD > STD<MTD	10	15.38%
Type - IB	VD > STD>MTD	16	24.61%
Type - II	VD = STD = MTD	1	1.54%
Type - IIIA	VD < STD<MTD	14	21.53%
Type - IIIB	VD < STD>MTD	17	26.15%
Type - IV	Bony suprascapular foramen	2	3.08%
Type - V	Absent notch	5	7.69%
	Total	65	100%

Table 2. Dimensions of suprascapular notches

Type of notch (Polguj's Classification)	Superior transverse diameter (STD) Mean ± SD	Middle transverse diameter (MTD) Mean ± SD	Maximum depth (VD) Mean ± SD
Type - I	5.79 ± 0.98	3.69 ±0.97	8.7 ± 1.43
Type - III	8.56 ± 1.80	6.46 ± 1.79	5.86 ± 1.27

Table 3. Distance (in mm) between the SSN and supraglenoid tubercle in various types of notches.

Type of notch (Polguj's Classification)	Mean ± SD	Range
Type - I	26.83 ± 1.82	23.0 – 30.1
Type - III	25.62 ± 1.83	22.9– 33.5

glenoid cavity were higher for Type I followed by Type III. The difference in the mean values between both types was not statistically significant (Table 5).

However, the mean value of the distance between the SSN and the spinoglenoid notch was higher for Type III than it was in Type I. The difference in the mean values between both types was not statistically significant (Table 6).

As the deepest point of the SSN was considered in measuring distances between the SSN and supraglenoid tubercle or spinoglenoid notch, these distances were correlated with VD in Types I and III SSN.

A weak to fair positive but statistically significant correlation between VD and distance between the SSN notch and supraglenoid tubercle in TypeIII and Type I respectively (Table 4). On the other hand, a weak negative correlation was observed between VD and distance between the SSN and spinoglenoid notch in Type I, while a weak positive correlation was found between the same parameters in Type III. The correlation was statistically not significant in both types (Table 7).

Table 4. Correlation between the depth of notch (VD) with distance between the SSN and supraglenoid tubercle in Types I and III SSN.

Type of SSN	'r' value	'p' value
Type - I	0.348	0.043 *
Type - III	0.223	0.023 *

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

Table 5. Distance (in mm) between the spinoglenoid notch and the posterior rim of the glenoid cavity.

Type of notch (Polguj's Classification)	Mean ± SD	Range
Type - I	13.99 ± 1.16	11.1 – 17.1
Type - III	13.68 ± 1.12	11.0 – 18.2

Table 6. Distance (in mm) between the SSN and the spinoglenoid notch.

Type of notch (Polguj's Classification)	Mean ± SD	Range
Type - I	21.08 ± 0.84	19.7 – 22.7
Type - III	21.43 ± 0.84	19.7 – 23.4

Table 7. Correlation between the depth of notch (VD) with Distance between the SSN and the spinoglenoid notch.

Type of SSN	'r' value	'p' value
Type - I	- 0.239	0.185
Type - III	0.088	0.342

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

DISCUSSION

Potential morphological factors which predispose a patient to SNES include the shape of the SSN (Dunkelgrun et al., 2003); band-shaped (Polguj et al., 2013), bifurcated (Polguj et al., 2012a, b), or completely ossified (Tubbs et al., 2013) STSL; the presence of the anterior coracoscapular ligament (ACSL) (Polguj et al., 2012a, b); the course of the suprascapular nerve and vessels (Polguj et al., 2015); hypertrophy of the infraspinatus muscle (Duparc et al., 2010).

Several morphological variations and classification of the SSN were reported in many populations (Rengachary et al., 1979; Iqbal and Khan, 2010; Sinkeet et al., 2010; Wang et al., 2011). This study concerned with measurements of the SSN and the safe zone distances in Egyptian scapulae.

Polguj et al. (2011) reported that the size and shape of the SSN may be a factor in SNES. In the current study, five types of SSN were observed based on the measured parameters according to Polguj classification. In the studied scapulae, 7.69% revealed the absence of a SSN (Type V).

The above finding is consistent with the study by Soni et al. (2012) However, this was contrary to a study conducted by Wang et al. (2011) who recorded this type in 28% of Chinese studied scapulae.

In addition, Rengachary et al. (1979) reported that absent SSN may be responsible for suprascapular nerve compression by the ossified superior transverse scapular ligament.

In this work, type IV with SSF was only observed in 3.08% of studied scapulae. This was supported by the study of Natsis et al. (2007) in which this type was detected in 7.3% of 423 scapulae, and it was concluded that the presence of foramen was associated with the ossified STSL. Furthermore, Polguj et al. (2011) observed the ossification of this ligament in German, Turkish, Italian, Polish and French.

However, it was later described by Polguj et al. (2013) three types of STSL. The STSL may appear as a fan-shaped ligament (Type I), band-shaped ligament (Type II) and a bifid structure (Type III). The ossified band-shaped STSL should be considered as a potential risk factor in SNES because the space below the bony bridge is significantly reduced compared with the case of the ossified fan-shaped ligament (Polguj et al., 2014). On the other hand, the presence of ossified STSL may be associated with a predilection for a traction-type injury of the suprascapular nerve (Rengachary et al., 1979).

In addition, according to the case given by Polguj et al. (2012a), the ACSL is located below the STSL. The suprascapular artery and nerve ran below ACSL, which increases the likelihood of SNES.

However, interestingly, the ACSL may prevent the development of SNES when the suprascapular nerve runs over the ACSL, in which case the ligament acts as a support for the nerve. Later four types of the arrangement of the suprascapular triad at SSN were distinguished by Polguj et al. (2015). In case the entire triad runs below the ligament, resulting in the most significant reduction of the space beneath the STSL. In contrast, suprascapular notch veins (SNV), by running along the bottom of the SSN, may protect the suprascapular nerve from irritation by the bone borders of the notch (Reineck and Krishnan, 2009).

In this study, the most prevalent groups were Type III accounting for 47.63% where the VD was shorter than the STD. This is in agreement with Ticker et al. (1998) in Americans, Wang et al. (2011) in Chinese, Polguj et al. (2011) in Poles, Soni et al. (2012), Sangam et al. (2013) in Indian, Mahdy and Shehab (2013) in Egyptians. Type I SSN was seen in 40% and had longer VD compared with STD. This is in accordance with Natsis et al. (2007) who found this type I in 41.85%, having a notch with the longest VD.

The previously described five types of the SSN in the present study are in accordance with the results of Polguj et al. (2011), who reported five types of SSN. Type I had longer maximal depth than the STD. Type II had equal MD, STD, and MTD. In type III STD was longer than maximal depth. In type IV a bony foramen was present. Type V was without a distinct notch.

However, Natsis et al. (2007), in scapulae of German origin, distinguished five types of SSN having a different description. They reported a Type I without a discrete notch; Type II, a notch which had the longest in its transverse diameter; Type III, a notch that was the longest in its vertical diameter; Type IV, a bony foramen and type V, a notch with a bony foramen. Typing of the SSN may have clinical significance for suprascapular nerve entrapment, as a narrow SSN has been found in patients with SNES (Rengachary et al., 1979).

The mean value of safe zone distances differed with the type of SSN. Different authors revealed variable findings. A comparative analysis of such results with the present study for safe zone distances was displayed in (Table 8).

The present statistical study revealed a weak positive but statistically significant correlation between VD and distance between the SSN notch and supraglenoid tubercle in Type I and Type III. This is in agreement with Hafezji (2016).

Consistent with findings by Mahdy and Shehab (2013), Hafezji (2016), a weak negative correlation observed between VD and distance between the SSN and the spinoglenoid notch in Type I. on the other hand, Hafezji (2016) found a weak positive correlation between the same parameters in Type III with non-significant correlation in both types, which is in good agreement with the results of the present study.

The above findings contradict the study by Sinkeet et al. (2010), Vyas et al. (2013) and Wang et al. (2011): these authors examined safe zone distances and reported no significant correlation with dimensions of the SSN.

Furthermore, Natsis et al. (2008) reported that the surgeons should be aware of the SSN typing through the radiological examination. Preoperative notch identification allows for a proper choice of the surgical interventions to decompress the suprascapular nerve.

CONCLUSION

The present work displayed the anatomical variants of SSN and analyzed the measurement of safe zone distances to help the clinicians and surgeons to manage different pathological conditions of the shoulder, in order to avoid iatrogenic injury. However, the present study was done with a limited number of Egyptian dry scapulae. More anatomical, radiological and surgical studies should be done with histopathological examination of the suprascapular nerve.

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REFERENCES

ALI MB, HASSANEIN GH (2015) Variations of suprascapular notch in adult Egyptian scapulae. *Int J Anat Res*, 3(4): 1536-1542.

BAYRAMOĞLU A, DEMIRYÜREK D, TÜCCAR E, ERBIL M, ALDUR M, TETIK O, DORAL M (2003) Variations in anatomy at the suprascapular notch possibly causing suprascapular nerve entrapment: An anatomical study. *Knee Surgery, Sports Traumatology, Ar-*

Table 8. Comparative analysis of safe zone distances in different studies of the world.

Mean distance (in mm)	Type of SSN	Sinkeet et al. (2010)	Vyas et al. (2013)	Wang et al. (2011)	Hafezji (2016)	Present study
between suprascapular notch & supraglenoid tubercle	Type-I	27.35	27.52	31.59	28.23	26.83
	Type-III	29.03	27.44	33.33	28.42	25.62
between spinoglenoid notch & the posterior rim of the glenoid cavity	Type - I	16.5	15.61	16.28	15.39	13.99
	Type - III	17.2	15.61	16.36	15.08	13.68
between the suprascapular notch and the spinoglenoid notch	Type - I			20.13	22.48	21.08
	Type - III			20.80	22.83	21.43

throscopy, 11(6): 393-398.

BOYKIN RE, FRIEDMAN DJ, ZIMMER ZR, OAKLANDER AL, HIGGINS LD, WARNER JJ (2011) Suprascapular neuropathy in a shoulder referral practice. *J Shoulder Elbow Surg,* 20(6): 983-988.

DUNKELGRUN M, IESAKA K, PARK SS, KUMMER FJ, ZUCKERMAN JD (2003) Interobserver reliability and intraobserver reproducibility in suprascapular notch typing. *Bull Hosp Jt Dis,* 61(3-4): 118-122.

DUPARC F, COQUEREL D, OZEEL J, NOYON M, GEROMETTA A, MICHOT C (2010) Anatomical basis of the suprascapular nerve entrapment, and clinical relevance of the supraspinatus fascia. *Surg Radiol Anat,* 32(3): 277-284.

GOSK J, URBAN M, RUTOWSKI R (2007) Entrapment of the suprascapular nerve: Anatomy, etiology, diagnosis, treatment. *Ortop, Traumatol, Rehabil,* 9(1): 68-74.

GUMINA S, ALBINO P, GIARACUNI M, VESTRI A, RIPANI M, POSTACCHINI F (2011) The safe zone for avoiding suprascapular nerve injury during shoulder arthroscopy: An anatomical study on 500 dry scapulae. *J Shoulder Elbow Surg,* 20(8): 1317-1322.

HAFEZJI HM (2016) An osteological study of measurement of safe zone to prevent iatrogenic suprascapular nerve injury and its correlation with type of suprascapular notch. *Int J Res Med Sci,* 4(11): 5034-5040.

HAZRATI Y, MILLER S, MOORE S, HAUSMAN M, FLATOW E (2003) Suprascapular nerve entrapment secondary to a lipoma. *Clin Orthop Rel Res,* 411: 124-128.

IQBAL K, IQBAL R, KHAN S (2010) Anatomical variations in shape of suprascapular notch of scapula. *J Morphol Sci,* 27(1): 1-2.

KHAN AM, GUILLET MA, FANTON GS (2001) Volleyball: Rehabilitation and training tips. *Sports Med Arthrosc Rev,* 9(2): 137-146.

KOPELL H, THOMPSON W (1959) Pain and the frozen shoulder. *Surg Gynecol Obstet,* 109(1): 92-96.

MAHDY AA, SHEHAB AA (2013) Morphometric variations of the suprascapular notch as a potential cause of neuropathy: Anatomical study. *J Amer Sci,* 9(3).

MOLONY DC, GHEITI AJC, KENNEDY J, GREEN C, SCHEPENS A, MULLETT HJ (2011) A cadaveric model for suprascapular nerve injury during glenoid component screw insertion in reverse- geometry shoulder arthroplasty. *J Shoulder Elbow Surg,* 20(8): 1323-1327.

MOORE KL, DALLEY AF, AGUR AM (2013) *Clinically oriented anatomy.* Lippincott Williams & Wilkins.

NATSIS K, TOTLIS T, TSIKARAS P, APPELL H, SKANDALAKIS P, KOEBKE J (2007) Proposal for classification of the suprascapular notch: A study on 423 dried scapulas. *Clin Anat,* 20(2): 135-139.

NATSIS K, TRIFON T, IOANNIS G, KONSTANTINOS V, EFTHYMIA P, PROKOPIOS T (2008) A bony bridge within the suprascapular notch. Anatomic study and clinical relevance. *Aristotle Univ Med J, 35*(1): 204-211.

POLGUJ M, JĘDRZEJEWSKI K, PODGÓRSKI M, TOPOL M (2011) Correlation between morphometry of the suprascapular notch and anthropometric measurements of the scapula. *Folia Morphol,* 70(2): 109-115.

POLGUJ M, JEDRZEJEWSKI K, TOPOL M (2012a) The bifid anterior coracoscapular ligament: A new morphological variation and its potential clinical implications. *Folia Morphol,* 71(4): 282-284.

POLGUJ M, JEDRZEJEWSKI K, MAJOS A, TOPOL M (2012b) Variations in bifid superior transverse scapular ligament as a possible factor of suprascapular entrapment: An anatomical study. *Int Orthop, 36*(10): 2095-2100.

POLGUJ M, JEDRZEJEWSKI K, PODGORSKI M, MAJOS A, TOPOL M (2013) A proposal for classification of the superior transverse scapular ligament: Variable morphology and its potential influence on suprascapular nerve entrapment. *J Shoulder Elbow Surg,* 22(9): 1265-1273.

POLGUJ M, SIBINSKI M, GRZEGORZEWSKI A, WASZCZYKOWSKI M, MAJOS A, TOPOL M (2014) Morphological and radiological study of ossified superior transverse scapular ligament as potential risk factor of suprascapular nerve entrapment. *Biomed Res Int,* 2014:613601.

POLGUJ M, ROZNIECKI J, SIBINSKI M, GRZEGORZEWSKI A, MAJOS A, TOPOL M (2015) The variable morphology of suprascapular nerve and vessels at suprascapular notch: A proposal for classification and its potential clinical implications. *Knee Surg Sports Traumatol Arthrosc,* 23(5): 1542-1548.

REINECK JR, KRISHNAN SG (2009) Subligamentous suprascapular artery encountered during arthroscopic suprascapular nerve release: A report of three cases. *J Shoulder Elbow Surg,* 18(3): 1-3.

RENGACHARY SS, BURR D, LUCAS S, HASSANEIN KM, MOHN MP, MATZKE H (1979) Suprascapular entrapment neuropathy: A clinical, anatomical, and comparative study: Part 2: Anatomical study. *Neurosurgery, 5*(4): 447-451.

RENGACHARY SS, NEFF JP, SINGER PA, BRACKETT CE (1979) Suprascapular entrapment neuropathy: A clinical, anatomical, and comparative study. Part 1: Clinical study. *Neurosurgery,* 5(4): 441-446.

SANGAM MR, DEVI SSS, KRUPADANAM K, ANASUYA K (2013) A study on the morphology of the suprascapular notch and its distance from the glenoid cavity. *J Clin Diagn Res,* 7(2): 189-192.

SINKEET S, AWORI K, ODULA P, OGENG'O J, MWACHAKA P (2010) The suprascapular notch: Its morphology and distance from the glenoid cavity in a Kenyan population. *Folia Morphol,* 69(4): 241-245.

SONI G, MALIK V, SHUKLA L, CHABBRA S, GAUR N (2012) Morphometric analysis of the suprascapular notch. *Internet J Biol Anthropol,* 5(1): 20-27.

TICKER JB, DJURASOVIC M, STRAUCH RJ, APRIL EW, POLLOCK RG, FLATOW EL, BIGLIANI LU (1998) The incidence of ganglion cysts and other variations in anatomy along the course of the suprascapular nerve. *J Shoulder Elbow Surg,* 7(5): 472-478.

TUBBS RS, NECHTMAN C, D'ANTONI AV, SHOJA MM, MORTAZAVI MM, LOUKAS M, SPINNER RJ (2013) Ossification of the suprascapular ligament: A risk factor for suprascapular nerve compression? *Int J Shoulder Surg,* 7(1): 19-22.

VAN MEIR N, FOURNEAU I, DEBEER P (2011) Varicose veins at the spinoglenoidal notch: An unusual cause of suprascapular nerve compression. *J Shoulder Elbow Surg,* 20(7): 21-24.

VORSTER W, LANGE CP, BRIËT RJ, LABUSCHAGNE BC, DU TOIT DF, MULLER CJ, DE BEER JF (2008) The sensory branch of the suprascapular nerve: An anatomic study. *J Shoulder Elbow Surg,* 17(3): 500-502.

VYAS KK, RAJPUT HB, ZANZRUKIYA KM, SUTTARWALA I, SARVAIYA BJ, SHROFF BD (2013) An osseous study of suprascapular notch and various dimensions of safe zone to prevent suprascapular nerve injury. *Ind J Appl Basic Med Sci,* 15(20): 27-39.

WANG HJ, CHEN C, WU LP, PAN CQ, ZHANG WJ, LI YK (2011) Variable morphology of the suprascapular notch: An investigation and quantitative measurements in Chinese population. *Clin Anat,* 24(1): 47-55.

ZEHETGRUBER H, NOSKE H, LANG T, WURNIG C (2002) Suprascapular nerve entrapment. A meta-analysis. *Int Orthop,* 26(6): 339-343.