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Ossified Superior Transverse Scapular Ligament: Case Report and Literature Review

Ligamento Transverso Superior de la Escápula Osificado: Informe de Caso y Revisión de la Literature

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SUMMARY: Complete ossification of the superior transverse scapular ligament (STSL) converts the suprascapular notch into a rigid tunnel, predisposing the suprascapular nerve to compression, especially when the calibre is < 4 mm. Three dry adult scapulae (two right, one left) from the King Saud University collection were examined. Notch type, ossified-STSL shape, and tunnel/bridge dimensions were measured with a 0.01-mm digital caliper. All specimens displayed full STSL ossification forming a true foramen—two fan-shaped, one band-shaped. Mean tunnel opening was 6.16 × 2.52 mm (circumference 18.96 mm). The bony bridges averaged 11.10 × 4.70 mm, leaving an effective width < 4 mm in every case. Finite-element modelling of similarly constricted tunnels shows contact stress on the nerve rises throughout abduction, with marked peaks near full elevation. Although total STSL ossification is reported in only 4 - 10 % of scapulae, the extreme narrowing observed here lies well within the recognised "danger zone" for neuropathy. Overhead athletes and manual workers may experience dynamic compression that routine examination misses; thus, high-resolution CT or MRI is advised when electromyography suggests suprascapular nerve injury. Where conservative care fails, arthroscopic release achieves pain and strength improvement in 90 - 96 % of patients. Even isolated complete STSL ossification can create critically narrow suprascapular foramina that amplify biomechanical stress on the nerve; early imaging and timely arthroscopic release are key to preventing irreversible deficit.

KEY WORDS: Suprascapular Nerve; Nerve Compression Syndrome; Scapula; Ligament; Ossification.

INTRODUCTION

Osteogenesis of the scapula begins via endochondral ossification from the eighth to eleventh gestational week. At least eight primary ossifying centers appear in the scapula: one for the body, two each for the coracoid process and acromion, and single centers for the medial border, inferior angle, and lower glenoid rim (Tekin & Dogan, 2023). Secondary (epiphyseal) centers arise around puberty, most notably the subcoracoid center, which contributes to the superior glenoid and fuses by the age of puberty (Tekin & Dogan, 2023). The suprascapular notch is a small cleft in the superior border of the scapula, just medial to the coracoid process. Normally, the suprascapular nerve (SSN) traverses the suprascapular notch, whereas the corresponding artery and vein pass over it (Bagoji *et al*., 2020). The superior transverse suprascapular ligament (STSL), a delicate fibrous structure, spans the suprascapular notch, and ossification of the STSL can transform the notch into a fibro-osseous tunnel referred to as the suprascapular foramen (SSF) (Bagoji *et al*., 2020). The notch may narrow as a result of partial ossification of the STSL. The shallow notch that surgeons encounter in adult patients is due to the transformation into the tunnel by these developmental changes (Tekin & Dogan, 2023).

Particularly in overhead athletes, nerve compression can cause pain, weakness, or wasting in the supraspinatus and infraspinatus muscles, which are supplied by the SSN (Bagoji *et al*., 2020). Between 5 % and almost 31 % of people have SSF ossification (Silva *et al*., 2007; Tubbs *et al*., 2013). This variation emphasizes how ligament ossification is influenced by mechanical and genetic factors. Fan-shaped suprascapular foramina may provide a larger opening compared to band-shaped ones; however, both types may remain asymptomatic until a threshold of nerve-to-bone contact is reached, particularly during elevation or cross-body follow-through in throwing athletes (Polguj *et al*., 2013). Accurate diagnosis relies on clinical evaluation, electrodiagnostic studies, and imaging, especially computer

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tomography (CT) scans and magnetic resonance imaging (MRI). Physical therapy is frequently the first treatment option. For persistent cases, surgical decompression is the following step, which has demonstrated good results with a 96 % post-surgery improvement rate (Memon *et al*., 2019).

MATERIAL AND METHOD

Three adult, dry scapulae (two right-sided, one left-sided) were retrieved from the osteological teaching collection of the Department of Anatomy, Medical College, King Saud University. Age, sex, and ancestry were unknown. To rule out osteophytes or other pathological alterations that might deform the suprascapular region, each bone was examined macroscopically. Every scapula's anterior surface was photographed orthogonally under uniform daylight-balanced lighting, using a 1-cm scale. A calibrated digital caliper was used to record, in triplicate,

- Vertical (height) and transverse (width) of the suprascapular foramen (SSF),
- Internal circumference of the foramen, and
- Maximum length and width of the ossified superior transverse scapular ligament (STSL).

The mean of the three readings served as the definitive value for each variable. Each ossified STSL was categorised as fan- or band-shaped according to the morphological scheme proposed by Polguj *et al*.(2013) A transverse canal diameter < 4 mm was deemed to lie within the "danger zone" for suprascapular nerve entrapment, following the thresholds reported by Tubbs *et al*. (2013) and Polguj *et al*. (2014). The study relied exclusively on anonymised skeletal material that had been archived for teaching; in accordance with institutional policy and Saudi national regulations, no additional ethical approval or informed consent was required.

Measurements of the suprascapular foramina resulting from the ossification of the superior transverse scapular ligament (STSL) are presented in the table. The external measurements of each STSL are given as ligament length and width in mm, along with the vertical length and transverse width of the foramina. Any missing data is represented by a dash (-). Additionally, the measurements from the current study are compared with previous measurements reported in the literature. It is important to note that the 4-mm threshold for suprascapular nerve entrapment is below this measurement.

RESULTS

We studied three dried human scapulae—two right and one left—of unknown age, sex, and ethnic origin from the osteological collection of the Department of Anatomy, Medical College, King Saud University. Under standardized lighting, each bone was photographed with a high-resolution digital camera, after which a calibrated metric digital caliper was used to measure the STSL and the resultant SSF (accuracy ± 0.01 mm). Macroscopic inspection found no fractures, osteophytes, or other pathologies on the surrounding surfaces (Fig. 1). In all three specimens, the STSL was completely ossified, creating a true, oval foramen that ran obliquely from medial to lateral. Two foramina had fan-shaped bony roofs, whereas one exhibited a band-shaped roof. The mean ossified ligament dimensions were 11.10 mm × 4.70 mm, and the corresponding foramina average measured 6.16 mm in vertical length and 2.52 mm in transverse width, with an 18.96 mm circumference.

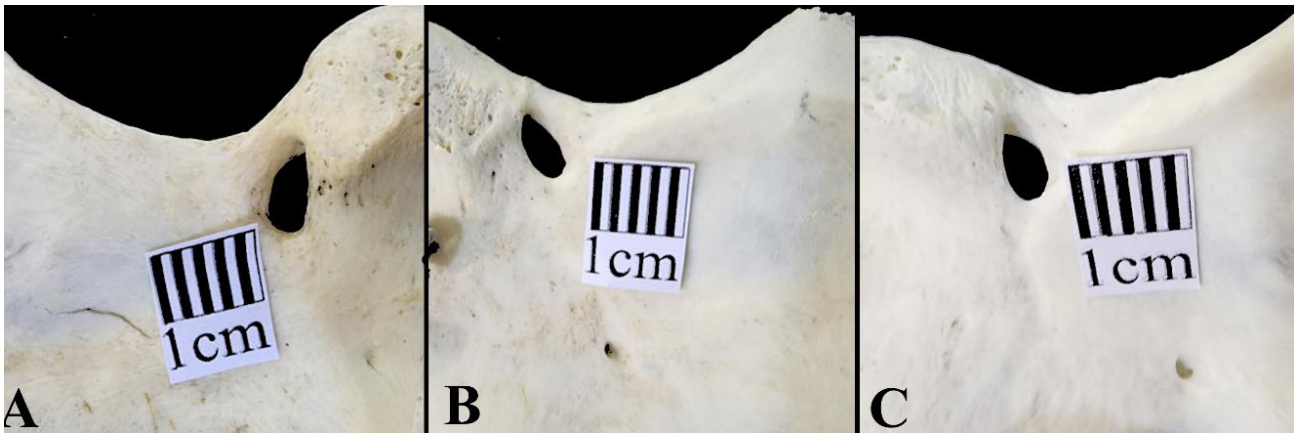

Fig. 1. Morphology of the ossified suprascapular foramina. **A.** Left scapula: Complete ossification of the superior transverse scapular ligament (STSL) leads to an oval foramen, with the long axis oblique to the superior border. **B.** Right scapula: An ossified STSL creates a narrow, slit-like foramen (less than 4 mm), often linked to higher suprascapular nerve entrapment rates. **C.** Right scapula: The bony bridge forms a broader, rigid foramen. All the photographs were taken at the anterior surface of the scapula, all accompanied by a 1 cm scale for reference.

DISCUSSION

Scapular ossification progresses from the eighth gestational week through late puberty. Complete ossification of the STSL transforms the spacious suprascapular notch into a rigid, small foramen, which compresses the SSN. The three dry scapulae samples in this study exemplify this variation: All displayed an oval, obliquely orientated SSF created by full STSL ossification, with average dimensions of 6.16 mm (length) × 2.52 mm (width) and a circumference of 18.96 mm, while the ossified ligaments averaged 11.10 × 4.70 mm. Compared to published cadaveric and imaging studies, the foramen length sits at the lower end of the reported 6–12 mm range, and its width is narrower than most previous observations, which are between 3 mm and 8 mm (Das *et al*., 2007; Tubbs *et al*., 2013; Arora *et al*., 2017; Passey *et al*., 2021) (Table I). Foramina widths below 4 mm have been consistently associated with a significant increase in SSN entrapment, highlighting the clinical importance of morphometric findings (Tubbs *et al*., 2013; Polguj *et al*., 2014). Similar lengths but wider widths were reported by Kapetanakis *et al*. (2016), highlighting the regional and ethnic variations in STSL ossification patterns.

Biomechanical implications. Finite-element models demonstrate that when the arm is raised, the tunnel dimension is halved if the STSL ossifies. This doubles the hoop stress on the SSN and causes an increase in intraneural pressure of up to 30 % during overhead movements (Yoo *et al*., 2022). Furthermore, a sharper inferomedial rim is produced by the oval foramen, further increasing nerve angulation (Boykin *et al*., 2010). This plays a part in the perineurial fibrosis and histological axon loss seen in ossified specimens. As a result, the nerve becomes more vulnerable to traction neuritis and the so-called "sling effect." The foramina, which are smaller than 4 mm, likely experience disproportionately high hoop stress and shear forces during repetitive abduction and external rotation. This repetitive motion, often referred to as the "hand-up, thumb-back" position common among tennis and volleyball players, pulls the SSN medially, and as a result, the nerve may rub against the bony rim (Boykin *et al*., 2010). This recurrent stress may precipitate neuritis, weakness in the supra- and infraspinatus muscles, and poorly defined posterior shoulder pain (Boykin *et al*., 2010). The high incidence of nerve entrapment observed in overhead athletes may be explained by that.

In situations where a double foramen is present, the nerve travels in a convoluted S-shaped path, increasing shear stress at both apertures even though dual tunnels were not seen in this study (Bagoji *et al*., 2020). In order to customize the trajectory of arthroscopic burrs and avoid iatrogenic fractures or unintentional arterial injuries, it is crucial to identify the type of SSF prior to surgery and determine whether the foramen is narrow, oblique, or doubled. Early surgical decompression has produced success rates of over 90 % when conservative measures have failed (Memon *et al*., 2018).

The SSF's observed variation among populations could be caused by a number of factors. For instance, research indicates a higher prevalence of the supraorbital foramen in colder climates, while the supraorbital notch is commonly found in warmer regions (Tomaszewska *et al*., 2012). Could these factors cause the same changes in the suprascapular foramen.

CONCLUSION

This case report shows the clinical significance of complete ossification of the STSL, which transforms the suprascapular notch into a rigid foramen capable of compressing the SSN. While the three specimens demonstrated an ossified STSL, there were several limitations: (1) the dry bones lack demographic context, making it impossible to analyze age, sex, or race-related prevalence; (2) biomechanical inferences were based on finite-element models instead of specimen-specific simulations; and (3) potential soft-tissue pathologies could not be assessed using osseous material alone.

Table I. Morphometry of the ossified suprascapular foramina reported in the literature in comparison with the present case report.

Study	Foramen length (mm)	Foramen width (mm)	Foramen circumference (mm)	Ligament length (mm)	Ligament width (mm)
Das *et al*. (2007)	12.00	8.00	-	20	7
Tubbs *et al*. (2013)	The mean diameters 2.6		-	-	-
Polguj *et al*. (2014) Fan-shaped	7.17	8.75	-	-	-
Band-shaped	7.03	5.35	-	-	-
Kapetanakis *et al*. (2016)	6.46	3.88	-	11.7	9.5
Arora *et al*. (2017)	7.00	4.00	17	-	-
Passey *et al*. (2021)	6.12	3.67	-	7	4.3
Current study (mean measurements for the three scapulae)	6.16	2.52	18.96	11.1	4.7

The findings emphasize the importance of thorough pre-operative imaging for posterior shoulder pain or disproportionate supra- and infraspinatus weakness, especially in overhead athletes and manual laborers. Surgeons should be aware of unusual bony tunnels at the coracoid root or dual canals. Early recognition and customized decompression are crucial to prevent irreversible suprascapular neuropathy.

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RESUMEN: La osificación completa del ligamento transverso superior de la escápula (LTSE) convierte la incisura supraescapular en un túnel rígido, lo que predispone al nervio supraescapular a la compresión, especialmente cuando el grosor es < 4 mm. Se examinaron tres escápulas secas de adultos (dos derechas, una izquierda) de la colección de la Universidad Rey Saud. El tipo de incisura, la forma osificada del LSTE y las dimensiones del túnel/puente se midieron con un cáliper digital de 0,01 mm. Todos los especímenes mostraron osificación completa del LTSE formando un foramen verdadero: dos en abanico y uno en banda. La abertura media del túnel era de 6,16 × 2,52 mm (circunferencia de 18,96 mm). Los puentes óseos promediaron 11,10 × 4,70 mm, dejando una anchura efectiva < 4 mm en todos los casos. El modelado de elementos finitos de túneles con constricción similar muestra que la tensión de contacto sobre el nervio aumenta a lo largo de la abducción, con alzas marcados cerca de la elevación completa. Aunque la osificación total del LTSE se reporta en solo el 4 - 10 % de las escápulas, el estrechamiento extremo observado aquí se encuentra dentro de la "zona de peligro" reconocida para la neuropatía. Los atletas que realizan movimientos por encima de la cabeza y los trabajadores manuales pueden experimentar una compresión dinámica que la exploración rutinaria no detecta; por lo tanto, se recomienda una TC o RM de alta resolución cuando la electromiografía sugiere una lesión del nervio supraescapular. Cuando el tratamiento conservador falla, la liberación artroscópica logra una mejora del dolor y la fuerza en el 90 - 96 % de los pacientes. Incluso la osificación completa aislada del LTSE puede crear forámenes supraescapulares críticamente estrechos que amplifican la tensión biomecánica sobre el nervio; la obtención de imágenes tempranas y la liberación artroscópica oportuna son clave para prevenir un déficit irreversible.

PALABRAS CLAVE: Nervio supraescapular; Síndrome de compresión nerviosa; Escápula; Ligamento; Osificación.

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