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HIGH PREVALENCE OF COMPLETE OSSIFICATION OF SUPERIOR TRANSVERSE SCAPULAR LIGAMENT WITH THEIR MORPHOMETRIC ANALYSIS AND ITS CLINICAL SIGNIFICANCE

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Abstract:
Background: There is a notch called the suprascapular notch on the superior border of the scapula at its lateralmost end which is converted into a foramen by the Superior Transverse Scapular Ligament (STSL). This foramen allows the passage of the suprascapular nerve which innervates supraspinatus and infraspinatus muscle. Ossification of the superior transverse scapular ligament led to entrapment neuropathy of the suprascapular nerve leading to disuse atrophy of these two rotator cuff muscles-supraspinatus and infraspinatus muscles- making it more prone to shoulder dislocation.
Objective: measure the prevalence of complete ossification of superior transverse scapular ligament and its clinical importance.
Material and methods: A descriptive cross-sectional study was conducted at Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar and ESIC
Medical College, Bihta, Patna, Bihar between April 2023 and December 2024 on forty-three (43) dried human scapulae (right-23, left-20) of unknown sex and age kept for undergraduate bone demonstration classes. Each scapula was observed and analyzed for complete ossification of the superior transverse scapular ligament on its superior border. Scapula having a damaged superior border was excluded from the study. Photographs of scapulae with complete ossification of the superior transverse scapular ligament were captured with a digital camera.
Result: The prevalence of ossification of the STSL was 13.9 %. Most of the ossified STSL were of band type. The percentages of fan-shaped and band-shaped STSL were 33% (2/6) and 66% (4/6) respectively.
Conclusion: The higher prevalence of ossification among the band-shaped type compared to the fan-shaped superior transverse scapular ligament is in sharp contrast to other studies that reported a higher prevalence of ossification in the fan-shaped STSL. The band-shaped ossified superior transverse scapular ligament with the higher potential for ossification and consequent narrowing of the supra-scapular foramen has the higher risk factor for suprascapular nerve entrapment syndrome.

Key words-Suprascapular notch, Suprascapular Foramen (SSF), Superior Transverse
Scapular Ligament (STSL), Proximal Width (PW), Distal width (DW), Bony bridge (BB), Mean Vertical Diameter (MVD), Mean Transverse Diameter (MTD).

Introduction- The Scapula is a paired flat, plate-like triangular bone (apex faces downward) forming a pectoral girdle with the clavicle connecting the upper limb's appendicular bones with the axial bones. It has two surfaces (costal and dorsal), three borders (superior, medial, lateral), three processes (spinous process, coracoid process, acromion process), and three angles (inferior or apex, lateral or glenoid and medial or superior) [1].
The superior border of the scapula presents a notch called the suprascapular notch on its lateralmost end just proximal to the glenoid fossa (which articulates with the humerus to form the shoulder joint). The suprascapular notch converts into suprascapular foramen with the attachment of a superior transverse scapular ligament over it. This foramen allows the
passage of the suprascapular nerve and suprascapular vein whereas the suprascapular artery crosses above the ligament as shown in Figure 1.

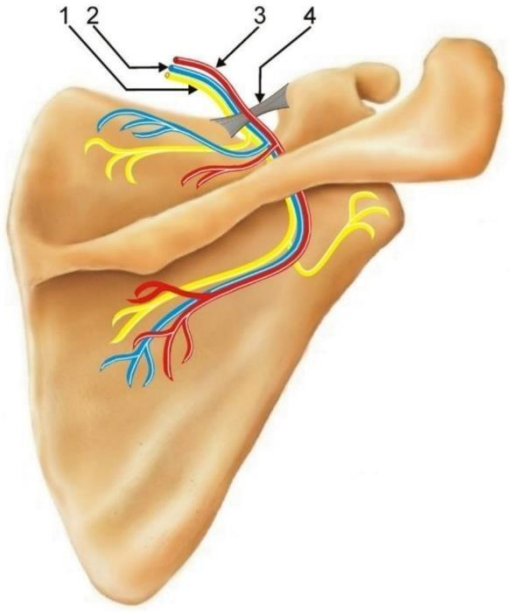

Fig.1: Showing a dorsal aspect of the scapula (Right sided) having a suprascapular notch on its superior border which is converted into a foramen called suprascapular foramen by a superior . transverse scapular ligament (4), which allows passage of suprascapular nerve (1) and vein (2) It supplies the supraspinatus and infraspinatus, two of the four muscles that form the rotator whereas the suprascapular artery (3) passes above the ligament.

The suprascapular nerve is a branch of the upper trunk of the brachial plexus at Erb's point. It innervates the supraspinatus and infraspinatus, two of the four muscles comprising the rotator cuff around the shoulder joint, which is responsible for providing stability to the joint. It is not only motor in nature but also receives proprioceptive sensation from the acromioclavicular and glenohumeral joint. After emerging from the brachial plexus, the suprascapular nerve runs beneath the trapezius and omohyoid muscles, before it crosses the suprascapular foramen and supplies the supraspinatus muscle and after passing across the spinoglenoid foramen, it supplies infraspinatus muscle.

The clinical significance of the ossification of the superior transverse scapular ligament lies in the fact that with the ossification, the foramen becomes compact and rigid resulting in entrapment neuropathy of the suprascapular nerve leading to shoulder pain, weakness, tingling, numbness around the shoulder joint, and wasting of rotator cuff muscles

(supraspinatus and infraspinatus) [2-4]. Besides this, the ossification of STSL can lead to the restriction of shoulder abduction and external rotation. Additionally, awareness of the anatomical variations and ossification of STSL is of paramount importance in diagnosis and treatment planning.

Most of the studies done so far have focused on determining the type of STSL, and not on morphometric analysis. Hence, the present study was conducted to do the morphometric analysis of the scapulae. This is more likely to contribute valuably to the existing research, and to better understand and help orthopedic surgeons perform surgery of the supra-scapular nerve entrapment neuropathy more effectively and safely. Hence, a clear understanding of the anatomy and potential complications of the ossified STSL is essential for anatomists, radiologists, neurosurgeons, and orthopedic surgeons.

Methodology:

A descriptive cross-sectional study was conducted on 43 dried human scapulae (right-23, left-20) of unknown sex and age kept for undergraduate bone demonstration classes at Bhawan Mahavir Institute of Medical Sciences, Pawapuri,Nalanda,Bihar and ESIC Medical College, Bihta, Patna. The study period was from April 2023 to December 2024.

Each scapula was observed and analyzed for complete ossification of the superior transverse scapular ligament on its superior border. Scapulae with damaged superior borders were excluded from the study. After the scapulae were meticulously observed for the presence of complete ossification of the superior transverse scapular ligament, morphometry of the suprascapular foramen was taken with the help of a standard vernier caliper **(Fig:2)**

The morphometric analysis of the scapulae involved the observation and measurement of the following parameters:

1. Shape of superior transverse scapular ligament, whether it is band-shaped or fan-shaped (**Fig:2c,2d**)
2. length of the ossified ligament
3. proximal width of the bony bridge (**Fig:2c,2d**)
4. distal width of the bony bridge (**Fig:2c,2d**)
5. middle vertical diameter of the suprascapular foramen (**Fig:2a**)
6. middle horizontal diameter of the suprascapular foramen (**Fig:2a**)

The Photographs of observed variations of the scapulae were captured using a digital camera; the results were compared and discussed with previous studies.

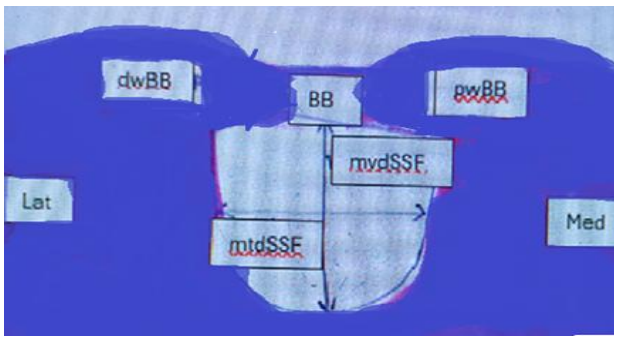

Fig-2a: Schematic diagram showing various dimensions of the suprascapular notch turned into a foramen by an ossified superior transverse scapular ligament.

BB: Bony bridge; pwBB: proximal width of the Bony Bridge; dwBB: distal width of the Bony Bridge; mvdSSF: middle vertical diameter of Suprascapular Foramen; mtdSSF: middle transverse diameter of Suprascapular Foramen; Lat: Lateral; Med: Medial

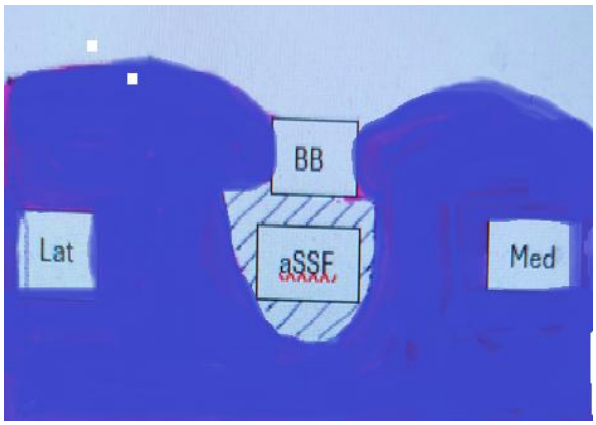

Fig-2b: Schematic diagram showing various dimensions of the suprascapular notch turned into a foramen by an ossified superior transverse scapular ligament:

BB: Bony Bridge; aSSF: area of Supra Scapular Foramen; Lat: Lateral; Med: Medial

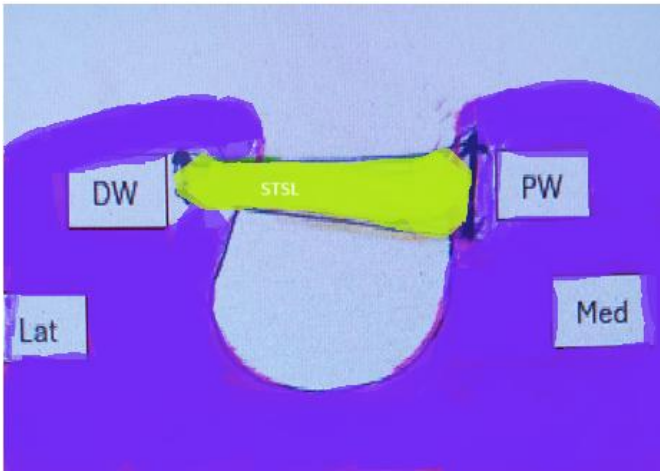

Fig-2c: Schematic diagram showing Fan-shaped Superior Transverse Scapular Ligament (STSL):

DW: Distal width; PW: Proximal Width; Lat: Lateral; Med: Medial

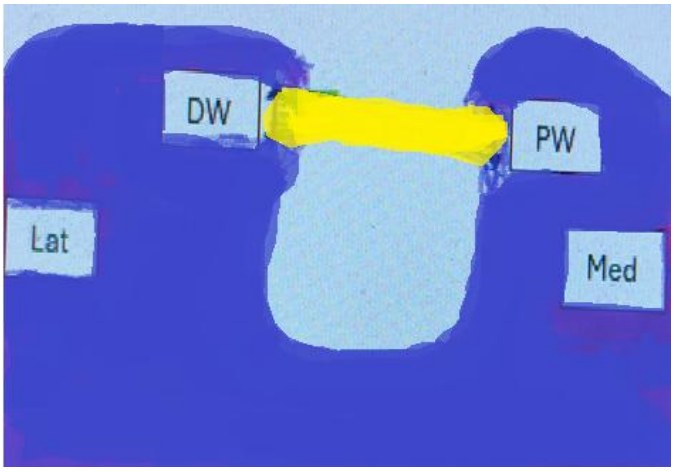

Fig-2d: Schematic diagram showing Band-shaped Superior Transverse Scapular Ligament (STSL):

DW: Distal width; PW: Proximal Width; Lat: Lateral; Med: Medial

Results:

Of the 43 dry scapulae studied, 23 were from the right side, while 20 belonged to the left side. Six (6) out of the 43 scapulae examined, showed ossification of the STSL making the percentage of ossified scapulae at 13.9. Out of 6 ossified STSLs, the percentages of the fan-shaped and band-shaped were 33% (2/6) and 66% (4/6) respectively. Based on the measurements of the maximal proximal and distal widths of the bony bridge and by applying metric criteria used in the classification of the STSL types [5], it was found that band-shaped types, (9.3%; 4/43) were more often ossified than the fan-shaped types (4.65%; 2/43) as shown in Figure 2-7 below.

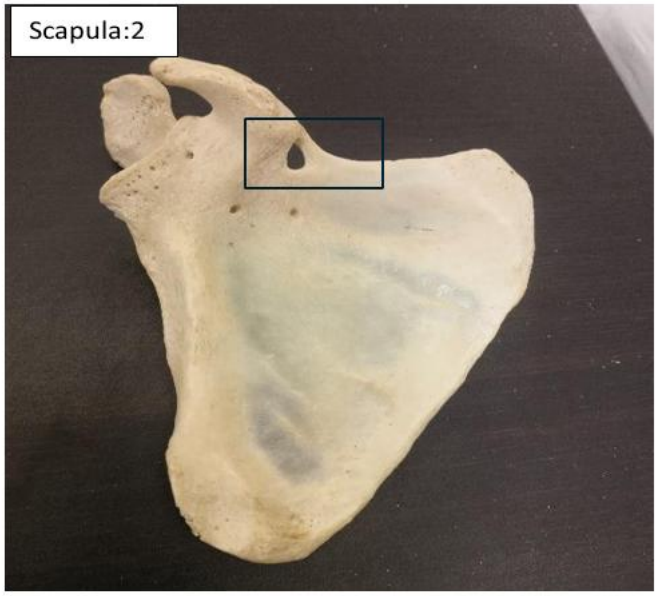

Fig:3 shows band-shaped ossified STSL in the right Scapula (encircled area).

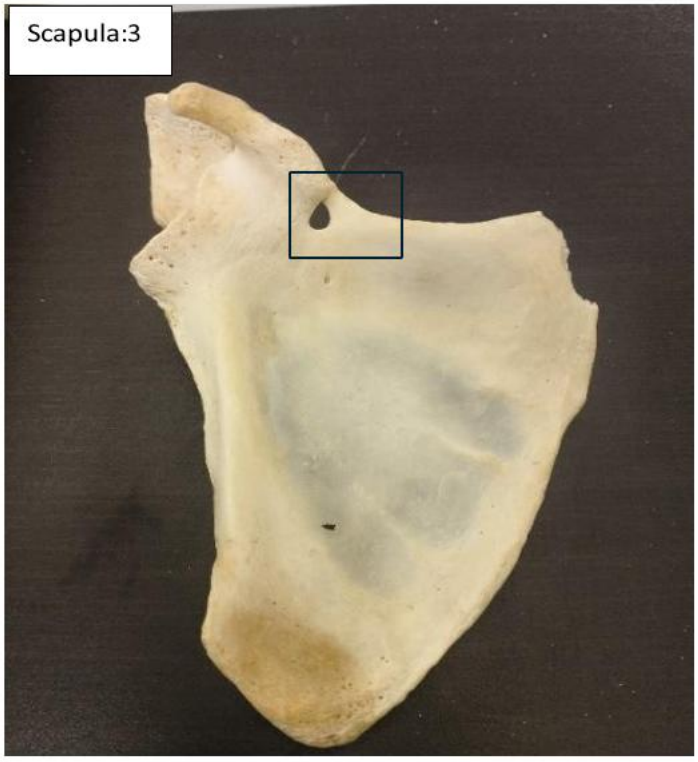

Fig:4 shows band-shaped ossified STSL in the right scapula (encircled area).

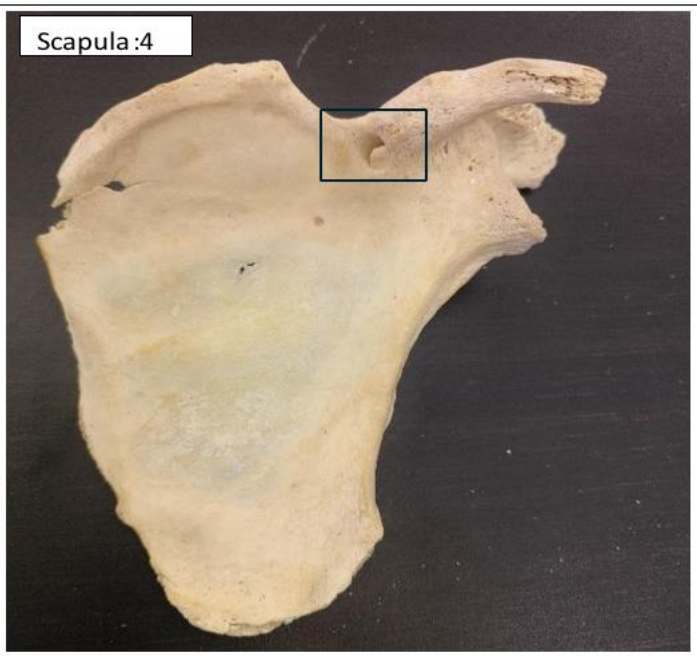

Fig:5 shows band-shaped ossified STSL in the left scapula (encircled area) .

Fig:6 shows a fan-shaped ossified STSL in the right scapula (encircled area).

Fig: 7 shows band-shaped ossified STSL in the right scapula (encircled area).

The morphometric measurements of six scapulae observed in the present study are compared in Table 1 below.

Table- 1: Showing various measurements of ossified Bony Bridge (BB) and Supra Scapular Foramen (SSF)

	Shape of Bony Bridge (BB)	Length of BB	Proximal Width (PW) of BB	Distal width (DW) of BB	Middle Vertical Diameter Of SSF	Middle Transverse Diameter Of SSF	Area of SSF	Side of Scapula
Scapula 1	Fan- shaped (PW>2XDW)	1 cm	1 cm	0.4 cm	1 cm	0.6 cm	0.3 cm^2	Left
Scapula 2	Band -shaped (PW<2XDW)	1.2 cm	0.7 cm	0.5 cm	0.8 cm	0.4 cm	0.15 cm^2	Right
Scapula 3	Band -shaped (PW=2XDW)	1 cm	1 cm	0.5 cm	0.7 cm	0.5 cm	0.51 cm^2	Right
Scapula 4	Band- shaped (PW<2XDW)	0.8 cm	1.2 cm	0.9 cm	0.7 cm	0.4 cm	0.14 cm^2	Left
Scapula 5	Fan -shaped (PW>2XDW)	1.3 cm	0.6 cm	0.2 cm	1.2 cm	0.6 cm	0.33 cm^2	Right
Scapula 6	Band- shaped (PW=2XDW)	1.2 cm	1 cm	0.5 cm	1.1 cm	0.7 cm	0.34 cm^2	Right

In the present study, the mean surface area of the Suprascapular Foramen (aSSF) was greater in the band-shaped compared to the fan-shaped bony ridge (1.14 cm^2 and 0.45 cm^2 respectively). Likewise, the mean transverse diameter of the suprascapular foramen was greater in fan-shaped than in the band-shaped bony ridge (0.6 cm and 0.5 cm respectively). In contrast, the mean vertical diameter of the suprascapular foramen was greater in the band-shaped than in the fan-shaped bony ridge (0.825 and 0.54 cm respectively). The number of specimens was too low to perform any statistical analysis.

Discussion:

There is great variability in the prevalence of ossified STSL amongst different countries: it ranges from a minimum of 1.3% in Finland to a maximum of 30.76% in Brazil. It ranges from 3%-10% in most countries, as mentioned in Table 2. According to a study by Tubbs et. al. [6], the most common site of suprascapular nerve compression is the suprascapular foramen, which gets narrowed due to complete ossification of the superior transverse scapular ligament. They also found signs of neuronal degeneration of the suprascapular nerve following compression. Ticker et. al. [7] and Rengychary et al. [8] observed that even ossified STSL becomes a risk factor for surgeons while doing nerve decompression in patients with signs and symptoms of suprascapular nerve entrapment neuropathy. Tubbs et al. [6] found that a completely ossified superior transverse suprascapular ligament was the most important predisposing factor for suprascapular nerve entrapment. In their analysis, all specimens with ossified STSL displayed signs of neural degeneration in the suprascapular nerve [6].

Table: 2- Shows the prevalence of ossified STSL in various countries of the world along with their sample size.

Researcher	Country	Ossified STSL in %	Number of specimen(n)
1.Kajava [9]	Finland	1.5%	N=133
2. Tubbs et. al. [6]	Turkey	3.7%	N=120
3.Rengachary et. al. [8]	USA	4.0 %	N=221
4.Polguj et. al. [10]	Poland	4.72%	N=616
5.Olivier [11]	France	5.0%	N=100
6.Ticker et al. [7]	USA	5.0%	N=79

7.Wang et. al. [12]	China	4.08%	N=295
8.Natsis et. al. [13]	Germany	7.3%	N=423
9.Silva [14]	Brazil	30.76%	N=221
10. Present study	India	13.9%	N=43

Cohen et. al. [15] emphasized that ossified STSL had a genetic correlation and discussed the tendency of transfer of ossification of STSL from father to son. Table- 3 compares the prevalence of ossified STSL among the right and left scapulae by different researchers.

Table: 3- shows the prevalence of side predominance of ossified STSL in different studies.

Researcher	Right scapula	Left scapula	Number of specimens with ossified STSL
Polguj et. al. [10]	52.3% (23/44)	47.7% (21/44)	44
Silva et. al. [14]	52.94% (36/68)	47.05% (32/68)	68
Masoud et.al.[16]	60% (3/5)	40% (2/5)	5
Jawed et. al. [17]	64.28% (18/28)	35.71% (10/28)	28
Present study	66.66% (4/6)	33.33% (2/6)	6

In this study, ossification of the superior transverse scapular ligament showed a right predominance as it was found in 66.66% of the scapulae, a finding consistent with most of the studies (Table 3). The right-sided predominance of ossification of STSL can be attributed to the fact that the maximum percentage of the population is right-handed. The prevalence of ossification of STSL according to shapes by various researchers is described in Table 4.

Table: 4- shows the prevalence of ossification of STSL in different shapes of STSL

Researcher	Prevalence of ossification in Fan-shaped STSL	Prevalence of ossification in Band shaped STSL
Polguj et. al. [10]	54.6%	41.9%
Kharay et. al. [18]	61.5%	38.5%
Ticker et. al. [7]	77%	23%
Bayramoglu et. al. [19]	62.5%	25%
Duparc et. al. [20]	63.3%	36.7%
Sangam et. al. [21]	69.23%	26.92%
Present study	33.33%	66.66%

In the present study, the prevalence of ossification was higher (66.66%) among the band-shaped type compared to the fan-shaped superior transverse scapular ligament. This is in sharp contrast to other studies that reported a higher prevalence of ossification in the fan-shaped STSL (Table 4).

Limitation: the number of specimens in this study was too low to perform any significant statistical analysis.

Conclusion: The prevalence of ossification of the STSL was 13.9 %. The percentages of the fan-shaped and band-shaped were 33% (2/6) and 66% (4/6) respectively. The prevalence of ossification was higher (66.66%) among the band-shaped type compared to the fan-shaped superior transverse scapular ligament. This is in sharp contrast to other studies that reported a higher prevalence of ossification in the fan-shaped STSL. The band-shaped ossified superior transverse scapular ligament

with the higher potential for ossification and consequent narrowing of the supra-scapular foramen has the higher risk factor for suprascapular nerve entrapment syndrome.

It may give rise to various clinical symptoms and progressive muscle weakness and atrophy if the condition is not diagnosed and treated early. Hence, the anatomical knowledge of ossified STSL is essential for the clinician, radiologist, and surgeon who frequently deal with suprascapular nerve entrapment syndrome, and necessitates further research into it.

Conflicts of interest- Nil

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