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# Variable morphology of the suprascapular notch: A proposal for classification in Chinese population

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ABSTRACT

*Background:* The variable of the suprascapular notch (SSN) is a common cause in suprascapular nerve (SN) entrapment. Hence, knowledge of SSN variations may be predictive valuable for the predisposition to compression of SN. The aim of this study was to propose the classification of SSN in Chinese population and took this complex morphology into account.
*Material and methods:* 308 human dry scapulae were analyzed thoroughly and systematically in this study. Morphological variations of the SSN were observed by visual inspection and the classification of SSN was determined by geometrical measurements. Then measurement results were averaged and recorded.
*Results:* Chinese dry scapulae were measured, we found seven types of SSN. Type I (√, 44.8%) was the most common, followed by type II (U, 41.9%) to VII (double O, 0.6%). Right scapulae were larger in depth of SSN and thickness of A and C. Type VII (double O) had the deepest SSN and type I (√) was widest among five types. For BC, type I (√) was shorter than type III (V). For thickness of A, type VII (double O) was greater than type I (√). For thickness of C, type I (√) and type II (U) were shorter than type III (V). There were no significant differences in other measurements between types and sides of body. Seven types of SSN in Chinese population were defined in our study.
*Conclusion:* These anatomical variations of the SSN may improve the diagnostic rate and success rate of the surgical for the suprascapular nerve entrapment.



## 1. Introduction

The Suprascapular Notch(SSN)is a depression, which is situated at the superior border of the scapula, and medial to the coracoid process (Antoniou et al., 2001; Vastamaki and Goransson, 1993). This is an important incisura. Of this site, the superior transverse suprascapular ligament (STSL) covers on the SSN, and under the STSL is the suprascapular nerve (SSN) and artery. The SSN is vulnerable in the setting of bony injury (Kowalczuk, 2018). Therefore, the SSN may be a limiting factor for the suprascapular nerve and adjacent neurovascular structures, so that this site easily causes compression and injury to the SN, which can result in SN entrapment syndrome (Pecina, 2001). And of all shoulder pain, 1-2% is caused by entrapment of the SN (Zehetgruber et al., 2002). Thus, the anatomic information of SSN is significant in the management of entrapment neuropathy.

The first description of the SN entrapment at the site of the SSN was made by Kopell and Thompson (1959). Then Rengachary et al. (1979a,b) offered six types of SSN. From their point of view, the size of SSN may have predictive value in determining the predisposition to compression of SN, and the narrow notch had greater

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opportunity to be found in patients with the SN syndrome (Bhatia et al., 2006; Hrdicka 1942; Ofusori et al., 2008; Yücesoy et al., 2009). From then on, more studies focused on this topic, and offered many views. Studies have been carried out in different population. Olivier (1960); Vallois (1925) and Natsis et al. (2007) studied the SSN aim at French, Italian and Greek, respectively. Urgüden et al. (2004) and Bayramoğlu et al. (2003) studied Turks. Edelson (1995); Tubbs (2003); Rengachary et al. (1979a,b); Rengachary et al. (1979a,b) studied American. And Hrdicka (1942) studied native American and Alaskan Eskimos. Then Sangam et al. (2013) and Agrawal et al. (2015) studied this structure aiming at Indian. Also, there was a study carried by Podgórski et al. (2016) aimed at Poland pediatric population. Nevertheless, little attention was paid to this issue in the Chinese population. Sangam et al. (2013); Kumar and Sharma (2014) and Polguj et al. (2015a,b) proposed it may be some correlations between the SSN type and SN entrapment. However, their classification was not comprehensive, and only six types of SSN were proposed in their study.

We measured abundant intact dry Chinese scapulae, and classified SSN in terms of the shape and size, which made the classification more intuitionistic and visual. Our study offered a plentiful and new classification of SSN. To our knowledge, no such abundant and comprehensive variable morphologies study of the SSN in Chinese population described in this study has been reported previously. This anatomic information is significant in the management of entrapment neuropathy.

## 2. Material and methods

### 2.1. Material

Ethical approval was given by the medical ethics committee of School of Basic Medical Sciences, Southern Medical University. A total of 308 intact dry Chinese scapulae were collected from the School of Basic Medical Sciences, Southern Medical University, Guangzhou, Guangdong province, China. Age and sex of the donors were unknown.

### 2.2. Methods

All scapulae were observed and measured. Firstly, the SSN was morphologically classified based on its shape and size which have been observed by visual inspection. Then, anatomical structure was measured and analyzed according to standard definitions and using procedures, precision as described elsewhere (2001). Inclusion criteria for the participation in this study were aged from 20 to 60 years old and belonged to the Chinese Han nationality. The scapulae which satisfied the following subjects were ruled out: (1) The undeveloped complete scapulae from the patient that under 20 years old & the osteoporosis scapulae from the patient that over 60 years old; (2) Congenital shoulder malformation; (3) Having a fracture. Measurements were carried out by vernier caliper(SOMET$^{TM}$CN-25 1234, accurate to 0.1 mm) and recorded in millimeters. Each scapula was measured for the following (Fig. 3):

(1) The depth and the width of SSN.
(2) AB: The distance between point A and point B (*point A* the nadir of the SSN, *point B* the vertical line from point A to scapular spine where it meets with the point A).
(3) BC: The distance between point B and point C (*pointC* a point of the submit of scapular spine).
(4) BD: The distance between point B and point D (*point D* the nadir of the spinoglenoid notch).
(5) CE: The distance between point C and point E (*point E* the acromial angle).
(6) CF: The distance between point C and point F (*point F* the medial edge of the scapula).
(7) AG: The distance between point A and point G (*point G* superior angle of scapula).
(8) Thickness of point A, B, and C.

**Table 1**
Measured values of SSN based on sides of body.

| | Left | Right |
|---|---|---|
| Depth of SSN | 5.63 ± 1.50* | 6.28 ± 1.94 |
| Width of SSN | 10.66 ± 3.54 | 10.70 ± 3.55 |
| AB | 12.78 ± 2.97 | 12.82 ± 2.95 |
| BC | 29.70 ± 4.43 | 30.00 ± 5.01 |
| BD | 13.16 ± 2.55 | 12.70 ± 2.82 |
| CE | 37.48 ± 5.77* | 39.42 ± 6.26 |
| CF | 79.23 ± 7.42 | 79.22 ± 7.12 |
| AG | 49.69 ± 6.24 | 51.01 ± 5.94 |
| Thickness of A | 2.37 ± 0.69* | 2.70 ± 0.72 |
| Thickness of B | 8.50 ± 1.41 | 8.76 ± 1.63 |
| Thickness of C | 12.15 ± 3.68* | 13.19 ± 3.54 |

SSN, surprascapular notch.
* P < 0.05 Vs Right.

To avoid the inter-observer variation, each of the measurements was carefully observed twice by the same investigator. The investigator is a researcher which works in Department of Human Anatomy of Southwest Medical University of China and engaged in anatomical work for more than 5 years.

## 3. Statistical analysis

All data were categorized according to morphology and side of the body (left or right). And statistical differences in the side of the body were assessed using independent sample t-tests. One-way ANOVA and Tamhane's T2 were used to analyze the statistical differences in the morphology of the body. All statistical analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA), and a P value < 0.050 was considered to be statistically significant.

## 4. Results

Among 308 scapulae (143 left scapulae, 165 right scapulae), seven types of SSN were found. The shape of each SSN was shown on Fig. 1 and Fig. 2. Type I (√, 44.8%) and type II (U, 41.9%) were more common. The frequency of type III (V), type IV (O), type V (ʊ) and type VI (W) was 6.2%, 2.9%, 1.9% and 1.6%, respectively. Type VII (double O, 0.6%) was the lesser type which was found in 2 scapulae. The mean ± standard deviation of each parameter was shown on Table 1 and Fig. 4.

Measured values of SSN based on sides of body (Table 1)

It was evidently that difference existed between sides of body. For depth of SSN, CE, and thickness of A and C, right scapulae were all larger than left ones (Depth of SSN 6.28 ± 1.94 mm on the right side vs. 5.63 ± 1.50 mm on the left side, p = 0.004; CE 39.42 ± 6.26 mm on the right side vs. 37.48 ± 5.77 mm on the left side, p = 0.041; thickness of A 2.70 ± 0.72 mm on the right side vs. 2.37 ± 0.69 mm on the left side, p = 0.076; thickness of C 13.19 ± 3.54 mm on the right side vs. 12.15 ± 3.68 mm on the left side, p = 0.012).

Measured values of SSN based on classification (Fig. 4)

We observed significant differences in depth and width of SSN, AB, BC, thickness of A, B, C between different types. Type VII (double O) had the deepest SSN (11.05 ± 0.38). However, width of type I (√) and type II (U) were greater (type I 12.56 ± 3.18, p = 0.000; type II 9.93 ± 2.73, p = 0.009) than type V (6.75 ± 2.15). For AB, type I (√) and type II (U) were shorter (type I 12.63 ± 2.57, p = 0.010; type II 12.45 ± 2.75, p = 0.007) than Type VI (W) (16.05 ± 3.95). For BC, type

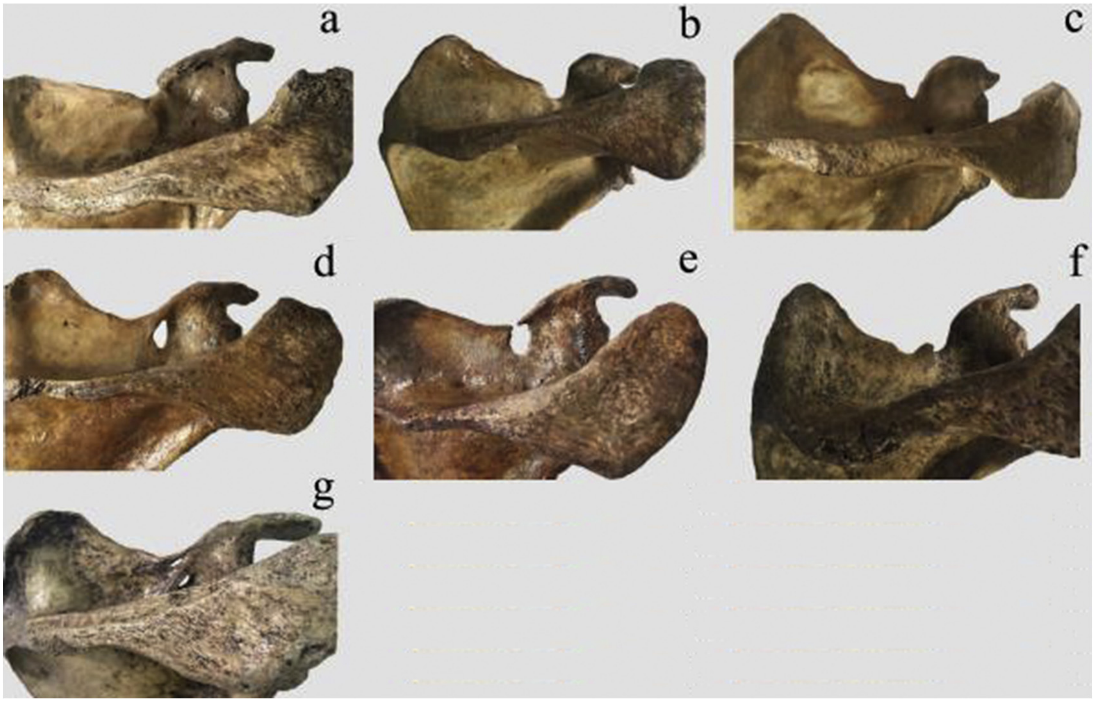


**Fig. 1.** Specimens of different types of suprascapular notch.
(a) Type I means √-shape. (b) Type II means U-shape. (c) Type III means V-shape. (d) Type IV means O-shape. (e) Type V means ℧shape. (f) Type VI means W-shape. (g) Type VII means double O-shape.

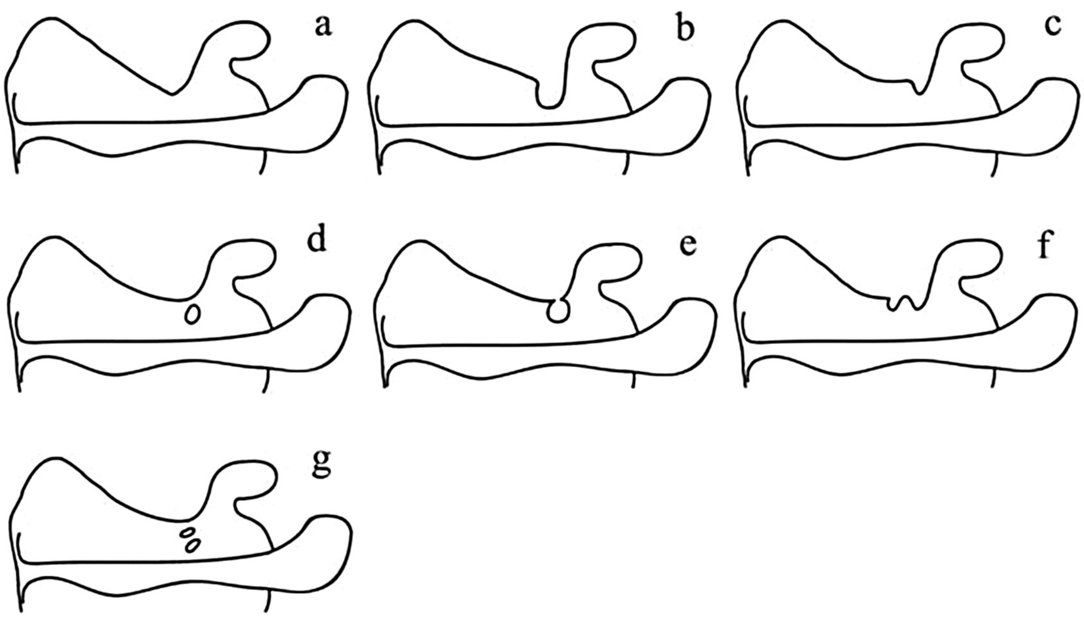


**Fig. 2.** Sketches of different types of suprascapular notch shown on a diagram.
Type I means √-shape. (b) Type II means U-shape. (c) Type III means V-shape. (d) Type IV means O-shape. (e) Type V means ℧shape. (f) Type VI means W-shape. (g) Type VII means double O-shape.

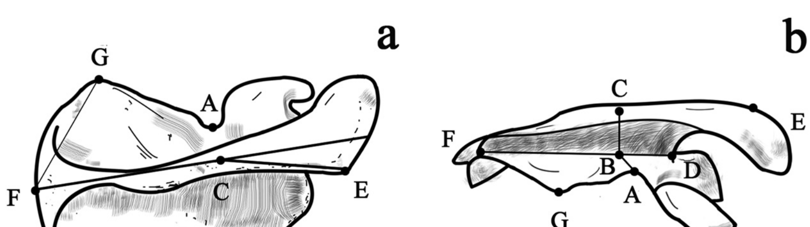


**Fig. 3.** point A: the nadir of the SSN, point B: the vertical line from point A to scapular spine where it meets with the point A, point C: a point of the submit of scapular spine, point D: the nadir of the spinoglenoid notch, point E: the acromial angle, point F: the medial edge of the scapula, point G: superior angle of scapula.

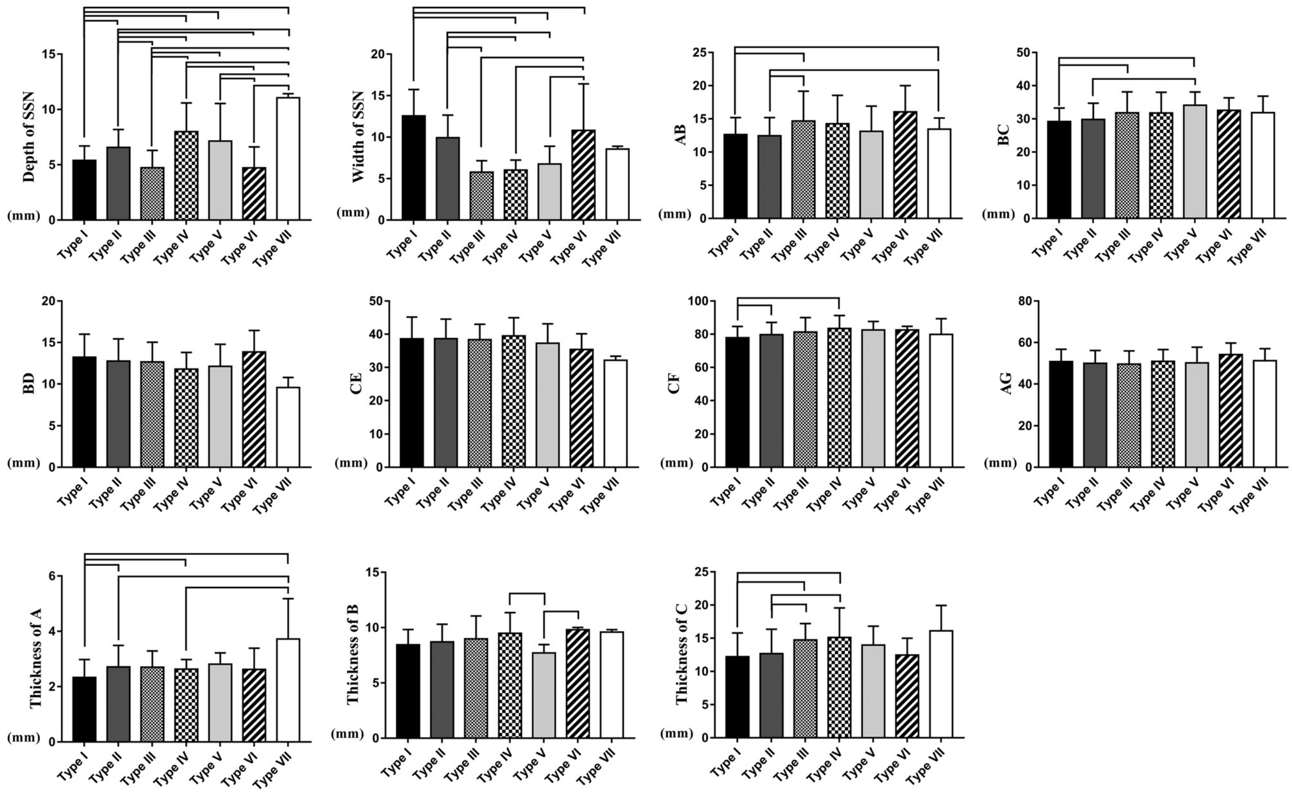


**Fig. 4.** Measured values of SSN based on classification.

I (√) and type II (U) were shorter (type I 29.19 ± 4.08, p = 0.012; type II 29.81 ± 4.92, p = 0.029) than type V (34.10 ± 4.01). For thickness of A, type VII (double O) was the greatest (3.72 ± 1.46) among four types (type I p = 0.006, type II p = 0.044 and type VII). And for type III, the mean thickness of C was 14.74 ± 2.47, while the figure for type I was lower at 12.21 ± 3.59 (p = 0.004) and type II was lower at 12.67 ± 3.69 (p = 0.020).

## 5. Discussion

When it comes to the anatomical variations, some potential factors which predispose a patient to SN entrapment contain the shape of the SSN (Dunkelgrun et al., 2003), the presence of the anterior coracoscapular ligament (Avery et al., 2002), band-shaped (Polguj et al., 2013a,b), bifurcated (Polguj et al., 2012a,b), or completely ossified (Tubbs et al., 2013) STSL, the course of the SN and vessels (Piyawinijwong and Tantipoon, 2012). Moreover, the morphologic features of the STSL and SSN were the most commonly admissive possible predisposing factors of SN entrapment. (Polguj et al., 2014) Nowadays, several studies which focus on the classification of SSN have been carried out in different populations. However, little attention is paid to this issue in the Chinese population and their classification is not comprehensive. This study offered a full-scale and straightforward classification of the SSN aiming at Chinese population.

The first classification of SSN was stated by Hrdicka (1942). In this study, he separated the SSN into five types based on visual observation: In type I, the SSN was absent; in type II to IV, the SSN respectively were shallow, medium and deep; and in type V, a complete foramen was formed. Later, Olivier (1960) proposed five types of SSN. This classification was similar with Hrdicka's, and proposed that type V was formed by completely ossified STSL. This can be an important factor of suprascapular entrapment (Polguj et al., 2012a,b). And it may have correlations with ban-shaped STSL. According to Polguj M's study (2014) the ossified band-shaped STSL should be considered as a potential risk factor in suprascapular nerve entrapment because the space below the bony bridge is significantly reduced compared with the case of the ossified fan-shaped ligament. However, Hrdicka's and Olivier's studies were not based on specific geometrical parameters. It was worth noting that Rengachary described six types of SSN in 1979, the classification depended on the bony configuration and enclosures. The first type lacked a discrete notch. Their second type was a wide, blunt "V"-shape notch, which took up about a third of the scapulae. The third type was symmetrical and "U"-shape. In the type IV, the notch was fairly small and "V"-shape, which frequently caused SN impression. The fifth type was similar to the type "III" with its minimal diameter along the superior border of the scapula. In the sixth type, the STSL was completely ossified, resulting in a bony foramen. Also in Iqbal and Iqbal (2011) based on the shape, described three types of SSN: U-shaped (13.2%), V-shaped (20%) and J-shaped (22%). Polguj et al. (2015a,b) assessed the sensitivity and specificity of various types of SSN using sonography.

Our study offered seven types of SSN in all, revealing that SSN variations were common in Chinese population. In western population, the U-shape type was the most common and the O-shape was rare. A similar result in Chinese population was proposed in our study. Polguj et al. found the trifid STSLs in a large U-shaped SSN whose middle band was completely ossified (Polguj et al., 2012a,b). And they described the anterior coracoscapular ligament (ACSL), which was a bifid STSL (an additionally singular fibrous band extending on the front side of the SSN, below the STSL). ACSL brought the nerve into osculating contact with the bony floor of the SSN as well as intensifying the risk of neuropathy (Polguj et al., 2013a,b) Type I (√) and type II (U) were the most general types (44.8%; 41.9%), while the frequency of type IV (O) was only 2.9%. Sinkeet et al. (2010) proposed that it was plausible to say that the epiphysis influences the shape of the

SSN. We found a distinct type of SSN which was double O-shape type. And this type was not found in western population, only once proposed by Wang et al. (2011). This might be developed from the bified ossified STSL (Polguj et al., 2012a,b). Polguj et al., (2012a,b) believed that the bifid type of entity might be one of the possible causes of SN entrapment, which had the same result as ours.

The frequency of type VII (double O) was the smallest of all (0.6%). In the present study, the absent SSN was not observed.

Suprascapular neuropathy has become an increasingly recognized pathologic process and cause of shoulder pain and weakness during the past few decades (2018). Meanwhile, Kopell and Thompson (1959) first described the SN entrapment may occur at the site of the SSN. Albino et al. (2013) proposed the SN entrapment was more likely to be associated with SSN of type III (the type was symmetrical and "U"-shaped). Then Dunkelgrun et al. (2003) stated that U-shape notch had a larger area than V-shape notch, which was the reason why V-shape notch was more connected with the SN entrapment. Also, our study showed a similar result. We analyzed the mean values of SSN based on sides of body and classification respectively and found that type I (√) was the shallowest (6.57 ± 1.62) compared to other types and was the widest (12.56 ± 3.18) among five types (type I, II, III, IV and V, all p = 0.000). Width of type I (√) and type II (U) were greater (type I 12.56 ± 3.18, p = 0.000; type II 9.93 ± 2.73, p = 0.009) than type V (6.75 ± 2.15). For AB, type I (√) and type II (U) were shorter (type I 12.63 ± 2.57, p = 0.010; type II 12.45 ± 2.75, p = 0.007) than Type VI (W) (16.05 ± 3.95). For BC, type I (√) and type II (U) were shorter (type I 29.19 ± 4.08, p = 0.012; type II 29.81 ± 4.92, p = 0.029) than type V (34.10 ± 4.01). For thickness of A, type VII (double O) was the greatest (3.72 ± 1.46) among four types (type I p = 0.006, type II p = 0.044 and type VII). And for type III, the mean thickness of C was 14.74 ± 2.47, while the figure for type I was lower at 12.21 ± 3.59 (p = 0.004) and type II was lower at 1 2.67 ± 3.69 (p = 0.020). We also view that right scapulae were larger in depth of SSN and thickness of A and C than left ones (p = 0.004, p = 0.041, p = 0.076, p = 0.012 respectively). There were no significant differences in other measurements between types and sides of body. The type VII of SSN was narrower and deeper than other types which could be more predisposed to injury by the sharp bony walls of this structure (2010). Type I (√) and type II (U) had a fairly wide and shallow notch. We also observed the border of the two types was smoother than other types. The results may suggest that the type I (√) and II (U) should have less possibility to result in the SN entrapment.

We measured 308 intact dry Chinese scapulae and analyzed the figures. It offered a full-scale and visual classification of SSN aiming to Chinese population. Seven types SSN were found, and we classified them based on observation and quantitative analyzation. The presented classification of the SSN is simple, easy to use, clearly-described, which allows one to clearly distinguish seven types of these structures. When considering percutaneous or arthroscopic treatment, understanding the possible anatomic variation of SSN may guide treatment decisions, and prevent unnecessary vascular insult.

However, Limitations still exist in this study. Firstly, we obviously lack data concerning the correlation between SSN morphology and suprascapular nerve entrapment. Also the samples in this research are limited to the southern part of China and the sex and ages of donors are unknown. Secondly, although one researcher measured all the specimens twice carefully, there were still possible a few observational errors. Thirdly, we only used the manual measurement, and if possible the computed tomography and 3D scan technology can produce more precisely results. Lastly, the inferences about SSN are limited.

## 6. Conclusion

We have shown that morphologies of SSN described as associated to SN entrapment are also frequently observed in the Chinese population. And the results imply that right scapulae have more chance to present SN entrapment. This anatomical discovery can improve the diagnostic rate and success rate of the surgical for the suprascapular nerve entrapment.

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## Ethical note

The research complied with protocols approved by the medical ethics committee of School of Basic Medical Sciences, Southern Medical University.

## Conflict of interest

No conflict of interest exits in the submission of this manuscript, and the manuscript is approved by all authors for publication.

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