ORIGINAL RESEARCH

The scapular notch: a Uruguayan cadaveric study of 62 dry scapulae

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Abstract

Introduction: The scapular notch is a depression on the superior border of the scapula, located medially to the coracoid process, through which suprascapular nerve enters the supraspinous fossa.

This paper aims to describe the main anatomical aspects of scapular notch, measuring anatomical parameters for identification of this region during surgical procedures, and compare the obtained data with previous worldwide publications.

Material and methods: Sixty-two dry scapulae of Uruguayan specimens were studied at the Anatomy Laboratory of the Faculty of Medicine, Universidad Centro Latinoamericano de Economía Humana (UCLAEH) in Maldonado, and the Faculty of Medicine, University of the Republic in Montevideo, Uruguay, and analyzed for variations.

Results: Of the 62 studied scapulae, 33 were right sided and 29 left sided. Anatomical variations were found in 19 specimens, which included 5 flattened shape notches (8.1%), and 14 ossified notches (22.6%), from which 4 (6.5%) were complete and 10 (16.1%) were incomplete. Scapular notch is located at an average distance of 66.7 mm (SD: 4.7) medially from the lateral border of the acromion.

Conclusions: Anatomy of the scapular notch is variable. The scapular notch can be located at the junction between the medial two thirds and the lateral one third of the superior scapular border. Anatomical variations of this region play an important role in the development of entrapment neuropathies and in surgical considerations for brachial plexus injuries reconstruction.

Keywords: scapular notch; suprascapular nerve; anatomy; variations; injury; entrapment

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Introduction

The suprascapular nerve (SSN) arises from the superior trunk of the brachial plexus. It runs posteriorly towards the superior border of the scapula and usually passes below the superior transverse scapular ligament (STSL) to reach the supraspinous fossa. In its further extent, the nerve turns downward to reach the infraspinous fossa, where it branches. The SSN provides motor innervation to the supraspinatus and infraspinatus muscles and also sends sensory branches to the coracohumeral and coracoacromial ligaments, subacromial bursae, and the acromioclavicular joint[1-4].

Compression of the SSN at the scapular notch (SN) is characterized by shoulder pain, and in severe cases, shoulder abduction and external rotation weakness in addition to supraspinatus and infraspinatus muscle atrophy[5]. Moreover, SSN is a common target in brachial plexus surgery for patients with impaired shoulder abduction, and the posterior approach for SSN neurotization is an alternative approach in some selected cases[6-8]. Therefore, a thorough knowledge of anatomical variations of SN, STSL, and the surrounding structures is imperative.

Materials and Methods

Sixty-two dry human adult cadaveric scapulae were investigated. The study was conducted at the Anatomy Laboratory of the Faculty of Medicine, Universidad Centro Latinoamericano de Economía Humana (UCLAEH) in Maldonado, (n=36) and the Faculty of Medicine, University of the Republic in Montevideo, (n=26), Uruguay.

The specimens were measured with a Vernier millimeter caliper (Mitutoyo Co., Tokyo, Japan). The following parameters were measured: A) Lower scapular angle to the lateral scapular angle, B) Lateral edge of the coracoid process to the superior scapular angle, C) Superior scapular angle to the lower angle, D) Depth of the SN, E) Width of the SN, and F) Lateral edge of acromion to the SN (***Figure 1***).

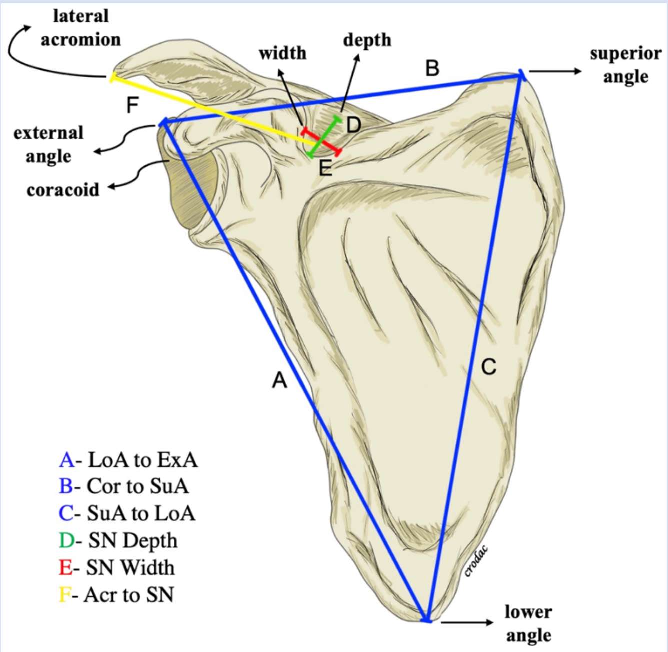

Figure 1. Scapular measured parameters: A) LoA to ExA, B) Cor to SuA, C) SuA to LoA, D) Depth of SN, E) Width of SN, F) Acr to SN. LoA, Lower angle; ExA, Lateral angle; Cor, Lateral coracoid edge; SuA, Superior angle; SN, Scapular notch; Acr, Lateral acromion edge

The average of all measurements and the standard deviation (SD) of width and depth of SN and the distance from the acromion to SN (F distance) were calculated. The relation between the length of the superior border of scapulae and F distance was analyzed. Statistical analysis of data was performed with the IBM SPSS Statistics v26 software.

Results

Of the 62 dry scapulae studied, 33 correspond to the right-side scapulae and 29 to the left-side scapulae. The obtained measurements (ranges, averages, and SD) are presented in ***Table 1***.

Table 1. Measurements of analyzed parameters.

Measure	Range	Average (SD)
lateral scapular border length	108-161	132.2 (9.9)
superior scapular border length	62-130	96.6 (8.1)
medial scapular border length	123-181	152.5 (15.8)
scapular notch depth	1-11	5.5 (2.2)
scapular notch width	2-14	7.5 (2.8)
lateral acromion to scapular notch distance	53-83	66.7 (4.7)

We recognized variations in 19 specimens (30.6%) that could make difficult the SN identification during surgical procedures or predispose to SSN entrapment at this level. The anatomical variations included SN flattening or osseous bridges (complete or incomplete). Of these morphological variants 8 (24.2%) were located on the right side, while 11 (37%) were on the left side. The difference between each side was not statistically significant.

We found a "nearly" flattened SN in 5 pieces (8.1%) and osseous bridges in 14 pieces (22.6%), of which 4 (6.5%) were complete (also known as scapular foramen) and 10 (16.1%) were incomplete.

A correlation between the length of the superior scapular border and distance from the acromion to SN was performed, and we identified that the distance from acromion to SN was 52 to 74% (average 61.3%) of the length of the superior scapular border. This means that the SN can be located at an average distance of 66.7 mm from the acromion (Table 1) or at the junction of the medial two-thirds and the lateral one-third of the superior border of the scapula.

Discussion

The SSN provides motor innervation to the supraspinatus and infraspinatus muscles and sensory innervation to the acromioclavicular joint. It reaches the supraspinous fossa passing through the SN, a bony landmark that is closed superiorly by the STSL, turning the SN into a fibro-osseous foramen[4,8-13] (***Figure 2***).

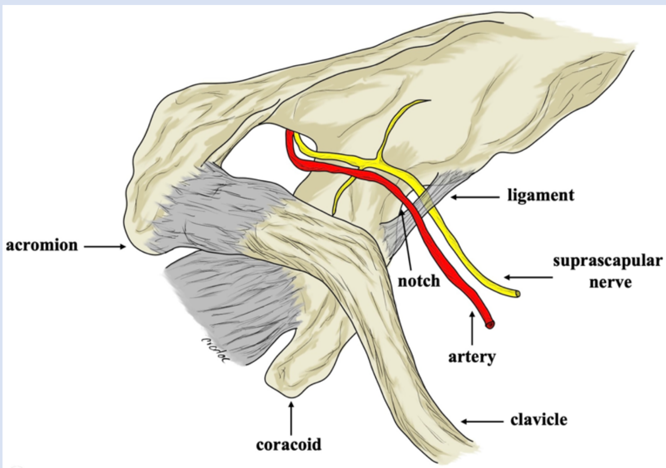

Figure 2. Scapular notch regional anatomy and content

This bony structure may be a potential site for entrapment or traction injuries in brachial plexus or isolated trauma of the SSN[2,4,15-17]. Many surgical procedures may require surgeons to approach the SSN distally to the SN. In consequence, anatomical variations of the SN, such as width, depth, anatomical orientation, osseous bridges, deserve anatomical and clinical considerations (***Figure 3A and 3B***).

Even though there are anatomical data that may seem irrelevant or redundant, each population has its own ethnic and anatomical variants. Before now, the anatomical variations of the scapular notch have not been studied in the Uruguayan population. Accordingly, it seems useful to contribute our findings to literature published from other countries[9,18,19].

The practical significance of the anatomy of the SN region lies in its application during brachial plexus reconstructive surgery, diagnosis and management of SSN neuropathy, anesthetic blockages of the nerve, and the risk of iatrogenic injury in some orthopedic surgical and non-surgical procedures[2,5-7,10,15,16,20,21].

In peripheral nerve surgery, the SSN is surgically treated for brachial plexus repair and its decompression for isolated entrapment neuropathy[6,22,23]. After dissection through trapezius and supraspinatus muscles fibers, the SN may be located by palpation[7,24]. However, the presence of an ossified STSL or a flattened scapular notch may render it difficult to localize this notch by palpation[22]. We observed such kind of anatomical variation in 14.5% of our specimens (8% flattened notch and 6.5% completely ossified STSL). The STSL should be divided to achieve nerve decompression, and facilitate its mobilization for repair in brachial plexus surgery. The presence of complete or incomplete ligament ossification adds greater difficulty to the surgical procedure[22].

The same consideration is applicable to SN entrapment neuropathy, for which it is necessary to divide the ligament for nerve release. A flattened notch or a completely ossified ligament increase the difficulty to identify the notch. Yavari et al. stated that 11.6% of 43 patients in whom a posterior surgical approach was performed for SSN neurotization had a "difficult" anatomy that made identifying the notch challenging[21]. They perform an osteotomy to release the SSN in 5 cases.

We found complete or partial ossification in 22.6% of our studied specimens, including 16.1% with an incomplete osseous bridge and 6.5% with a complete bridge. The incidence of complete ossification (scapular foramen) in our series is similar to French and Italian series[2,15,25]. A higher frequency of scapular foramen has been reported in in Indian (9.7-10%), European (5-6.1%) and North American populations (3.7-4%)[25]. The lowest prevalence of complete ossification of STSL is seen in Eskimo population (0.3%)[2,15], and the highest prevalence is seen in Brazilian population (30.7%)[22].

The prevalence of complete foramen in our study is similar to European population, which correlates with the ethnic distribution of Uruguayan population. In other words, 85.3% of our population is made up of Caucasian people, descendants of European immigrants, predominantly from Spain and Italy. Only 10.5% are dark-skinned and less than 5% are descendants of our aboriginal population (Charrúas, Chana-Timbúes, Guenoas, and Yaros)[26].

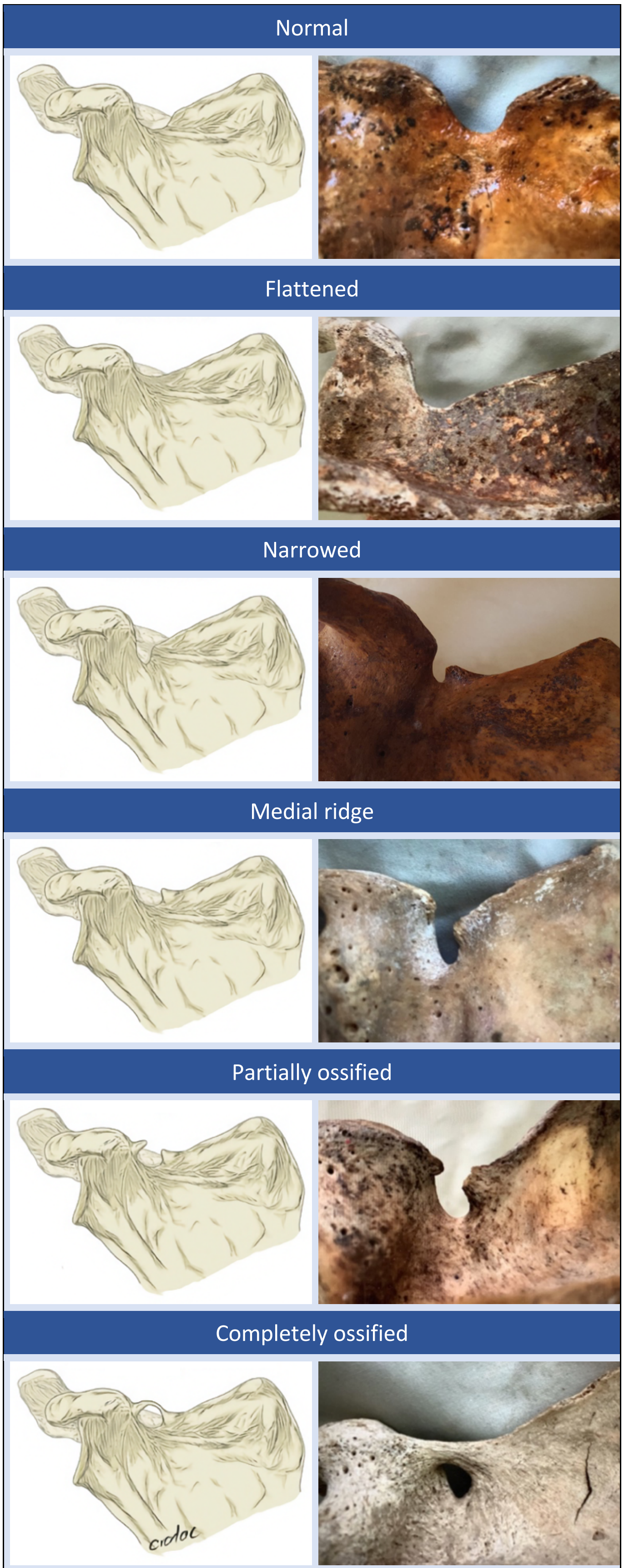

Figure 3. Scapular notch variations or types: schematic representation (left) and cadaveric specimens (right)

Tubbs et al. reported an incidence of 5-5.7% of ossified STSL, while other authors reported that 3.7-18% of human being have a partial ossification and 5-9.8% have a complete ossification[10,15,27-29]. It is paramount to recognize ossified ligaments during preoperative approach to properly remove them. Morphological features of the SN and SSN can be evaluated in real time with the aid of ultrasonography, especially in patients in whom surgical treatment has been considered[11](***Figure 4***).

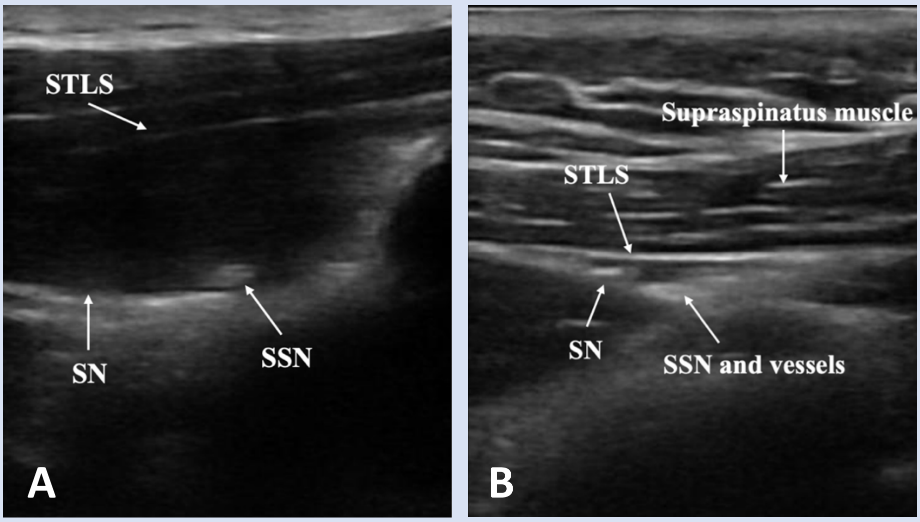

Figure 4. Ultrasonographic evaluation of scapular notch. A. Type II right sided normal SN with single unossified STLS. B. Type III left sided flattened SN with single unossified STLS. SN, Scapular notch; SSN, Suprascapular nerve; STLS, Superior transverse scapular ligament.

In a study conducted on dry scapulae and corpses, the authors carried out a histological study of cadaveric pieces with ossified ligaments and used corpses without an ossified ligament as control group. They found that in specimens with ossified ligaments, the SSN showed thickening of its diameter, fibrosis, and signs of nerve degeneration distal to the ligament. Therefore, they concluded that ossification of the STSL was a risk factor for the development of entrapment neuropathy[2]. However, a high incidence of ossified STSL does not proportionally correlate with the occurrence of SSN entrapment. Some researchers stated that SSN entrapment is responsible of painful shoulder in 0.3-2% of cases, and the incidence of ossification of STSL reaches 5-6% in general population. [2,4,5,9,10,13,20,27,29,32]. Ossification is a risk factor, but as expected, not the only responsible factor for nerve entrapment.

Regarding the "origin" of osseous bridges (osteophytes), Moriggl et al. suggest that its origin is related to endochondral ossification, as may occur with the Achilles tendon. Bony spurs are known to increase with age in the STSL, perhaps associated with the long-term effects of mechanical loading, as with Achilles tendon bony spurs or sesamoid bones in several body ligaments.

Moriggl et al. studied the cytoarchitecture of 7 STSL of adults with an average age of 57 years and ranged between 32 and 75 years, and described 3 cases with osteophytes, one of them with a sesamoid bone[16]. There is much evidence to support the idea that the formation of many bony spurs is triggered by the influence of mechanical forces over bones and ligaments. People with increased age, high weight bearing, or athletes are expected to have higher frequency of osseous bridges or complete foramina.

A second anatomical variation of STSL is the presence of a bifid or duplicated ligament. Polguj et al. described two anatomical forms of bifid STLS[15]. The first subtype has a superior and inferior band, and the second subtype has an anterior and posterior band (bifid in transverse plane). The incidence of double STSL reaches 3.1-3.8%, but the presence of an ossified double STSL is extremely rare. We did not find this anatomical variation in our sample, also considered a risk factor for SN entrapment[29].

Finally, data concerning gender dimorphism of the SN are controversial.

In a study of 812 specimens (cadaveric and radiological study of dry scapulae), Polguj et al. found a greater rate complete ossification of the ligament in men (6.4%) relative to 3.8% in women[9]. The same authors analyzed a dry scapulae sample in 2013 and observed complete ossification of the ligament in 7.4% of the cases. Females had a tendency for having the ligament ossified more frequently than men (9.1% vs 4.9% respectively). In a review, Polguj stated that males are more prone for having a calcified STSL, which may explain why SSN entrapment is more frequent in males. Nevertheless, more data is necessary to confirm if gender dimorphism increase the incidence of STSL ossification[21].

Another topic of interest is the content of the scapular foramen. Polguj et al. described four variations in the arrangement of the structures (SSN nerve, artery, and vein) passing through the SN[3]. In type I (61.3 %), the suprascapular artery travels above the STSL, while the suprascapular vein and SSN travel below. In type II (17 %) the two vessels traverse above the STSL, and the nerve is situated underneath the ligament. In type III (12.3 %), the suprascapular vessels and nerve lay underneath the ligament. For last, type IV (9.4 %) involves the combination of the other variants, albeit duplicated.

Specimens with a type III arrangement were found to have the smallest suprascapular opening diameter compared with the others. This may predispose patients to SSN entrapment, but further studies are needed to validate this finding[30]. SSN entrapment is complex and results from factors, such as the shape, length and width of the SN, the shape of the STSL (band or fan like), the presence of bifid STLS, anatomical variations of other ligamentous structures (anterior coracoscapular ligament), the number of neurovascular structures traversing the notch (such as in type III per the Polguj classification), the presence of hypertrophied suprascapular muscle, ossification degree of STSL, or the presence of tumors or “tumor like local pathology” (e.g., ganglion cysts)[3,9,12,31-33].

One interesting observation of our study is the F distance measurement from the lateral edge of the acromion to the center of the scapular notch. The average distance was 66.7 millimeters, matching with our previous anatomical and surgical studies, and is a key for the intraoperative localization of the SN. Previously, we postulated that in posterior surgical approach to SN decompression or neurotization with spinal accessory nerve, anatomical landmarks are of value[6]. We found that suprascapular and spinal accessory nerves are located at 70 and 110 millimeters, respectively, medially to the lateral aspect of the acromion. Our findings in this series confirm our previous data in a small sample of cadaveric specimens.

An incision to performing a spinal accessory nerve to SN neurotization should include these two anatomical landmarks. When we studied the correlation between the distance from acromion to SN/length of the superior border of the scapula, we found that distance from acromion to SN is 61% of the length of superior border of the scapula. The SN can be located at the junction of the medial two-thirds with the lateral one-third of the superior scapular border.

Conclusions

Anatomical variations in the morphology of SN may influence the development of SSN entrapment, but the information obtained by anatomical reports is contradictory. Ossification of STSL is frequent in general population (3.7 to 9.8%), whereas the incidence of SN entrapment is very low. Cadaveric anatomical studies indicate that fibrosis and nerve degeneration are proportional to the ossification degree of STSL, though it is not possible to link these findings to a clinically significant SN entrapment syndrome. Future studies examining brachial plexus surgery and SN decompression should consider these anatomical variations.

Disclosures

Conflict of Interest: All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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