Sexual dimorphism of the suprascapular notch – morphometric study

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Abstract

Introduction: The concept of the study was to compare the morphometry of the suprascapular notch (SSN) in females and males because its size and shape may be a factor in suprascapular nerve entrapment.
Material and methods: The measurements of 81 scapulae included morphological length and width, maximal width and length projection of the scapular spine, and width and length of the glenoid cavity. The width-length scapular and glenoid cavity indices were calculated. In addition to standard anthropometric measurements three other dimensions were defined and collected for every SSN: maximal depth (MD), superior (STD) and middle (MTD) transverse diameters.
Results: The analysis of the measurements allowed us to distinguish five types of SSN. Type I (26%) had longer maximal depth than superior transverse diameter. Type II (3%) had equal MD, STD and MTD. In type III (57.6%) superior transverse diameter was longer than maximal depth. In type IV (7.4%) a bony foramen was present. Type V (6%) was without a discrete notch. Types I and III were divided into two subtypes: A (MTD was longer than STD) and B (MTD < STD). Distribution of the suprascapular notch types in both sexes was similar. However, MD, STD and MTD were significantly higher in males. The superior transverse suprascapular ligament was completely and partially ossified in 7.4% and 24.7% respectively.
Conclusions: The presented classification of the suprascapular notch is simple, easy to use, and based on specific geometric parameters which allow one to clearly distinguish five types of these structures. All dimensions of SSN were significantly higher in males than in females.

Key words: suprascapular notch, human, variation, female, male.

Introduction

Suprascapular nerve entrapment is characterized by pain in the posterolateral region of the shoulder, atrophy of the infra- and supraspinatus muscles and weakness of the arm's external rotation and abduction. Approximately 1-2% of all shoulder pain is caused by this syndrome, and therefore can be easily overlooked in the differential diagnoses of shoulder discomfort [1-3]. Suprascapular nerve entrapment was first described by Kopell and Thompson in 1959 [4]. They reported that abduction or horizontal adduction of the shoulder exerted traction on the suprascapular nerve (SN), which led to its compression against the superior transverse scapular ligament (STSL). The main site of compression of the suprascapular nerve (SN) was the suprascapular notch (SSN), which was located at the superior border of the scapula, just medial to the base of the coracoid process [1, 5].

Anatomical variations of the suprascapular notch were important as possible predisposing factors for compression of the suprascapular nerve in this region, especially for individuals who were involved in violent overhead activities, such as volleyball players and baseball pitchers [2, 6].

According to a current professional bibliography search, there is not a complete photographically documented description of the sexual dimorphism of the suprascapular notch based on adequate quantitative (measurements of the SSN) material. Therefore, the challenge of this study was to gather, analyse and provide photographic documentation of a large number of specimens.

The present study, using specific geometric parameters, describes a new method of classifying suprascapular notch variations. This method is simple, easy to reproduce and allows each type to be clearly distinguished, so it can be used in further investigations in ultrasonography or computed tomography.

Material and methods

A total of 81 dried human scapulas were included in the study. The sample consisted of 40 left and 41 right individuals. All investigations were performed in the Chair of Anatomy, 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 20th century (1950s).

The osteometric measurements were carried out according to standard definitions and using procedures, precision and equipment as described elsewhere [7-10]. Measurements of the scapula were made using an electronic digimatic caliper. For consistency, one digimatic caliper was used for all measurements, each measurement was made twice by one investigator, and the mean of the values was taken. Each scapula was measured for the following (Figure 1):

1. Morphological length (M1),
2. Morphological width (M2),
3. Projection length of scapular spine (M7),
4. Maximal width of scapular spine (M9),
5. Length of the glenoid cavity (M12),
6. Width of the glenoid cavity (M13).

The osteometric measurements and their symbols (M1-M2, M7, M9 and M12-M13), as well as the definition of the scapular indices, were taken from the standard anthropometry handbook [9] with the exception of three suprascapular notch dimensions defined as follows (Figures 2-5):

1. The maximal depth (MD) — the maximum dimension of the longitudinal measurements taken in the vertical plane from an imaginary line between

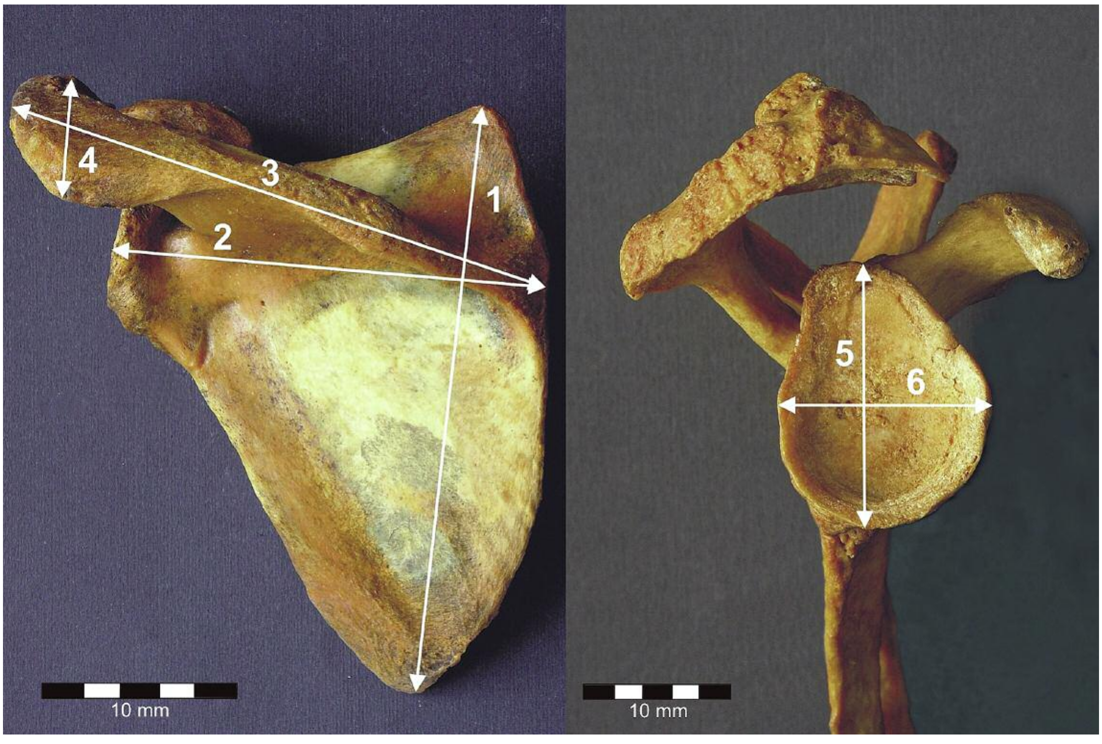

Figure 1. Osteometric measurements of the scapula
1 – morphological length, 2 – morphological width, 3 – projection length of scapular spine, 4 – maximal width of scapular spine, 5 – maximal length of glenoid cavity, 6 – width of glenoid cavity

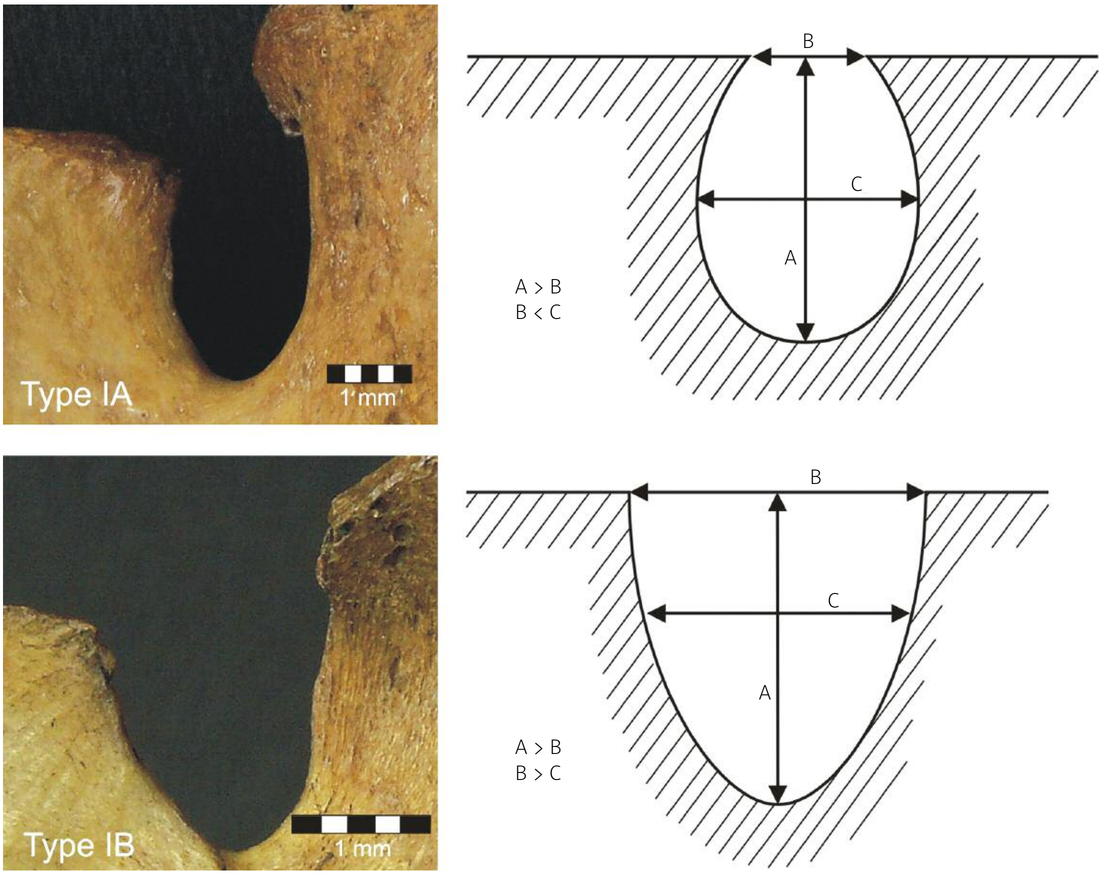

Figure 2. Type I suprascapular notch. Diameters of SSN: A – maximal depth (MD), B – superior transverse (STD), C – middle transverse (MTD)

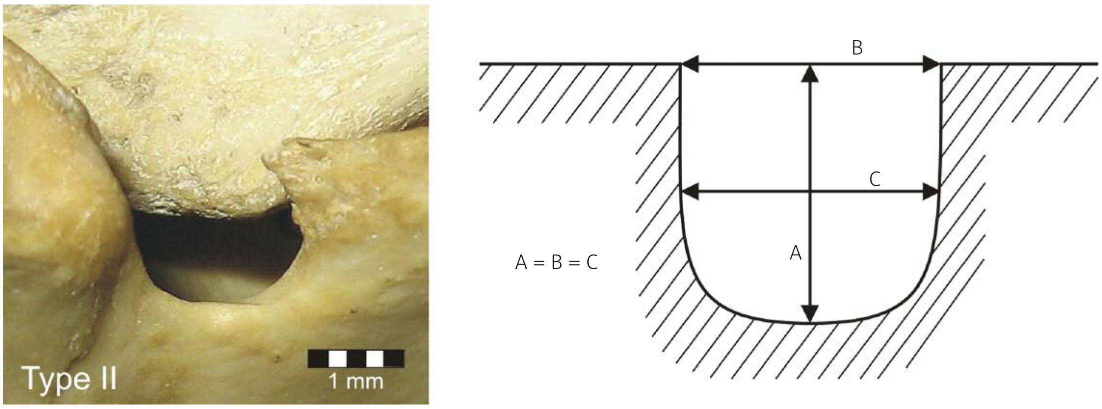

Figure 3. Type II suprascapular notch. Diameters of SSN: A – maximal depth (MD), B – superior transverse (STD), C – middle transverse (MTD)

superior corners of the notch to the deepest point of the suprascapular notch.
2. The superior transverse diameter (STD) – the maximum dimension of the horizontal measurements taken in the horizontal plane between corners of the SSN on the superior border of the scapula.
3. The middle transverse diameter (MTD) – the dimension of the horizontal measurements taken in the horizontal plane between opposite walls of the SSN at half the dimension of MD, perpendicular to it.

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

A photographic technique was used for measurements and typing. The camera and scapula posi-

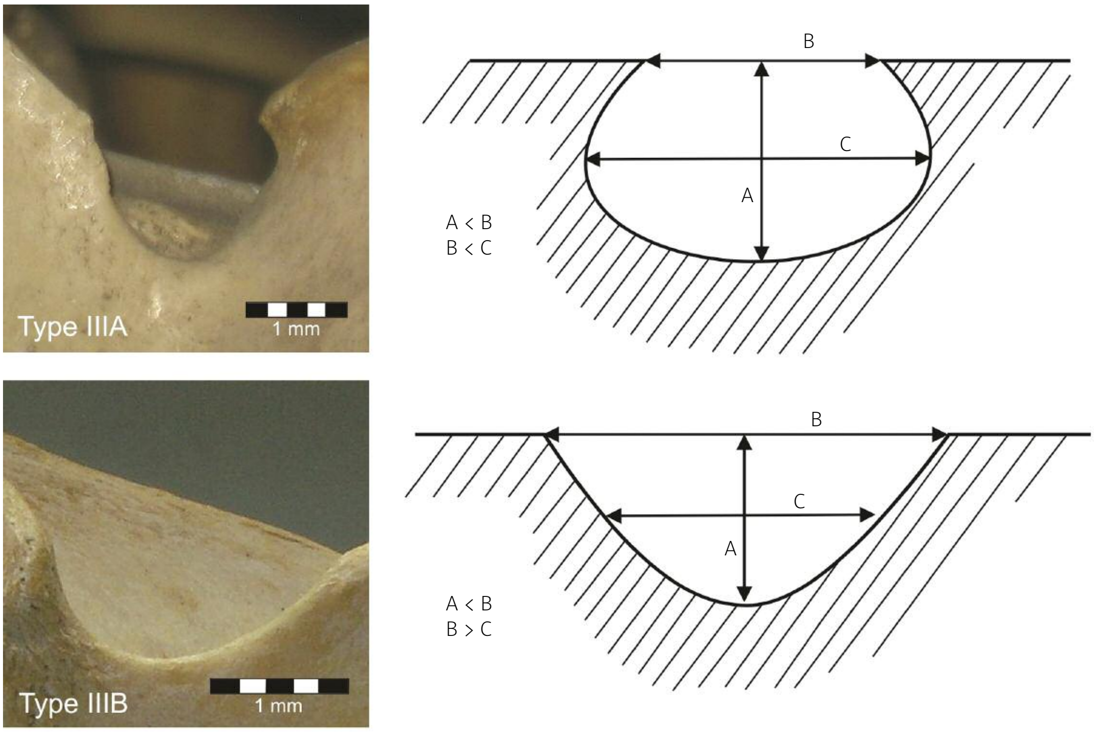

Figure 4. Type III suprascapular notch. Diameters of SSN: A – maximal depth (MD), B – superior transverse (STD), C – middle transverse (MTD)

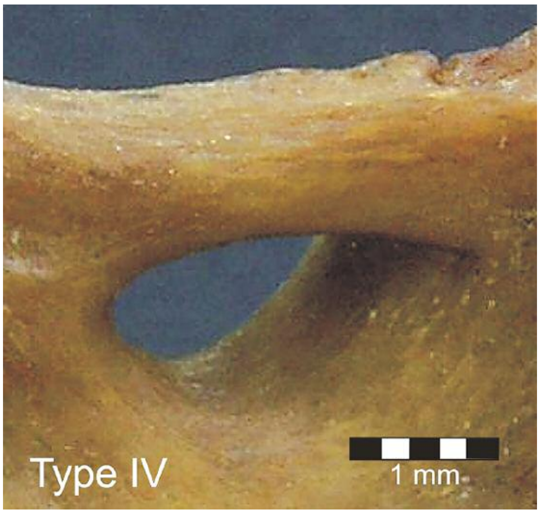

Figure 5. Type IV suprascapular notch

tions were standardized for all images to obtain an anterior view of each scapula. All scapulas were fixed with an adjustable clamp and ring stand at the same distance from the camera. After digital photographic documentation was obtained, three dimensions of the suprascapular notch were measured using MultiScanBase v.14.02 software (Computer Scanning System II, Warsaw, Poland). MultiScanBase v. 14.02 is a professional program whose functions include visualization, archiving, processing and analysis of images, with particular emphasis on measurement functions. Its advantage is automation of the process of analysis, even for poor quality images, allowing measurements of distance, density, surface area, and angle. This software has been widely used in some research, e.g. measurement of points on the mandible of common shrew [11], measurements of *Daphniola* Radoman shell morphometry [12], measurements of the diameters and density of vessels [13, 14], and enabling manual karyotyping [15].

According to the anthropometric rules (Koszelev classifications and Olivier classifications) describing sexual dimorphism, all scapulas were divided into three groups: female, male and non-classified [9] (Table I).

Statistical analysis

Data analysis was performed using the Statistica 8 software (StatSoft Polska, Cracow, Poland). Distribution of continuous variables was investigated with the Shapiro-Wilk test in order to check whether the distribution was normal. Descriptive statistics were used as the mean and standard deviation for continuous variables. The statistical difference between the suprascapular notch measurements in both sexes were examined using the Mann-Whitney test. A p level of < 0.05 was accepted as statistically significant.

Results

Five types of suprascapular notch were observed (Figure 6). Type I (26%) had a longer maximal depth (MD) than superior transverse diameter (STD). This

Table I. Measurements of the scapula

Measurements [mm]	Female				Male			
	Average	SD	Min	Max	Average	SD	Min	Max
Morphological length	144.18	8.14	130	162	165.39	6.22	154	178
Morphological width	93.06	4.53	79	101	105.68	4.3	95	117
Projection length of scapular spine	124.91	5.85	108	134	139.95	5.07	125	149
Maximal width of scapular spine	37.9	4.05	30	45	46.59	4.04	37	56
Length of the glenoid cavity	36.09	2.20	33	42	40.04	2.97	32	48
Width of the glenoid cavity	25.65	1.98	22	30	29.14	2.14	25	34
Width-length index [%]	64.65	3.22	58.67	69.29	63.67	2.82	58.38	71.43
Glenoid cavity index [%]	71.88	5.77	57.9	81.08	72.98	5.34	61.91	86.84
Maximal depth of SSN	5.91	2.13	2.00	12.8	7.14	2.60	1.60	14.3
Middle transverse diameter of SSN	6.91	1.62	3.00	10.8	8.08	3.44	3.50	23.9
Superior transverse diameter of SSN	7.48	1.99	4.30	13.2	8.82	3.09	3.90	21.00

SD – standard deviation, SSN – suprascapular notch. Female (n = 33), male (n = 41)

type was divided into two subtypes: IA and IB (Figure 2). In IA the middle transverse diameter (MTD) was longer than STD, while in IB it was shorter (MTD < STD). Type II (3%) had equal maximal depth, superior transverse diameter and middle transverse diameter (Figure 3). In type III (57.6%) the superior transverse diameter was longer than maximal depth. This type was divided into two subtypes: IIIA and IIIB (Figure 4). In IIIA the middle transverse diameter (MTD) was longer than STD, while in IIIB it was shorter (MTD < STD). In type IV there was a bony foramen (7.4%) (Figure 5). Type V was without a discrete notch (6%) (Figure 7). The frequency of the types and subtypes is presented in Figure 6.

Talking into consideration sex, the maximal notch depth (p = 0.009234), middle transverse diameter (p = 0.041987) and superior diameter were significantly (p = 0.0027208) higher in males than in females.

The frequency of subtype IA was lower in females (9.1%) than in males (14.6%), but in subtype IB it was higher in females (15.2%) than males (7.3%). Also completely ossified superior transverse ligament (type IV) was more frequent in females (9.1% vs. 4.9%). Distribution of other types of the suprascapular notch in the female and male population was very similar. The frequency of types and subtypes in males and females is presented in Figure 8.

The superior transverse suprascapular ligament (STSL) was completely or partially ossified in 7.4% and 24.7% respectively.

Discussion

Our investigations were partially similar to the ultrasonographic study by Yücesoy *et al*. [16]. They reported that the SSN depth was significantly higher in males than in females, but there was no significant difference for the notch width between the two sexes. However, in our study maximal depth of the SSN and its middle and superior transverse

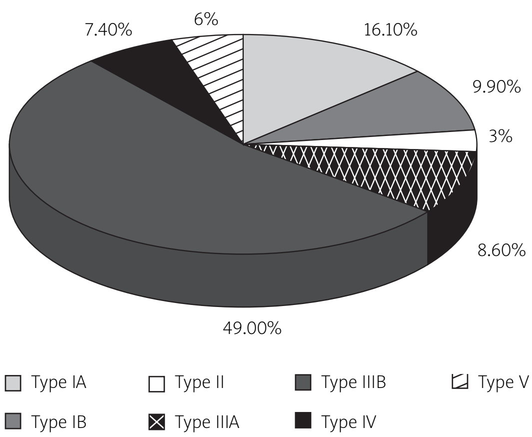

Figure 6. Frequency of the suprascapular notch types

Figure 7. Type V suprascapular notch

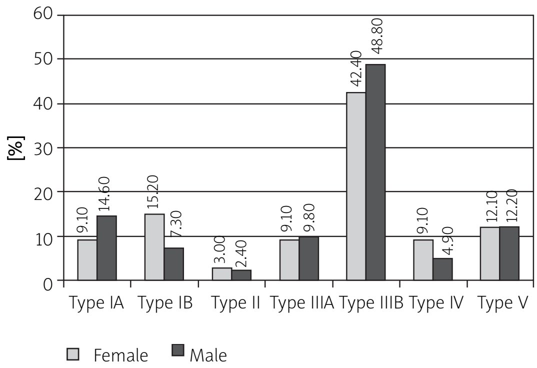

Figure 8. Distribution of the suprascapular notch types in female and male population

diameters were significantly higher in males than in females.

In the literature, the incidence of complete ossification of the superior transverse suprascapular ligament (STSL) varies from 3.7% to 12.5% [6, 17-23], and our relative percentage was 7.4%. Duparc *et al*. [24] mentioned that in 26.7% the STSL appeared calcified and rigid. Dunkelgrun *et al*. [17] and Ticker *et al*. [21] described partial ossification of this ligament in 18% and 12% respectively, while our relative percentage was 24.7%. Moriggl [25] mentioned that the calcified STSL was a sign of entrapment.

The size and shape of the suprascapular notch may be a factor in suprascapular nerve entrapment [17] because narrow SSN has been found in patients with this syndrome [26]. Rengachary *et al*. [20] stated that the size of the suprascapular notch played a role in the predisposition for suprascapular nerve entrapment, assuming that a small notch gave a larger chance of nerve impingement than a large one. The SSN typing, apart from the anatomical interest, may have clinical significance for suprascapular nerve entrapment [27].

Rengachary's classification [20] is still used today. It classified the SSN into 6 types. Type I was identical with our type V without a discrete notch. Type II was a wide, blunt V-shaped notch, with its maximum width along the superior border of the scapula. Type III was a symmetrical U-shaped notch with nearly parallel lateral margins. Type IV had a very small V-shaped notch. Type V had a U-shaped notch and partial ossification of the medial part of the STSL, and type VI had a bony foramen with a completely ossified STSL, identical to our type IV notch.

In 1998, Ticker *et al*. [21] conducted a cadaveric research study using a different classification system, separating the suprascapular notches into two types, namely a U-type and a V-type. The degree of ossification of the suprascapular ligament was evaluated separately. The U-shaped suprascapular notch was defined as having approximately parallel sides with a rounded base, and the V-shaped suprascapular notch was defined as having medial and lateral sides which converge towards a narrow base. Next, the degree of ossification of the superior transverse scapular ligament was determined classifying the notches into three groups: no ossification, partial ossification, and complete ossification (resulting in a bony foramen).

In 2003, Bayramoglu *et al*. [6] modified the classification of Rengachary *et al*. [20] and included only the U- and V-shaped notches, and the notch with ossification of the STSL. In 2007, Natsis *et al*. [27] described five different types of notches on 423 dried scapular bones: type I, without a discrete notch, 35 (8.3%); type II, a notch that was found to be longest in its transverse diameter, 177 (41.85%); type III, a notch that was longest in its vertical diameter, 177 (41.85%); type IV, a bony foramen, 31 (7.3%); type V, a notch and a bony foramen, 3 (0.7%).

In 2009 Duparc *et al*. [24] mentioned that a U-shape suprascapular notch was seen in 19 shoulders (63.3%) and a V-shape notch in 11 (36.7%). In the two types, the incisura could be more or less opened, narrower or wider.

The disadvantage of Bayramoglu's *et al*. [6] and Ticker's *et al*. [21] classifications was that they were not based on specific geometric parameters, unlike our method. The new classification that we suggest simplifies the classification procedure by only requiring three measurements and no further calculations. Our method is based on three specific geometric criteria of the notch: maximal depth (MD), middle transverse diameter (MTD) and superior transverse diameter (STD). Furthermore, it is easy to measure these three dimensions on a plain radiograph.

Dunkelgrun *et al*. [17] compared Rengachary's *et al*. [20] and Ticker's *et al*. [21] classifications, and in their opinion the suprascapular notch classification used by Ticker *et al*. [21] was more reliable and easy to use than the system used by Rengachary. Dunkelgrun *et al*. [17] stated that the U-shaped notches had a larger area than the V-shaped notches, leading to the assumption that a V-shaped notch would more likely be connected with nerve entrapment.

The present study aimed to establish a new method of classifying the suprascapular notch (SSN) morphology, which, contrary to existing methods, is simple, easy to use, and based on specific geometric parameters that clearly distinguish each type. Based on this classification, the frequency of each type of SSN in females and males was described. To our knowledge, the literature contains no similar study on this subject based on anthropometric evaluation. The type of notch might then be considered in diagnosing the syndrome. The projection in which the SSN is visualized clearly is the anteroposterior projection with the X-ray tube angled 15-30° caudally [28].

In conclusion, using MultiScanBase v.14.02 software for measurements and typing suprascapular notches, we were able to establish a precise classification of SSN variations, and also, for the first time, present their distribution in female and male scapulas.

Although distribution of the suprascapular notch types in both sexes was similar, the maximal notch depth and middle and superior diameters of SSN were significantly higher in males than in females.

The superior transverse suprascapular ligament, as a probable suprascapular nerve entrapment factor, was completely or partially ossified in 7.4% and 24.7% respectively.

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