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Correlation between morphometry of the suprascapular notch and anthropometric measurements of the scapula

M. Polguj[1], K.S. Jędrzejewski[1], M. Podgórski[1], M. Topol[2]

[1]*Department of Normal and Clinical Anatomy, Chair of Anatomy, Medical University of Łódź, Poland*
[2]*Department of Angiology, Chair of Anatomy, Medical University of Łódź, Poland*

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The concept of the study was to find the correlation between the morphometry of the suprascapular notch and basic anthropometric measurements of the human scapula.
The measurements of the human scapulae included: morphological length and width, maximal width and length projection of scapular spine, length of acromion, and maximal length of the coracoid process. The glenoid cavity was measured in two perpendicular directions to evaluate its width and length. The width-length scapular and glenoid cavity indexes were calculated for every bone. In addition to standard anthropometric measurements two other measurements were defined and evaluated for every suprascapular notch: maximal depth (MD) and superior transverse diameter (STD).
The superior transverse suprascapular ligament was completely ossified in 7% of cases. Ten (11.6%) scapulae had a discrete notch. In the studied material, in 21 (24.4%) scapulae the MD was longer than the STD. Two (2.3%) scapulae had equal maximal depth and superior transverse diameter. In 47 (57.7%) scapulae the superior transverse diameter was longer than the maximal depth. There was no statistically significant difference between anthropometric measurements in the group with higher MD and the group with higher STD. The maximal depth of the suprascapular notch negatively correlated with the scapular width-length index. The maximal depth of the scapular notch correlated with the morphological length of the scapulae. (Folia Morphol 2011; 70, 2: 109–115)

Key words: suprascapular notch, human, variation

INTRODUCTION

The scapula is one of the most interesting bones of the human skeleton because it presents many variations. Being essentially a functional product its anthropological value could hardly be expected to be very great; nevertheless, its variants have greater or lesser phylogenic, ontogenic, and racial significance. One of the most clinically important places on the scapula is the suprascapular notch (SSN). This structure is a depression on the lateral part of the superior border of the scapula, medial to the coracoid process. The SSN is closed by the superior transverse scapular ligament (STSL). The suprascapular nerve and vein run below this ligament, and above the STSL passes suprascapular artery [2, 14, 20, 25].

Morphological variations of the SSN are very important clinically for possible predisposing factors for compression of the suprascapular nerve in this

Address for correspondence: M. Polguj, Department of Normal and Clinical Anatomy, Chair of Anatomy, Medical University of Łódź, Poland, Narutowicza 60, 90–136 Łódź, tel: +48 42 630 49 49, e-mail: michal.polguj@umed.lodz.pl

region. Suprascapular nerve neuropathy is a big problem in some individuals who have been involved in violent overhead activities. In international-level high-performance volleyball players the frequency of this pathology was 33% [15]. Additionally, in the whole population approximately 1–2% all shoulder pain is caused by this syndrome. Suprascapular nerve entrapment was first described by Kopell and Thompson in 1959 [19]. The result of suprascapular nerve entrapment is weakness of the arm, difficulty in external rotation and abduction, and then atrophy of the infra- and supraspinatus muscles [1, 7, 10, 39].

Rengachary et al. [31, 32] stated that the size of the SSN played a role in the predisposition for suprascapular nerve entrapment. In their opinion, a small notch gave a greater chance of a nerve impingement than a large one. The SSN type, apart from the anatomical interest, may have some clinical significance for suprascapular nerve entrapment [13, 41]. The size and shape of the SSN may be a factor in suprascapular nerve entrapment because narrow SSNs have been found in patients with this syndrome [4, 16, 28, 40].

According to a current professional bibliography search, there is no description of the correlation between the diameters of the SSN and basic anthropometric measurements of the human scapula.

MATERIAL AND METHODS

A total of 86 dried human scapulae (40 left and 46 right) were included in the study. All investigations were performed in the Chair of Anatomy of the Medical University of Lodz. The research project and procedures were approved by the Bioethics Commission of the Medical University of Lodz (protocol No. RNN/12/10/KE). The bones were dated to the second half of the twentieth century (1950s).

The scapulae with completely ossified superior transverse scapular ligaments and scapulae with a discrete notch (16 specimens) were excluded from the morphometric study because it was not possible to collected two new SSN dimensions as described and defined below.

The osteometric measurements of 70 human scapulae (29 left and 41 right) were carried out using procedures and precision as described elsewhere [5, 23, 24, 33]. Each scapula was measured for the following (Fig. 1):
— morphological length (M1);
— morphological width (M2);
— projection length of scapular spine (M7);
— maximal width of scapular spine (M9);

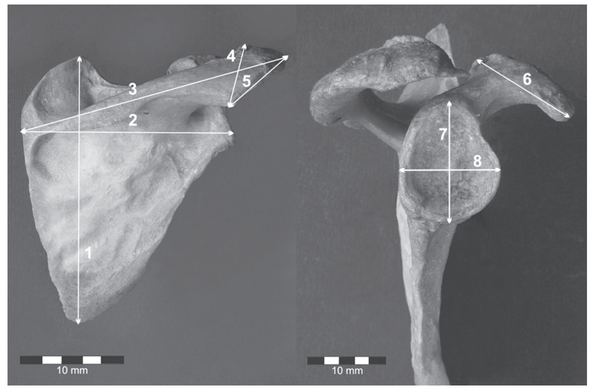

Figure 1. Osteometric measurements of the scapula: 1 — morphological length; 2 — morphological width; 3 — projection length of scapular spine; 4 — maximal width of scapular spine; 5 — length of acromion; 6 — maximal length of the coracoid process; 7 — length of the glenoid cavity; 8 — width of the glenoid cavity.

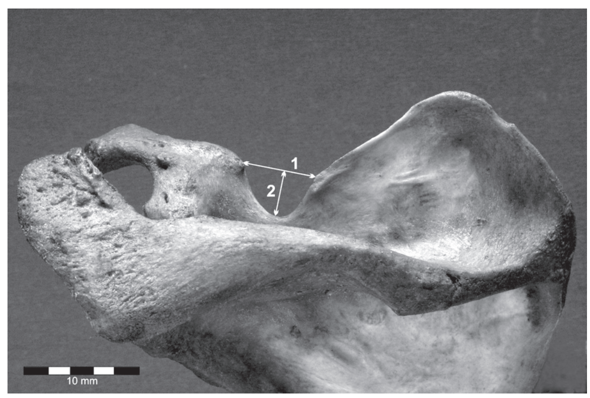

Figure 2. Dimensions of the suprascapular notch: 1 — superior transverse diameter; 2 — maximal depth.

— length of acromion (M10);
— maximal length of the coracoid process (M11);
— length of the glenoid cavity (M12);
— width of the glenoid cavity (M13).

The osteometric measurements and their symbols (M1–M2, M7, M9–M13), as well as the definition of the scapular indices, were taken without any alteration from the standard anthropometry handbook [24] with the exception of two newly described and defined SSN dimensions as follows (Fig. 2):
— the 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 SSN;
— the 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 scapulae.

The following indices were calculated using given values:
— width-length index (WLI): WLI = (M2/M1) × 100%;
— glenoid cavity index (GCI): GCI = (M13/M12) × 100%.

Statistical analysis

Data analysis was performed using Statistica 8 software (StatSoft Polska, Cracow, Poland). Distribution of continuous variables was investigated using the Shapiro Wilk test in order to check whether the distribution was normal or not. The Mann-Whitney test was used to determine the statistical difference between a group with higher MD and a group with higher STD, taking into consideration the basic anthropometric measurements of the scapulae. Descriptive statistics were used as mean and standard deviation (SD) for continuous variables. The correlation between the SSN measurements and basic anthropometric measurements of the scapulae were examined using the Spearman's rank correlation coefficient. A p level of < 0.05 was accepted as statistically significant.

Figure 3. The scapula with discrete suprascapular notch.

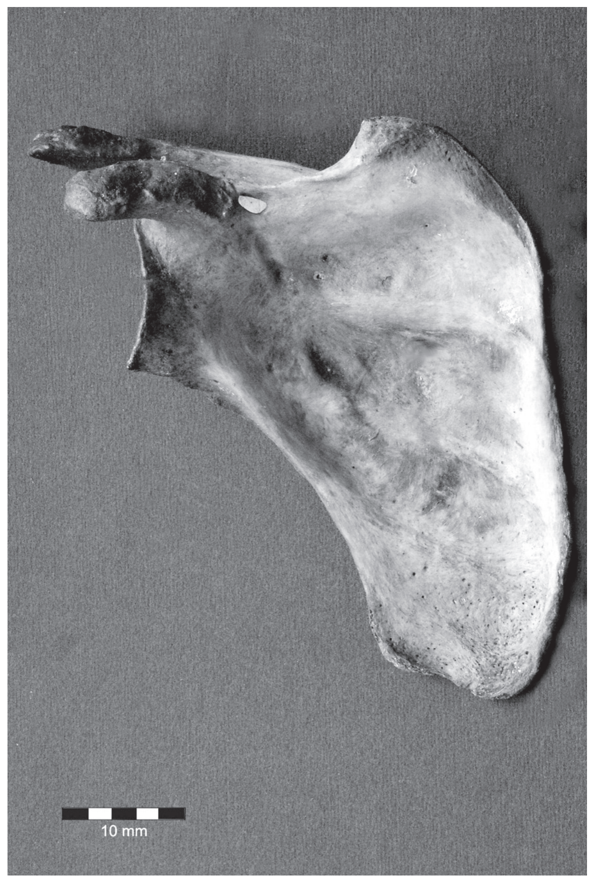

Figure 4. The scapula with bony foramen (superior transverse suprascapular ligament was completely ossified).

RESULTS

In the studied material ten (11.6%) scapulae had a discrete notch (Fig. 3). Bony foramen (superior transverse suprascapular ligament was completely ossified) was present in 7% of the cases (6 scapulae) (Fig. 4).

In 21 (24.4%) scapulae the MD was longer than the STD (Fig. 5A). Two (2.3%) scapulae had equal MD and STD (Fig. 5B). In 47 (57.7%) scapulae the STD was longer than the MD (Fig. 5C).

Talking into consideration the correlation between the SSN and basic anthropometric measurements of the scapulae, the MD of the SSN negatively correlated with the scapular WLI ($R = -0.327040$; $p = 0.005721$). However, it was highly characteristic of our results that the MD of the scapular notch correlated with the morphological length of the scapulae ($R = 0.265179$; $p= 0.026515$). There were no other statistically significant correlations between anthropometric measurements of the scapula and dimensions of the SSN.

In scapulae with longer MD (MD > STD) projection length of scapular spine, maximal width of scapular spine, maximal length of acromion, maximal width of the coracoid process, and length and width of the glenoid cavity were higher than in scapulae with longer STD (Table 1). In scapulae with longer STD (STD > MD) morphological length, morphological width, and WLI, GCI were higher than in bones with longer MD (Table 1). However, according to the Mann-Whitney test, there was no statistically significant difference between anthropometric measurements in both groups.

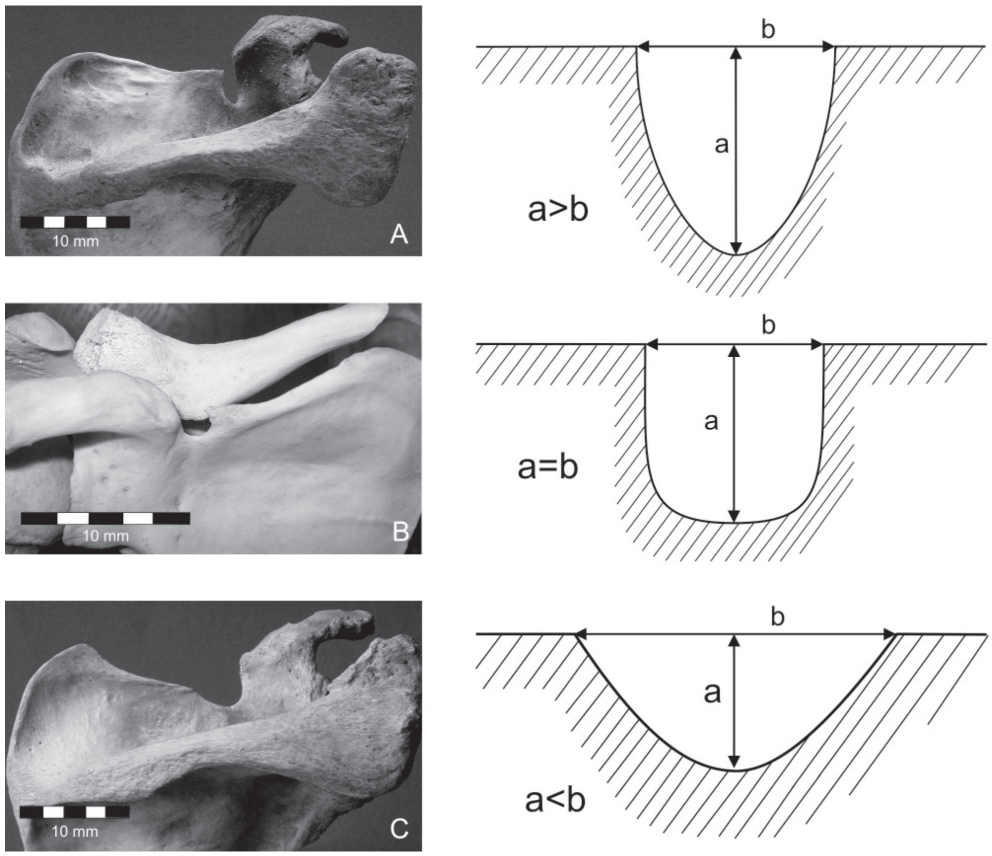

Figure 5. A. Scapulae with longer maximal depth; **B.** Scapulae with equal maximal depth and superior transverse diameter; **C.** Scapulae with longer superior transverse diameter; a — maximal depth of the suprascapular notch; b — superior transverse diameter of the suprascapular notch.

Table 1. Measurements and indices of the scapulae

Measurements and indices of the scapula [mm]	Scapulae with longer maximal depth (MD > STD)			Scapulae with longer superior transverse diameter (STD > MD)		
	Mean	**SD**	**Min–Max**	**Mean**	**SD**	**Min–Max**
Morphological length	155.71	11.49	133–172	156.4	11.75	130–178
Morphological width	99.1	7.45	88–114	100.84	6.52	87–113
Projection length of scapular spine	132.43	8.97	116–146	134.36	8.17	113–149
Maximal width of scapular spine	43.32	6.26	33–54	42.48	5.26	32–56
Length of acromion	45.31	6.74	34–56	44.33	5.26	33–56
Maximal length of the coracoid process	44.6	4.46	39–54	43.47	3.73	33–51
Length of the glenoid cavity	38.55	3.48	33–48	38.09	2.97	32–56
Width of the glenoid cavity	27.83	2.97	22–33.5	27.52	2.36	23–33
Width-length index (%)	63.7	3.5	58.5–70.7	64.76	3.15	58.4–71.6
Glenoid cavity index (%)	72.3	5.8	57.9–83.8	72.4	5.3	59.2–86.8

SD — standard deviation; Min — minimum; Max — maximum; MD — maximal depth of the suprascapular notch; STD — superior transverse diameter of the suprascapular notch

DISCUSSION

The incidence of bony foramen in scapulae (the STSL was complete ossified and SSN was closed) varied from 0.3% to 13.6% [3, 8, 11, 16, 17, 27, 29, 30–32, 34–38]. In our study it was 7% of cases. In the literature there are descriptions of double suprascapular foramen [16, 21]. Also Natsis et al. [27] described in 3 out of 423 (0.7%) scapulae the coexistence of a notch and a bony foramen.

Complete ossification of the STSL differs throughout the world. In the European population it was found in 5–6.5% (French; Olivier [29] and Vallois [37]), 6.1% (Italian; Vallois [38]), 7.3% (German; Natsis et al. [27]), and 6–12.5% (Turkish; Urguden et al. [36] and Bayramoglu et al. [3]) of cases. Complete ossification of the STSL in the US population was found in 3.7% Edelson [11], 3.7% Tubbs et al. [35], 4% Rengachary et al. [32], 5% Dunkelgrun et al. [8], and 5% Ticker et al. [34] of cases. However, in some populations complete ossification of the STSL was very rare, for example in Alaskan Eskimos 0.3% [17] or Native Americans 2.1–2.9% [16]. In addition there was only one such specimen found among Indian scapulae [18], but in some populations bony foramen was even more frequent than usual, e.g. Ancient Egyptian 13.6% [16].

Cohen et al. [6] described a familiar case of calcification of the STSL, affecting a 58-year-old man and his son, who had entrapment neuropathy of the suprascapular nerve.

Duparc et al. [9] mentioned that STSL appeared calcified and rigid in 26.7% of cases in the French population. Dunkelgrun et al. [8], Edelson [11], and Ticker et al. [34] described partial ossification of this ligament in the American population in 12%, 18%, and 18% respectively; our relative percentage was 23.3%. In Moriggl's [26] opinion, calcified STSL is a sign of entrapment. Loth described SSN as a progressive feature [21, 22].

There are several descriptions of SSN variations (Hrdicka 1942 [16], Olivier 1960 [29], Rengachary et al. 1979 [32], Ticker et al. 1998 [34], Bayramoglu et al. 2003 [3], and Natsis et al. 2007 [27]). However, Bayramoglu's [3], Hrdicka's [16], Olivier's [29], and Ticker's [34] studies were qualitative and not based on specific geometrical parameters.

In Olivier's [29], Hrdicka's [16], and Natsis's [27] classifications a bony foramen (complete ossification of the STSL) was described as type V, and in Rengachary's [32] as type VI.

Scapulae with higher maximal depth of the SSN were classified by Hrdicka [16] and Olivier [29] as type IV and by Rengachary et al. [32] and Natsis et al. [27] as type III. The distribution of such incidence was found in 31% of cases by Ticker et al. [34], 40% by Urguden et al. [36], 41.85% by Natis et al. [27], and in 48% by Rengachary et al. [32]. It was higher than in our study (24.4%).

Scapulae with higher STD were classified by Hrdicka [16], Olivier [29], Rengachary et al. [32], and Natsis et al. [27] as type II. The frequency of such SSNs was 24% of cases according to Urguden et al. [36], 31% according to Rengachary et al. [32], 33% according to Ticker et al. [34], and 41.85% according to Natis et al. [27], and it was always much lower than in our study (57.7%).

The frequency of the discrete notch in our study (11.6%) was also higher than that found in the articles by Rengachary et al. [32] (3%) or Natis et al. [27] (8.3%).

On the other hand, taking into consideration the shape of the SSNs, Ticker et al. [34], in 1998, divided them into two types, namely a U-type (U-shaped SSN 77%) and a V-type (V-shaped SSN 23%). The degree of ossification of the suprascapular ligament was evaluated separately, and the notches were classified into three groups: no ossification, partial ossification, and complete ossification (as a bony foramen). Also Bayramoglu et al. [3] described "U" and "V" shaped notches and the notch with ossification of the STSL. The frequency of these were 62.5% and 25%, respectively. Duparc et al. [9] mentioned that the U-shape SSN was seen in 63.3% of shoulders and a V-shape in 36.7% of shoulders. In both types the incisura could be opened to a varying degree, narrower or wider. Dunkelgrun et al. [8] stated that the U-shaped notches had a larger area than the V-shaped notches, leading to the assumption that a V-shaped notch is more likely to be connected with nerve entrapment.

The proper position of a scapula in which the SSN is visualised clearly is the anteroposterior projection with the X-ray tube angled 15–30° caudally [6]. However, this sometimes results in unnecessary exposure of patient to X-ray radiation because it is possible to measure morphological length and width of the scapula in living people [12]. Our study, for the first time, presented the correlation between the morphological length of the scapula and the MD of the SSN. It could be supposed that humans with longer scapulae will have deeper notches. However, there was no correlation between the morphological width of the scapula and the STD of the SSN. In wider scapulae there could not be a shallow SSN. In our opinion, this information was very important because it is possible to measure the morphological length and width of the scapula in living people and to anticipate the depth of the SSN without using X-ray.

The present study aimed to establish a correlation between the shape of the SSN and basic anthropometric measurements of the scapulae. Also it allowed a very precise description of anthropometric measurements in the scapulae in two groups with different SSN diameters (first with higher MD and second with higher STD). To our knowledge, scientific literature has not revealed a similar study on this subject based on anthropometric evaluation.

CONCLUSIONS

1. There were more scapulae with longer STD of SSN (STD > MD) (57.7%) than scapulae with longer MD of SSN (MD > STD) (24.4%).
2. The STSL was completely ossified in 7% of cases; a result which was most similar to studies on German, French, and Italian populations.
3. The MD of the scapular notch correlated with the morphological length of the scapulae; however, it negatively correlated witch the scapular WLI.
4. According to the Mann-Whitney test, there was no statistically significant difference between anthropometric measurements of the group with higher MD and the group with higher STD of the SSN.

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