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ORIGINAL ARTICLE

An anatomical study of the superior transverse scapular ligament of Jining population

Runyu Long[1] · Nan Wang[1] · Wentao Liu[1] · Zhiyang Liu[1] · Shihua Cheng[1] · Xin Zhang[2] · Xu Geng[2] · Chaotong Liu[1] · Ji Wang[1] · Mingqi Ding[1] · Ze Tian[2] · Jing Li[3]

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Abstract

Purpose The aim of this study was to determine the anatomical variations of the superior transverse scapular ligament (STSL) for better understanding the possible predisposing factors for suprascapular nerve entrapment.

Methods The study was using fifty 10% formalin solution-fixed human cadaveric shoulders. After dissection of the suprascapular region, the length, medial width, lateral width and middle width of the suprascapular opening were measured for each STSL.

Results The STSL displayed six types as: (1) band-shaped in 11 cases; (2) fan-shaped in 27 cases; (3) triangular-shaped in 5 cases; (4) linear type in 2 cases; (5) bifid in 1 case; (6) absent in 1 case. The ossified type of STSL was found in 3 cases. There were statistically significant differences in the length ($P=0.009$), medial width ($P=0.001$), lateral width ($P=0.029$) of the three types of fan-shaped, band-shaped and triangular-shaped. However, there was no statistical difference in the middle width of the suprascapular opening of the three types ($P=0.340$).

Conclusion Knowing the morphological features and variations of the STSL is important for better understanding the anatomical conditions, which could be taken into consideration during open suprascapular operations or arthroscopic decompressions.

Keywords Superior transverse scapular ligament · Classification · Variation · Anatomy · Suprascapular

Introduction

The suprascapular notch is roofed by the superior transverse scapular ligament (STSL), forming the suprascapular opening (SSO) [18]. The suprascapular nerve and vein pass through the SSO while the suprascapular artery runs over the STSL [12, 32]. This region is clinically important as it is the most common place of suprascapular nerve entrapment (SNE) [2]. The neuropathy results in deep, diffuse and arching pain in the posterior and lateral aspects of the shoulder and arm. Surgery is indicated for patients with intractable pain, weakness and muscular atrophy [31].

The size and the shape of the suprascapular notch are the most important factors in the etiopathology of SNE [5, 11]. A narrow suprascapular notch may predispose a patient to this neuropathy [22], and a "V" shaped notch is more likely to be associated with nerve entrapment [2]. Except for the notch, calcification of STSL has been determined to be one of the factors increasing the danger of SNE [4, 7, 19, 20, 22]. It is demonstrated that the rate of ossified STSL was higher in men and increased with the age [10]. According to Ticker et al. [25], the bifid type of STSL might also be one of the possible causes of nerve entrapment. However, earlier studies of the STSL have been simple and not supported by precise measurements [4, 6]. The aim of this study was to offer the quantitative classification of the STSL for better understanding the features of the suprascapular region.

✉ Jing Li
alexlijing800912@yahoo.com

[1] Grade 2017 of Academy of Basic Medicine, Jining Medical University, Jining, Shandong, China

[2] Grade 2018 of Academy of Basic Medicine, Jining Medical University, Jining, Shandong, China

[3] Department of Anatomy, Academy of Basic Medicine, Jining Medical University, Jining, Shandong, China

Materials and methods

Fifty shoulders of adult human donated bodies were dissected (47 males and 3 females, mean age 72 years, mean height 171 cm). The cadavers were preserved by the injection with 10% formalin solution and stored at −4 °C for more than 1 year. The dissection was carried out in the Department of Anatomy of Jining Medical University, Shandong, China. An incision along the clavicle was performed firstly, then the skin was separated from the trapezius muscle, deltoid muscle and pectoralis major muscle. The trapezius muscle was detached from the clavicle, acromion process and spine of the scapula. The deltoid and supraspinatus muscles were removed carefully, then the STSL and the suprascapular notch were exposed. The study was approved by the constituted Ethics Committee of the University and the study was conformed to the Declaration of Helsinki (1964).

The following parameters of the STSL were measured with a digital caliper (Mitutoyo Company, Japan):

1. *Length of STSL* The maximal distance of horizontal measurement between the lateral and medial borders of the ligament.
2. *Medial width of STSL (MW)* The maximal distance of longitudinal measurement between the superior and inferior borders of the ligament at its medial end.
3. *Lateral width of STSL (LW)* The maximal distance of longitudinal measurement between the superior and inferior borders of the ligament at its lateral end.
4. *Middle width (MW) of SSO* The distance from the middle point of the inferior border of the STSL to the deepest point of the suprascapular notch (Fig. 1).

To evaluate the relationship between the shape of STSL and the measurements, when MW/LW ≤ 2, the STSL was considered as band-shaped; 2 < MW/LW ≤ 5 as fan-shaped; MW/LW > 5 as triangular-shaped. When the average width of the STSL was less than 2 mm, then this kind of STSL was defined as linear type. Data analysis was performed with Statistical Package for the Social Science (SPSS 17.0) (IBM Corporation, USA). The data were expressed as mean value ± standard deviation. Analysis of variance (ANOVA) test was used to determine the overall differences in the middle width of SSO, the length, MW, LW of the fan-shaped, band-shaped and triangular-shaped STSL, respectively. Then Student's *t* test was used to determine the differences of the parameters between any two of the three types. A $P < 0.05$ was accepted as statistically significant.

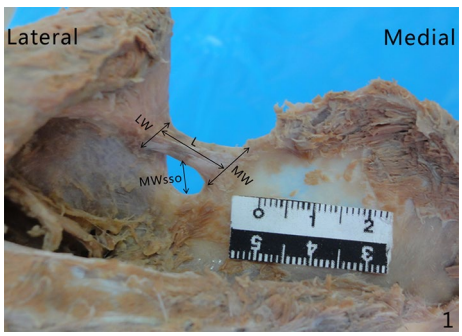

Fig. 1 Illustration of the measurements of the STSL. *MW* medial width of the STSL, *LW* lateral width of the STSL, *L* length of the STSL, *MWsso* middle width of the suprascapular opening

Results

The morphology of the STSL

The STSL showed the shape of six types: (1) band-shaped type in 11 cases; (2) fan-shaped type in 27 cases; (3) triangular-shaped type in 5 cases; (4) linear type in 2 cases; (5) bifid type of STSL in 1 case; (6) absence of STSL in 1 case. The ossified type of STSL was found in 3 cases (Fig. 2).

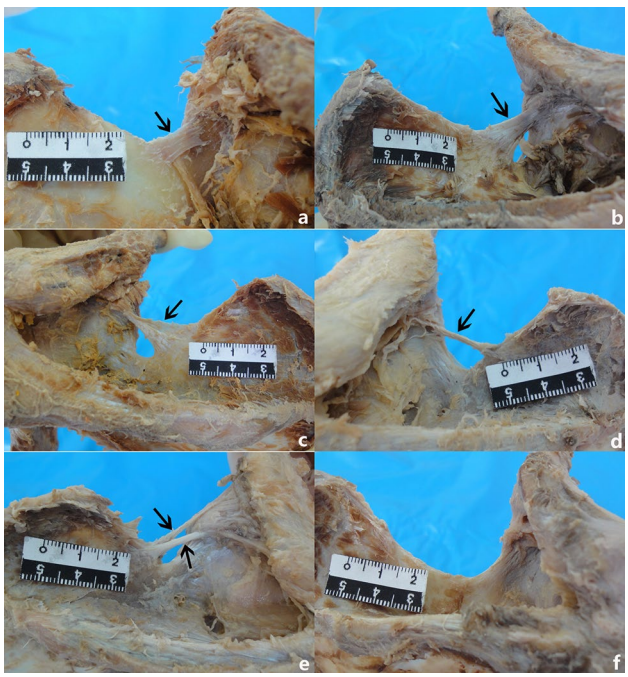

Fig. 2 The six types of the STSL. **a** Band-shaped type; **b** fan-shaped type; **c** triangular-shaped type; **d** linear type; **e** bifid type; **f** absence of STSL

Measurements of the STSL in band-shaped, fan-shaped and triangular-shaped types, and statistical analysis (Table 1)

The mean length in the specimens with band-shaped, fan-shaped and triangular-shaped was 14.35 mm, 18.09 mm and 18.46 mm, respectively. There was a significant difference in the three types according to ANOVA test ($P=0.009$). Significant differences were also observed between the types of fan-shaped and band-shaped types ($P=0.003$), band-shaped and triangular-shaped types ($P=0.017$) performed with Student's *t* test.

The mean MW in the types of band-shaped, fan-shaped and triangular-shaped was 8.26 mm, 15.54 mm and 17.64 mm, respectively. Of the three types, a significant difference was obtained with ANOVA test ($P=0.001$). According to Student's *t* test, significant differences were observed between the types of band-shaped and triangular-shaped types ($P=0.002$), fan-shaped and band-shaped types ($P=0.001$).

The mean LW in the types of band-shaped, fan-shaped and triangular-shaped was 6.00 mm, 5.00 mm and 3.11 mm, respectively. Of the three types, a significant difference was obtained with ANOVA test ($P=0.029$). According to Student's *t* test, significant differences were observed between the types of band-shaped and triangular-shaped types ($P=0.008$), fan-shaped and triangular-shaped types ($P=0.042$).

Discussion

The most important finding of the present study was to classify the morphology of STSL based on quantitative analysis. According to our results, compared with the band-shaped and fan-shaped types, both the mean length and mean medial width of the triangular-shaped STSL were maximal. However, no statistical difference was observed in the middle width of SSO of the three types, indicating that the STSL may not reduce the space for the passage of suprascapular nerve. Additionally, the linear type and the absent type of the STSL were rarely reported previously.

In the literature, two kinds of classifications of STSL were described [4, 18]. After dissection of 32 shoulders, Bayramoglu et al. [4] discovered 4 types of STSL. In 17 (53.1%) of the shoulders, the STSL showed a fan shape, which was the most common type. In 6 (18.8%) shoulders, the STSL presented another fan shape with the presence of an anterior coracoscapular ligament (ACSL). A third type (15.6%) of STSL contained the anterior and the posterior parts, while the fourth type (12.5%) was the calcification of the STSL. Compared with the present study, Bayramoglu et al. [4] classification was based on the relationship between the STSL and the suprascapular nerve, without precise measurements of the STSL.

In 2013, Polguj et al. [18] distinguished three types of STSL as fan (54.6%), band (41.9%), and bifid (3.5%), with fan-shaped STSL being the most common type. Statistically significant differences were observed in the area and middle width of SSO between the fan-shaped and band-shaped types. The area and middle width of SSO were smaller in specimens with an ACSL than in those without. It was the band-shaped STSL which reduced space for the course of the suprascapular nerve. This classification was simple; the STSL was single or bifid-shaped. In the present study, a more detailed classification was proposed. The fan-shaped STSL was the most common type, which was similar to earlier studies [4, 18]. However, there was no significant difference in the middle width of SSO in the three types. It is difficult to compare the present study with Bayramoglu et al. [4] and Polguj et al. [18] because a different typology was used. As ACSL was an independent structure that was present in 51.2% in Polguj et al. [18] description. Presence of the ACSL might reduce the space available for the suprascapular nerve at the suprascapular notch, so the ACSL was considered as an etiologic factor of SNE [4, 16]. ACSL should not serve as an objective criterion for classifying an independent type, as shown in type 2 in Bayramoglu et al. [4].

The STSL involving multiband has been reported [1, 4, 6, 13, 17, 25]. Ticker et al. [25] found a multiband STSL in 2 out of 79 (3%) and Polguj et al. [17] discovered 3 out of 96 (3.1%) shoulders. In type 5 of this study, the bifid STSL had a common medial attachment, and it was very similar to the second type of Polguj et al. [17]. Whether the bifid STSL had a common attachment or two independent anterior and posterior parts is clinically important, as one or all the branches of suprascapular nerve run between them [1]. In the trifid STSL of a 75-year-old white female [14], the

Table 1 Measurements of the STSL in band, fan and triangular types (ANOVA test)

Measurements (mm)	Band-shaped	Fan-shaped	Triangular-shaped	*P* value	*F*
Length	14.35 ± 2.55	18.09 ± 2.74	18.46 ± 4.01	0.009	5.470
MW	8.26 ± 3.21	15.54 ± 4.95	17.64 ± 5.87	0.001	8.430
LW	6.00 ± 2.20	5.00 ± 1.77	3.11 ± 1.11	0.029	3.935
MW of SSO	4.91 ± 1.58	5.53 ± 2.09	6.51 ± 0.97	0.340	1.113

MW medial width of STSL, *LW* lateral width of STSL, *MW of SSO* middle width of suprascapular opening

ligament had a common proximal attachment to the medial border and extended laterally with three bands that attached separately to the lateral border of the suprascapular notch.

The STSL may protect the suprascapular nerve at the suprascapular notch. However, it is probable that one of the factors of SNE is completely ossification of STSL [17]. The incidence of complete ossification of the STSL varied from 0.3 to 13.6% [4, 5, 7, 9, 11, 20–23, 25–27]. In the European population, it was reported in 6.1% of the Italian [28], 6.5% of the French [29], 7% of the Polish [15, 20], 7.3% of the German [11], and 6–12.5% of the Turkish [4, 27]. Complete ossification of the STSL in the US population was found in 3.7–5.5% [3, 7, 23, 25]. However, in some populations complete ossification was very rare, such as the Alaskan Eskimos in 0.3% [8] or native Americans in 2.1–2.9% [9]. But in some populations it was higher than usual, as the ancient Egyptians in 13.6% [9]. There were cases from Africa with 3% [24] and from Asia with 4.08% [30]. It was 4% in our study.

Double suprascapular foramen was also described previously. Natsis et al. [11] found 3 out of 423 scapulae the coexistence of a notch and a bony foramen. Duparc et al. [6] mentioned that STSL appeared calcified and rigid in 26.7% of cases in French population. Partial ossification of this ligament in the American population was 12% by Dunkelgrun et al. [5] and 18% by Ticker et al. [25]. Polguj et al. [20] reported 23.3% in Polish people. Our relative percentage was 6%, far less than the reported [5, 6, 20, 25]. It is suggested that the ossification degree differs throughout the world. The hypothesis of double suprascapular foramen was that the ossification of the single bundle STSL would create the upper bony bridge, and the lower bridge was created by the osseous transformation of the ACSL [12].

Partial and complete ossification or multi bands of the STSL may represent a risk during decompression of the suprascapular notch [13, 14, 19]. Knowledge of morphology of suprascapular notch region is important for a better understanding of the possible conditions that can promote SNE. Variations of the STSL should be taken into consideration during the surgical and arthroscopic procedures. Our study used a quantitative classification of the STSL, which was simple, reproducible and based on geometrical parameters that clearly distinguish each type. Single STSL presented here may not be the factors that reduce the space for the passage of suprascapular nerve. The absence of STSL may have clinical benefits as it would not narrow the opening of suprascapular notch.

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Author contributions RL and NW: study design/data collection/writing the manuscript; WL, ZL, SC, XZ, XG and ZT: data collection/cadaver dissection; CL, JW, MD: data analysis/figure processing; JL: study design/manuscript revision. All authors read and approved the final manuscript prior to submission. RL and NW contributed equally to this work.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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