Morphometric Variations of the Suprascapular Notch as a Potential Cause of Neuropathy: Anatomical Study

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Abstract: Background: Suprascapular nerve entrapment has several causes particularly at the suprascapular notch. Anatomical variation of the notch is considered as one of the causes. **Aim of the work:** Study the variations of the suprascapular notch in Egyptian scapulae considering them as possible predisposing factor for suprascapular nerve entrapment. **Material and Methods:** One hundred and thirty two dried scapulae were examined and classified. Vertical (VD) and transverse (TD) diameters of the suprascapular notch as well as the distance (SGND) between its lower margin and the base of the spinoglenoid notch were measured. For all scapulae, maximal width (W), maximal length (L) and their index (W/L) were recorded. The previous measurements were statistically studied. Comparative analysis of the measured parameters was done and percentage of each type was calculated. Morphological variations of the suprascapular notches were studied. **Results:** Five types of suprascapular notches were recorded; type I having no notch (6.06 %). Type II notch was the most prevalent type (45.45%) with longer TD. Type III notch (43.93%) had longer VD or equal VD and TD. Type IV with suprascapular foramen was found in 3.03% while 1.5 % was of type V which had a foramen with a notch. Highly significant negative correlation was present between VD of the notch with SGND in types II and III scapular notches. However, there was highly significant and significant correlation between TD with SGND as well as with L and W/L index in type III. There were no other statistically significant correlations between measured parameters of the scapulae with the dimensions of suprascapular notches. Also, there was no statistically significant difference between the measured parameters (SGND, W, L & W/L) in types I, II and III. Three morphological variations were detected in the scapulae having suprascapular notches (types II and III). They were U shape (76.27%), V shape (13.56%) and J shape (10.17%). **Conclusion:** This study classified the suprascapular notch into five types and three morphological variations which could be used in further investigations for management of suprascapular nerve entrapment.

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1. Introduction

The suprascapular notch is situated in the lateral part of the superior border of the scapula; just medial 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 has a tortuous course from the supraspinous fossa to the infraspinous fossa through spinoglenoid notch *(Piasecki et al., 2009; More et al., 2010 and Polguj et al., 2011).*

The anatomical variation of the suprascapular notch is recognized as one of the causes of suprascapular nerve entrapment which is usually represented by shoulder pain and muscle paralysis *(Henlin et al., 1992 and Natsis et al., 2007)*. There are several potential causes of nerve entrapment along its course, particularly at the vulnerable suprascapular and spinoglenoid notches, where nerve space is limited by bony and ligamentous constraints. Entrapment may occur following excessive nerve traction during overhead sports or as a result of massive retracted rotator cuff tears *(Piasecki et al., 2009)***.** Excessive movement of the shoulder exerts traction on the suprascapular nerve which leads to its compression against the superior transverse scapular ligament *(Soni et al., 2012)*. Therefore, the aim of this work was to study the variations of the suprascapular notch in Egyptian scapulae considering them as possible predisposing factor for suprascapular nerve entrapment.

2. Material and Methods

In this research, one hundred and thirty two dried, completely ossified, unbroken scapulae were collected from Department of Anatomy, Faculty of Medicine, Tanta University, Egypt. Their sex and medical history were unknown. Orientation of the side of the scapulae was done.

The suprascapular notches (SSN) were measured with two standard transparent elastic rulers according to *Natsis et al. (2007) and Wang et al. (2011).* This was done after determining an imaginary line joining the two superior corners of each notch to measure the followings:

- The vertical diameter (VD) of the SSN taken as the maximal diameter of the notch perpendicular to the imaginary line and not necessarily parallel to the vertical axis of the body (Figs. 1, 2).

- The transverse diameter (TD) of the SSN taken as the diameter perpendicular to the midpoint of the vertical diameter (Figs. 1, 2).
- The distance between the lower margin of the SSN and the base of the spinoglenoid notch (Fig. 2).

In the scapulae having no notches; the distance from a point just medial to the root of the coracoid process till the base of the spinoglenoid notch was measured. In the scapulae having suprascapular foramen instead of notch; the distance between the lower margin of the foramen and the base of the spinoglenoid notch was measured.

For all scapulae, another two measurements were done on the ventral surface (Fig. 3) and their index (W/L) was recorded:

- The width (W) which taken as the maximal transverse diameter joining the lateral angle (at the infraglenoid tubercle) and the widest point in the medial border corresponding to the root of the spine (in the dorsal surface).
- The length (L) which taken as the maximal longitudinal diameter joining the superior and the inferior angles of the scapula.

The previous measurements were recorded in millimeters and studied. Morphometric classification and typing of the suprascapular notches were done based on the morphology, specific parameters taken and on the previous description by *Natsis et al. (2007) and Polguj et al. (2011).* Percentage of each type depending on the vertical and the transverse diameters of the SSN was done and compared with the percentage of the previous studies.

Photographs of the ventral and superior scapular views were taken using a digital camera (Soni 6.0 Megapixels).

Statistical study

The collected data were studied using student *t* test (*Dawson-Saunders and Trapp, 2001*) and presented in tables. Analysis of the correlated parameters in different types and variations of notches was done.

3. Results

The present study revealed five different types of suprascapular notches as regards to presence of the notch and their measurements of the 132 examined scapulae. Each type has its own percentage (Table 1). There were 8 scapulae (6.06 %) having no notch and they were considered as type I (Fig. 4). The other 124 (93.94%) scapulae showed the other four types.

Type II was presented in 60 scapulae (45.45%). This was the most prevalent type, as the results of other studies (Table 2). The transverse diameter of the notch was longer than the vertical diameter (TD > VD) (Figs. 5- a,b) and (Table 1). Fortunately; two scapulae of known same cadaver showed two types, I and II, where the right scapula belonged to type I with no visible notch but the left scapula was type II with V-shaped notch (Fig. 6).Type III suprascapular notch was seen in 58 scapulae (43.93%) and had VD ≥ TD (Figs. 7-a,b,c,d) and (Table 1). Type IV with suprascapular foramen only without a visible notch was found in 4 scapulae (3.03%) (Fig. 8). Meanwhile 2 scapulae (1.5 %) were of type V which had suprascapular foramen associated with a visible notch in the superior border of the scapula (Fig. 9). Accidentally, a pair of the examined scapulae, belonged to same cadaver, had the same type and measurements. However, another pair of the same cadaver had different types as one of them was of type III and the other was of type IV.

Highly significant negative correlation was present between vertical diameter of the notch (VD) with distance between the lower margin of the SSN and the base of spinoglenoid notch (SGND) in types II and III. However, there was highly significant and significant correlation between transverse diameter of the notch (TD) with SGND as well as with the length of the scapula (L) and W/L index in type III. There were no other statistically significant correlations between measured parameters of the scapulae with the dimensions of suprascapular notches (Tables 3, 4). There was no statistically significant difference between the measured parameters (SGND, W, L & W/L) in types I, II and III (Table 5).

Table 1: Mean ± standard deviation of the measured parameters of different types:

	VD	TD	SGND	W	L	W/L
Type I 6.06 %			24.75±1.25	113.5±10.11	151.75±16.68	0.75±0.036
Type II 45.45%	5.68±2.37	8.23±2.20	22.03±3.81	107±8.93	144.3±13.03	0.743±0.04
Type III 43.93%	7.68±1.83	6.43±1.79	21.06±4.51	107.4±10.09	146.7±14.25	0.733±0.054
Type IV 3.03%			20±11.31	105.5±12.02	143.5±12.02	0.75±0.021
Type V 1.5 %			27±1.41	104±5.66	169±7.07	0.61±0.007

VD: Vertical Diameter TD: Transverse Diameter
SGND: Distance between the lower margin of the SSN and the base of spinoglenoid notch
W: Width of scapula L: Length of scapula
W/L: Index between width and length of the scapula

Table 2: Comparison of type percentage in the present study with previous studies:

	Type I	Type II	Type III	Type IV	Type V
Natsis *et al.,* 2007(Greek)	8.3%	41.85%	41.85%	7.3%	0.7%
Wang *et al.,* 2011 (Chinese)	28%	58.16%	28.23%	3%	none
Sinkeet *et al.,* 2010 (Kenyan)	22%	21%	29%	4%	2.9%
Soni *et al.,* 2012 (Indian)	5%	72%	20%	3%	none
Present study, 2012 (Egyptian)	6.06 %	45.45%	43.93%	3.03%	1.5 %

Table 3: Individual correlation between VD and TD with other measured parameters in type II SSN:

	VD		TD	
	r.	***p* value**	**r.**	***p* value**
SGND	-0.497	0.005**	-0.312	0.093
W	0.113	0.533	0.213	0.258
L	0.144	0.447	0.189	0.317
W/L	-0.071	0.708	-0.008	0.852

VD: Vertical Diameter TD: Transverse Diameter
SGND: Distance between the lower margin of the SSN and the base of spinoglenoid notch
W: Width of scapula L: Length of scapula
W/L: Index between width and length of the scapula
**Correlation is highly significant when *p* value < 0.01.

Table 4: Individual correlation between VD and TD with other measured parameters in type III SSN:

	VD		TD	
	r.	***p* value**	**r.**	***p* value**
SGND	-0.519	0.004**	0.733	0.001**
W	-0.090	0.625	-0.222	0.248
L	-0.102	0.598	0.579	0.001**
W/L	0.036	0.852	-0.438	0.012*

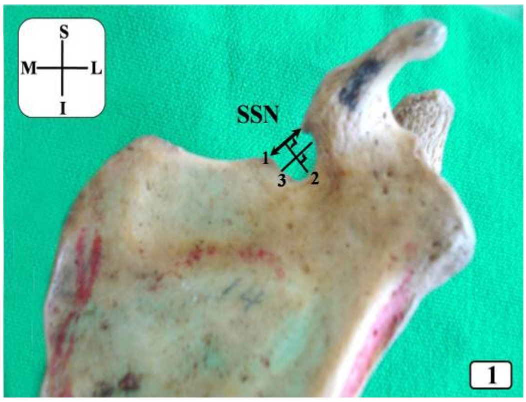
VD: Vertical Diameter TD: Transverse Diameter
SGND: Distance between the lower margin of the SSN and the base of spinoglenoid notch.
W: Width of scapula
L: Length of scapula
W/L: Index between width and length of the scapula
*Correlation is significant when *p* value < 0.05.
**Correlation is highly significant when *p* value < 0.01.

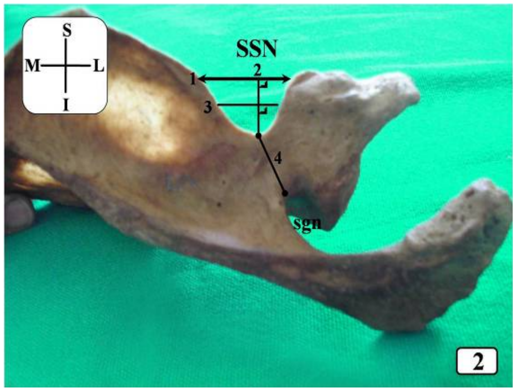
Table 5: P value of difference between the measured parameters of types I, II and III SSN:

	SGND	W	L	W/L
Type I versus Type II	0.516	0.507	0.832	0.730
Type I versus Type III	0.382	0.05	0.142	0.689
Type II versus Type III	0.407	0.955	0.862	0.370

SGND: Distance between the lower margin of the SSN and the base of spinoglenoid notch.
W: Width of scapula L: Length of scapula
W/L: Index between width and length of the scapula

According to the shape of the suprascapular notches that were present in 118 scapulae (belonged to types II and III), three morphological variations were detected. The most common one was U shape (76.27%). This variation may be shallow (18.64%) or deep (57.63%). All of the shallow U-shaped notch belonged to type II (Fig. 5a). The deep U-shaped notch could be wide (38.98%) or narrow with nearly parallel borders (18.64%) (Figs. 7-a,b). The latter one was considered as type III. However, half of the wide deep U- shaped notch considered as type II whereas; the other half belonged to type III. The second variation was V shape and was detected in 13.56%, most of them belonged to type II (Fig. 5-b). The third variation was J shape (10.17%), one half of which included in type II and the other half included in type III (Fig. 7-c). Moreover, 66.66% of the J-shaped supra-scapular notch had a spine (Fig. 7-d) while 16.66% of them had bony plate as well as a groove in the superior border medial to the notch (Fig. 7-e). Tapering spine had been also seen in the narrow deep U-shaped notch (27.3%). Concerning presence of bony plate, it was seen in 18 scapulae associated with groove (15.25%). Most of them were found in scapulae with V- shaped notch (Fig. 5-b) and the rest were found in either scapulae with shallow U-shaped notch or in J-shaped notch (Fig. 7-e).





Figs. 1, 2: Two photographs of two (left & right) scapulae showing the method of measurement of the suprascapular notch (SSN) where:

1. An imaginary line joining the two superior corners of the SSN.
2. The vertical diameter (VD) of the SSN taken as the maximal diameter of the notch perpendicular to the imaginary line.
3. The transverse diameter (TD) of the SSN taken as the diameter perpendicular to the midpoint of the vertical diameter.
4. The distance between the lower margin of the SSN and the base of the spinoglenoid notch (sgn).

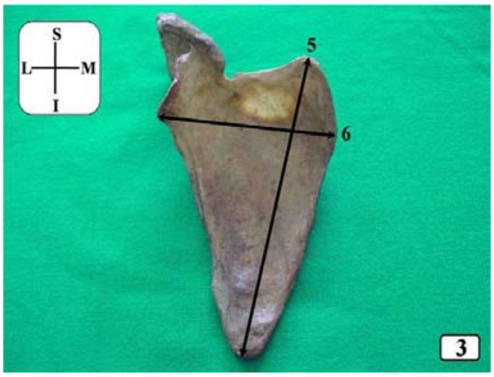


Fig. 3: A photograph of ventral view of a right scapula showing the method of the measured diameters where:

5. The length taken as the maximal longitudinal diameter joining the superior and the inferior angles of the scapula.
6. The width taken as the maximal transverse diameter joining the lateral angle (at the infraglenoid tubercle) and the widest point in the medial border corresponding to the root of the spine of the scapula (in the dorsal surface).

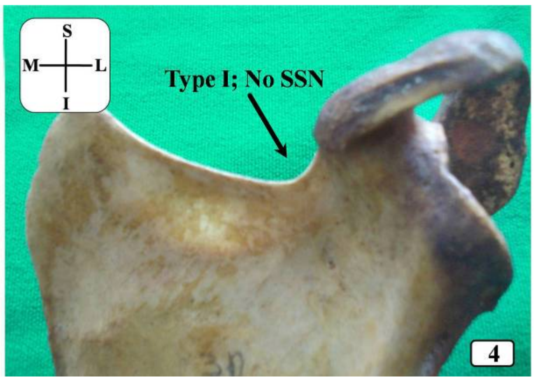


Fig. 4: A photograph of the ventral surface of a left scapula showing type I with no suprascapular notch (SSN) in the superior border (arrow) of the scapula.

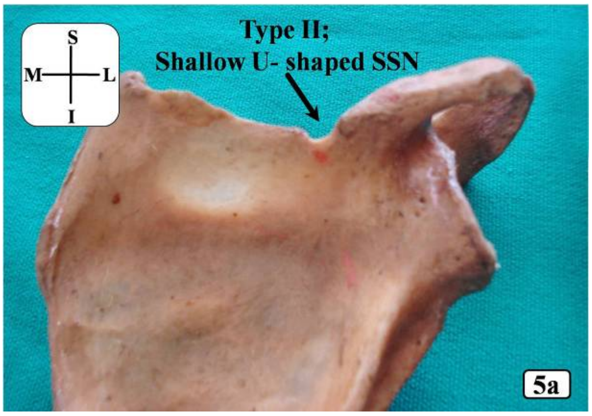


Fig. 5-a: A photograph of the ventral surface of a left scapula showing type II suprascapular notch (SSN) which appears shallow U-shaped (arrow) having TD > VD.

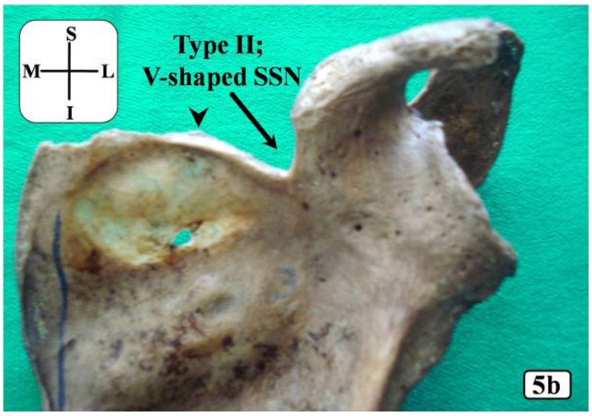


Fig. 5-b: A photograph of the ventral surface of a left scapula showing type II suprascapular notch (SSN) which appears V-shaped (arrow) having TD > VD. A thin plate of bone with a groove (arrow head) can be seen in the superior border medial to the notch.

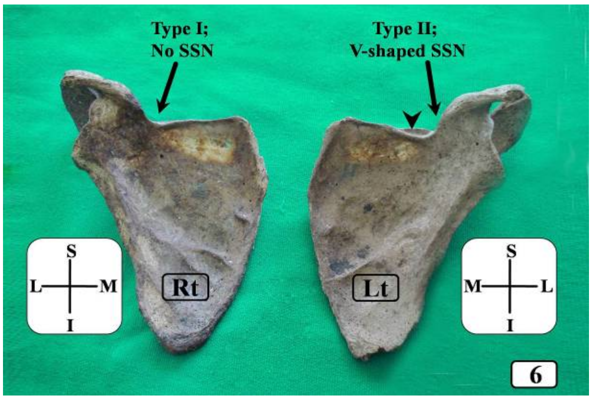


Fig. 6: A photograph of the ventral surfaces of two scapulae (right & left) of known same cadaver showing that the right scapula (Rt) has no visible suprascapular notch (SSN) (type I) but the left scapula (Lt) has type II SSN which appears V-shaped (arrow). A plate of bone with groove (arrow head) can be seen in the superior border medial to the V-shaped notch.

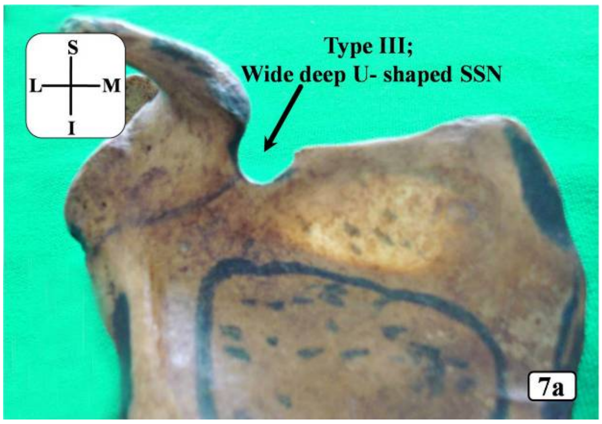


Fig. 7-a: A photograph of the ventral surface of a right scapula showing type III suprascapular notch (SSN) which appears wide deep U-shaped (arrow) having VD = TD.

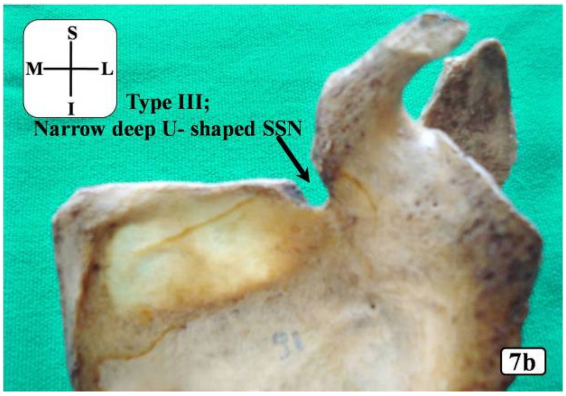


Fig. 7-b: A photograph of the ventral surface of a left scapula showing type III suprascapular notch (SSN) which appears narrow deep U-shaped (arrow) having VD > TD. Note the parallel borders of the notch.

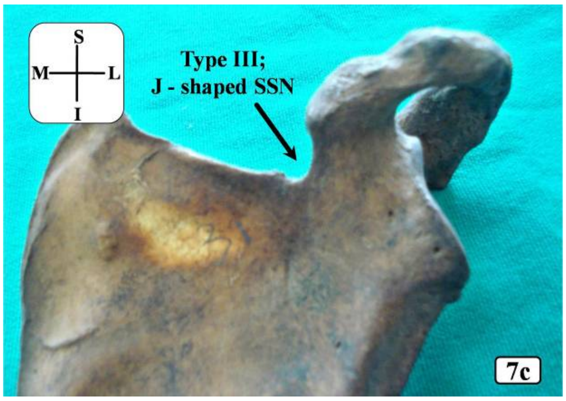


Fig. 7-c: A photograph of the ventral surface of a left scapula showing type III suprascapular notch (SSN) which appears J-shaped (arrow) having VD > TD.

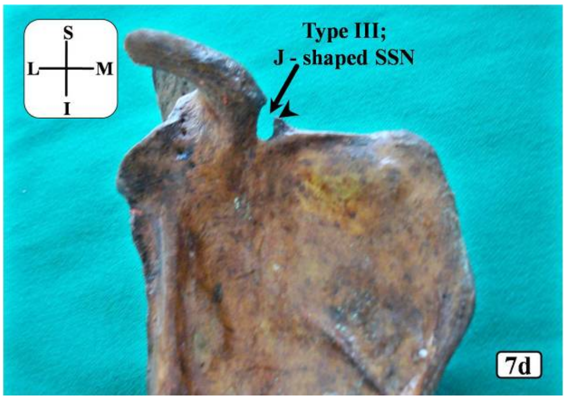


Fig. 7-d: A photograph of the ventral surface of a right scapula showing type III suprascapular notch (SSN) which appears J-shaped (arrow) having spine (arrow head).

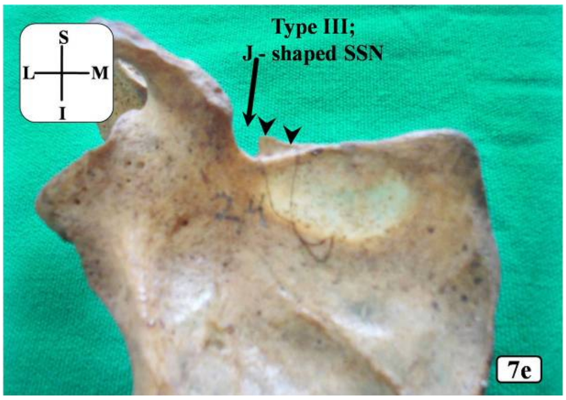


Fig. 7-e: A photograph of the ventral surface of a right scapula showing type III suprascapular notch (SSN) which appears J-shaped (arrow) having bony plate (arrow heads) and groove.

Fig. 8: A photograph of the ventral surface of a left scapula showing type IV having suprascapular foramen only (SSF) (arrow) without a visible notch in the superior border of the scapula.

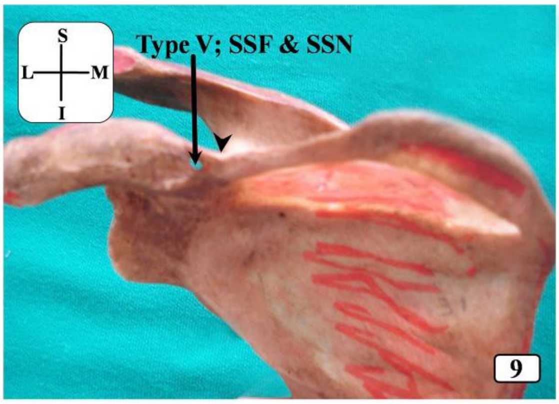


Fig. 9: A photograph of the ventral surface of a right scapula showing type V having suprascapular foramen (SSF) (arrow) associated with a visible notch (arrow head) in the superior border of the scapula.

4. Discussion

Suprascapular nerve entrapment is an acquired neuropathy secondary to compression of the nerve in the bony suprascapular notch more than in the spinoglenoid notch *(Callahan et al., 1991 and Duparc et al., 2010).*

For understanding of location and source of the entrapment syndrome, several morphological variations and classification of the suprascapular notch were reported in other populations. This study concerned with measurements of the suprascapular notch which represent the space for the passage of the suprascapular nerve. In addition, the distance between the lower margin of the suprascapular notch and the base of the spinoglenoid notch representing the length of the course of the suprascapular nerve into the infraspinous fossa was considered. Moreover, the width, length and width/length index of all scapulae were studied. *Yücesoy et al. (2009)* evaluated the notch width and depth as well as the superior transverse scapular ligament in 50 volunteers by means of ultrasound and they found narrow notches in patients with suprascapular nerve entrapment syndrome. *Polguj et al. (2011)* reported that the size and shape of the suprascapular notch may be a factor in suprascapular nerve entrapment.

Various workers have been classified suprascapular notch in different populations on the basis of parameters and shape of the notch *(Rengachary et al., 1979b; Iqbal et al., 2010; Sinkeet et al., 2010 and Wang et al., 2011). Rengachary et al. (1979b)* observed six types of supracapular notch in 211 cadaveric adult scapulae based on the shape. In the current study, five types of suprascapular notch were observed in 132 scapulae based on the measured parameters. Absence of suprascapular notch was observed in 6.06 % of the examined scapulae and was considered as type I while the other 124 (93.94%) scapulae showed the other four types. *Rengachary et al. (1979b)* suggested that absence of the suprascapular notch may be responsible for compression of the suprascapular nerve by the superior transverse scapular ligament which may be pronounced when the ligament is ossified. Absence of suprascapular notch in the present study was reported by *Soni et al. (2012).* However, the occurrence of this finding is not in accordance with Chinese study of *Wang et al. (2011)* who recorded this type in 28% studied scapulae.

In this study, type II suprascapular notch was the most prevalent type and found in 45.45% of the examined scapulae having longer transverse diameter than the vertical diameter **(**TD > VD). This is in agreement with *Natsis et al. (2007)* in Greek, *Wang et al. (2011)* in Chinese and *Soni et al. (2012)* in Indian**.** Type III suprascapular notch was seen in 43.93% and had longer or equal vertical diameter compared with transverse diameter (VD ≥ TD).This is in accordance with *Natsis et al. (2007)* who found this type (III) in 41.85%, having notch with longest vertical diameter. Accidentally, in the present study, scapulae that of the same cadaver had either the same type of suprascapular notch or showed two different types inspite of their similarity in scapular width and length. *Yücesoy et al. (2009)* in their ultrasonographic study stated that there is no detectable difference between two sides of the scapulae as regards to the measured notch width and depth.

In this work, type IV with suprascapular foramen was only found in 3.03% of examined scapulae while 1.5 % was of type V which had suprascapular foramen associated with a visible notch. *Natsis et al. (2007)* found type IV, bony foramen, in 7.3% of 423 scapulae and type V, bony foramen and notch, in 0.7%. They suggested that presence of foramen may indicate complete ossification of the superior transverse scapular ligament joining the two superior corners. *Polguj et al. (2011)* added that the ossification of this ligament was demonstrated in Turkish, German, French and Italian as well as Polish people. In Polish, the superior transverse scapular ligament was completely and partially ossified in 7 and 23.3%, respectively. In Indian; *Soni et al. (2012)* found complete ossification of the ligament with the notch being converted to foramen in 3% and partial ossification was seen in 11%. Furthermore, *Wang et al. (2011)* reported presence of double suprascapular foramen and added that type IV had the shortest distance between the lowest point of the suprascapular notch and the base of the spinoglenoid notch which was also noted in the present study.

Ticker et al. (1998) paid attention to type V (suprascapular foramen with notch) and explained its existence due to a bony bridge within the suprascapular notch. This bony bridge is the outcome of the ossification of an accessory superior transverse scapular band. They concluded that the bony bridge must be excised to achieve better surgical results for treatment of suprascapular nerve entrapment. Moreover, *Natsis et al. (2008)* reported that bony bridge within the suprascapular notch divided the notch into a bony foramen inferiorly and a notch superiorly and would limit the remaining space leading to suprascapular nerve entrapment.

Rengachary et al. (1979a) proposed the “sling effect” to explain suprascapular nerve injury against the inferior margin of the superior transverse scapular ligament. They reported that the site of origin and the site of termination of the nerve in the supraspinatus muscle are at a higher plane than that of the notch. Moreover, *Natsis et al. (2008)* stated that the radiologists, neurosurgeons and orthopaedic surgeons should bear typing of the notch in mind. Its identification during the preoperative radiological examination or intraoperatively is essential as it may alter the surgical technique of suprascapular nerve decompression**.**

The previously described five types of suprascapular notch in the present study are in accordance with the results of *Natsis et al. (2007)* who reported five types of suprascapular notch. Type I, without a discrete notch; type II, a notch which had longest in its transverse diameter; type III, a notch that was longest in its vertical diameter; type IV, a bony foramen and type V, a notch with a bony foramen. However, *Polguj et al. (2011)* determined five types of suprascapular notch having different description. They reported that type I had a longer maximal depth than superior transverse diameter. Type II had equal maximal depth, superior transverse diameter and middle transverse diameter. Type III had a superior transverse diameter longer than the maximal depth. Type IV was a bony foramen. Type V had a discrete notch. Typing of the suprascapular notch may have clinical significance for suprascapular nerve entrapement as a narrow suprascapular notch has been found in patients with suprascapular nerve entrapement syndrome *(Rengachary et al., 1979b)***.** A narrow notch in combination with an anomalous superior transverse scapular ligament causes sufficient constriction to be considered as a risk factor for suprascapular nerve entrapement syndrome (*Ticker et al., 1998 and Bayramoğlu et al., 2003).* On the other hand, *Natsis et al. (2007)* mentioned that abnormalities of superior transverse scapular ligament do not alter the notch typing because it is based on the bony variation in the notch and they can be easily observed on plane radiographs.

The present statistical study revealed highly significant negative correlation present between vertical diameter (VD) of the notch with distance between the lower margin of the suprascapular notch and the base of spinoglenoid notch (SGND) in types II and III notches. However, there was highly significant and significant correlation between transverse diameter (TD) of the notch with SGND as well as with the length of the scapula (L) and W/L index in type III. On the other hand, *Polguj et al. (2011)* stated that the maximal depth of the suprascapular notch negatively correlated with the scapular width-length index but correlated with the length of the scapulae.

This study revealed that there was no statistically significant difference between the measured parameters (SGND, W, L, W/L) in types I, II and III notches. This is in accordance with *Polguj et al. (2011)* who reported that there was no statistically significant difference between anthropometric measurements in the group with higher maximal depth and the group with higher superior transverse diameter which are corresponding to types III and II in this study.

According to *Sinkeet et al. (2010)* who reported that suprascapular nerve entrapment neuropathy is associated with the morphology of the suprascapular notch. This study revealed three morphological variations (U, V and J) of suprascapular notches in 118 scapulae. The most common one was U shape (76.27%) that 18.64% of them had nearly parallel lateral margins. Also, *Ticker et al. (1998)* found U-shaped suprascapular notches in 77%. *Sinkeet et al., (2010)* reported symmetrical U shaped notch in 29%

scapulae. Meanwhile, *Soni et al. (2012)* showed U-shaped notch in 58%.

In this work, the second morphological variation was V-shaped notch and detected in 13.56%. In contrast to this result, *Ticker et al. (1998), Bayramoğlu et al. (2003), Duparc et al. (2010) and Soni et al. (2012)* found V- shaped suprascapular notches in 23%, 25%, 36.7% and 7% respectively. *Dunkelgrun et al. (2003)* stated that the U-shaped notches had larger area than the V-shaped notches, leading to the assumption that a V-shaped notch is more likely to be vulnerable to nerve entrapment. The third variation of this study was J shape (10.17%); 66.66% of them had a spine while 16.66% of them had a bony plate as well as a groove in the superior border medial to the notch**.** In Indian, *Soni et al. (2012)* found J-shaped notch in 27%.

In the present study, tapering spine had been seen in the narrow deep U- shaped suprascapular notches (27.3%). This spine may be due to partial ossification of the medial part of the superior transverse scapular ligament resulting in a notch with small transverse diameter as reported by *Rengachary et al. (1979b).* Concerning presence of bony plate in this study, it was seen in 18 scapulae associated with groove (15.25%). Most of them were found in scapulae with V-shaped notch. *Rengachary et al. (1979b)* stated that frequent presence of a shallow groove represents the bony impression by the suprascapular nerve adjacent to the V-shaped notch. *Wang et al. (2011)* found eight cases with a narrow groove on the lowest point of suprascapular notch**.**

5. Conclusion

This study classified the suprascapular notch into five types and three morphological variations which could be used in further investigations for management of suprascapular nerve entrapment.

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