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Original Research Article

Ossification of Superior Transverse Scapular Ligament: Incidence, Etiological Factors and Clinical Relevance

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ABSTRACT

Introduction: The classic description of superior transverse scapular ligament (STSL) is a completely non-ossified single band and should be expected on average, in three-fourth of cases. Age, mechanical load, sex and genetic factors may be responsible for ossification of STSL. Variations in the STSL and the suprascapular notch are the most recognized possible predisposing factors for suprascapular nerve entrapment.
Aims: The present study was intended to document and compare the incidence of ossification of STSL in dry scapulae, to elucidate the reasons of ossification of STSL and to discuss its clinical significance.
Materials and methods: The present study was carried out on 122 (Right 64, Left 58) dried human scapulae of unknown sex.
Results: Macroscopic examination revealed that 4.92% scapulae had completely ossified STSL and 10.65% had partial ossification.
Conclusion: Incidence of ossification of STSL varies in different populations. Ossification may be influenced by age, mechanical load on ligament, sex and genetic factors and can be one of the risk factors for suprascapular entrapment neuropathy. So these facts should be considered while dealing with a case of painful shoulder.
Keywords: Ossification, Enthesis, Scapula, Superior transverse scapular ligament, Suprascapular nerve entrapment.

INTRODUCTION

The scapula is a large, flat, triangle bone almost completely clothed with muscles. Its superior border is separated laterally from the base of coracoid process by the suprascapular notch. The superior transverse scapular ligament (STSL) bridges this notch and forms an osteofibrous foramen through which suprascapular nerve travels. Suprascapular artery and vein usually pass over the ligament. [1-3] The superior transverse scapular ligament is a thin flat substantial band attached laterally to the base of the coracoid process and medially to the lateral wall of the suprascapular notch. [1, 3] The classic description of STSL is a completely non-ossified single band and should be expected on average, in three-fourth of cases. [4]

The suprascapular notch is frequently bridged by bone rather than a ligament, converting it into a bony foramen in some animals. [5] But in human, the STSL is sometimes ossified. [1, 6] The bony bridges are seen more often with increasing age suggesting that they may be related to enthesopathic effect. [7] The documented variation of STSL includes calcification, partial or complete ossification and multiple bands. [4] Variations in the STSL and the suprascapular notch are the most recognized possible predisposing factors for suprascapular nerve entrapment. [8] Suprascapular nerve entrapment neuropathy has also been described in clinical scenario without a visible ossification of STSL. [9] This is characterised by weakness of abduction and external rotation of the arm due to supraspinatus and infraspinatus muscle denervation, atrophy of these muscles and is frequently accompanied by ill-defined dull or burning pain on the posterolateral aspect of shoulder which exaggerate on activity. In some cases the pain radiates to the ipsilateral extremity, the side of the neck or the front of the chest. [10, 11]

Many research workers have reported that incidence of ossification of STSL vary in different population and is associated with suprascapular nerve entrapment but did not comment on the reasons of its ossification. In India very few data on ossification of STSL are available. So, proposal of this study was to document and compare the incidence of ossification of STSL in dry scapulae, to elucidate the reasons of ossification of STSL and to discuss its clinical significance.

MATERIALS AND METHODS

The present study was carried out on 122 (Right-64, Left-58) dried human scapulae of unknown sex obtained from Department of Anatomy, Velammal Medical College Hospital & Research Institute, Madurai, Tamilnadu and SVS Medical College, Mahabubnagar, Andhra Pradesh. Each scapula was observed for the presence of ossification (complete/partial) of the superior transverse scapular ligament. Representative photograph of ossified STSL were taken using digital camera (sony 16 megapixel). The scapulae with bilaterally damaged superior margin were excluded from the study.

RESULTS

Macroscopic examination revealed that 6 out of 122 (4.92%) (2-right side, 4-left side) scapulae had completely ossified STSL (Fig. 1 & 2) and 13 out of 122 (10.65%) (8-right side, 5-left side) had partial ossification (Fig. 3-6). Among completely ossified (6), 33.33% on right, 66.67% on left side and among partially ossified STSL (13), 61.54% on right side, 38.46% on left side. 103 (84.43 %) scapulae were found with no ossified STSL.

Figure 1: Right side scapula with completely ossified STSL.

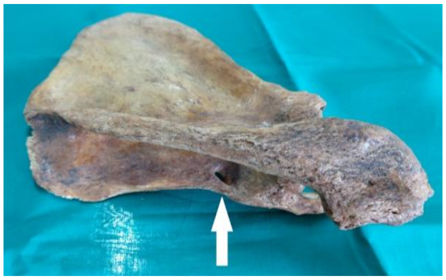

Figure 2: Left side scapula with completely ossified STSL.

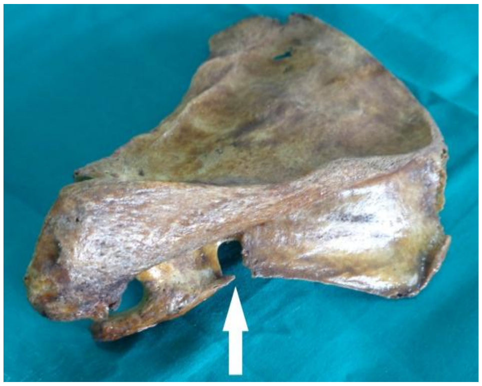

Figure 3: Right side scapula with partially ossified STSL.

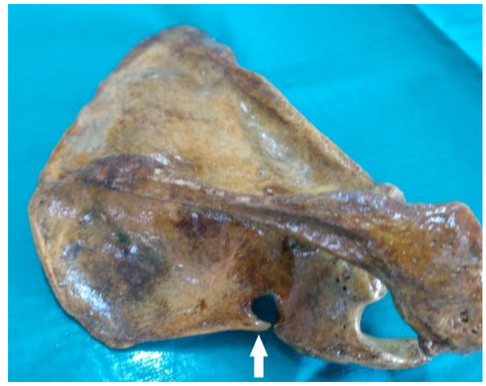

Figure 4: Left side scapula with partially ossified STSL.

Figure 5: Right side scapula with partially ossified STSL.

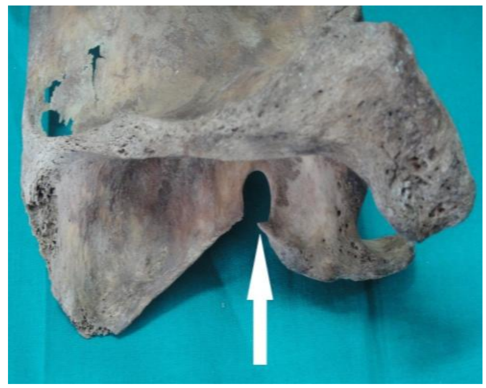

Figure 6: Left side scapula with partially ossified STSL.

DISCUSSION

The ossification of STSL is multifactorial and its incidence varies in different populations as shown in Table no.-1. In the present study we found 4.92% incidence of completely ossified STSL which is close to the report of Dunkelgrun [12] *et al*. (5%). Silva *et al*. [13] have reported 30.76% incidence which is quite high as compared to our study (4.92%). Gray DJ [14] found 6.34% (73 in 1151) suprascapular foramen but no foramen in 87 Indian scapulae. In some population complete ossification of STSL was very rare for e.g. in Alaskan Eskimos-0.3%, native American-2.1-2.9%. [7] Osuagwu *et al*. [9] reported a case of complete ossification of STSL in Nigerian male adult. Khan [5] & Das *et al*. [15] also have reported cases of complete ossification of STSL in Indian population. We also observed the scapulae with partial ossification of STSL and found the incidence 10.65% which is more than the report of Edelson [6] (8.1%) but less than the report of Ticker *et al*. [4] (18%), Dunkelgrun *et al*. [12] (12%), Polguej *et al*. [16] (23.3%). Other authors like Natsis *et al*.[17], Sinkeet *et al*.[18], Silva *et al*. [13], S D Jadhav *et al*. [19], Kalpana T *et al*. [20] did not include this aspect in their studies.

Table-1: Incidence of ossification of superior transverse scapular ligament in different populations.

S no.	Authors	Incidence of ossification in %		No. of specimen studied	Country
		Complete	Partial		
1	Natsis *et al.* [17]	7.3	--	423	Germany
2	Edelson *et al.* [6]	3.7	8.1	1000	America
3	Dunkengrun *et al.* [12]	5	12	623	America
4	Polguej *et al.* [16]	7.0	23.3	86	Poland
5	Sinkeet *et al.* [18]	2.9	---	138	Kenya
6	Ticker *et al.* [4]	5	18	79	America
7	Silva *et al.* [13]	30.76	---	221	Brazil
8	S D Jadhav *et al.* [19]	10.57	---	350	India (Maharashtra)
9	Kalpana T *et al.* [20]	2.0	---	100	India (Manipur)
10	Present study	4.92	10.66	122	India (Andhra Pradesh)

Most of the research papers only analyze the association of ossified STSL with suprascapular nerve entrapment neuropathy rather than to explain the reason for its ossification. In this study we focused and elucidated the etiological factors like age, mechanical load on ligament, sex and genetic factors responsible for ossification of STSL. For better understanding the role of these factors in ossification of this ligament, a brief about structure of enthesis (site of attachment) is needed. Enthesis, a connecting link between the bone and the ligament consists of four zones of tissue: pure dense fibrous connective tissue, uncalcified fibrocartilage, calcified fibrocartilage and bone. (Figure-7) Typically, the fibrous area is the most superficial or distal part of the enthesis. [21]

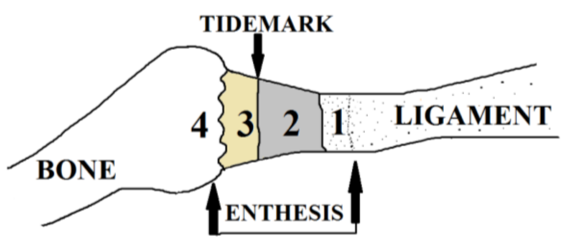

Figure 7: Sketch diagram showing structure of enthesis in limited sense.
Change in insertional angle between ligament/tendon and bone (extent of movement) is proportional to quantity (thickness) of uncalcified fibrocartilage(zone-2).
Physiological strength and loading of the ligament/tendon is proportional to thickness of calcified ligament (zone-3).
1-zone of dense fibrous connective tissue
2-zone of uncalcified fibrocartilage
3-zone of calcified fibrocartilage
4-part of bone

The amount of fibrocartilage varies between different ligaments, between two ends of same ligament and in the superficial and deep parts of the same attachment zone. [22] The fractional area of calcified fibrocartilage increases with age. [23] The calcified fibrocartilage that is considered to play a role in the ossification has been described in normal and abnormal ligaments and tendons. [24, 25] Thus it can be considered that incidence of ossification of STSL is more in advanced age people. This is supported by the fact that bony bridges (complete ossification of STSL) are more often seen with increasing age suggesting its relation to enthesopathic changes. [7]

Fibrocartilage entheses are typical attachment sites where joint movement creates a wide change in angle between the ligament/tendon and the bone. The primary role of the enthesis fibrocartilage is to dissipate stress concentration at the bony interface, promoting a gradual bending of ligament/tendon as the joint moves. The quantity of uncalcified fibrocartilage at an enthesis is well correlated to the extent of movement that occurs between ligament/tendon and bone. Movement is the mechanical stimulus that triggers the metaplasia of fibroblasts to fibrocartilage cells. [24, 26, 27] The thickness of the zone of calcified fibrocartilage and the extent of the interface that it provides for the bone may be related to the physiological strength and loading of the ligament/tendon. [28]

The STSL simply connecting two areas of same bone and having no direct attachment to any moving joint, has fibrocartilage entheses due to complex muscular, fascial and bony architecture of scapula – a bone that is liable to be deformed by the mechanical loads imposed on it by movements of the shoulder and upper extremity. It is a basic mechanical principle that stresses concentrations, in a highly complicated shaped structure focus on areas where there are deep indentations or protrusions. So during shoulder and upper extremity movements the muscles (specially supraspinatus and its fascia which is attached with STSL) contraction is likely to cause torsion of the upper part of the scapula. Such twisting movements can create significant stress concentrations at the STSL entheses and even lead to small changes in insertional angle at both ends of the ligament. Near the medial margin of suprascapular notch, superior border of scapula also gives origin to omohyoid muscle which is though weak, on contraction contributes to stress concentration at STSL due to its closeness to the ligament. The lateral end of STSL is also blend with the conoid part of coracoclavicular ligament, so force acting on coracoclavicular ligament is transmitted to STSL. Even in the absence of any connection between these two ligaments forces acting on coracoid process are indirectly transmitted to STSL due to its attachment to the base of coracoid process. This also adds to stress concentration at STSL lateral enthesis. [1, 3, 15, 29] The zonal arrangement of tissue (2 zones of fibrocartilage between ligament and bone) contributes to stress dissipation at entheses and may reflect a gradual change in mechanical properties from ligament to bone. [30] The fibrocartilage inhibits bone resorption or spread of mineralization into fibrous tissue. [24] Abnormal biomechanical forces can lead to a marked thickening of the zone of fibrocartilage and its eventual conversion to bone. [30] This can be supported by Scapinelli's [31] report that fibrocartilaginous nodule develop by metaplasia of the ligamentum nuchae of man in regions of great mobility, where the ligament is pressed against vertebral spines during neck flexion. They become calcified and are replaced by bone. [30]

The bony spurs (enthesophytes/osteophytes) are bony outgrowths that extend from bone to soft tissue of a ligament/tendon at its enthesis and represent a skeletal response to stress. Bony spurs surrounded by extra-cellular matrix rich in type II collagen and aggrecan suggest that the method of ossification in STSL is endochondral. They can occur in association with high levels of physical activity, are more common with increasing age and are more frequently found in male than female. [3, 32] Rasmussen [33] *et al*. reported that fibrocartilage developed from fibrous tissue in the os penis of rat and calcified with age under the influence of androgens. Glucksmann & Cherry [34] have shown that testosterone administered to female rats induces the development of an os clitoridis containing fibrocartilage. Hrdlicka [7] in his work has mentioned that bony bridges are found more in Caucasian male. These findings indicate that male predominance in ossification of ligaments may have some endocrinal basis and application of same for STSL ossification can be the topic for further research. Some individuals have greater tendency to form bone than others, both at the margins of joints and at the entheses. Such individuals form bone at the levels of mechanical stress that do not trigger comparable osteogenesis in others due to their genetic predisposition to more bone formation. [32] Cohen [35] *et al*. have described a familial case of calcification of STSL causing entrapment neuropathy of the suprascapular nerve affecting both father and son, suggesting that the ossification of STSL may have a genetic basis.

The STSL is the only part of osteofibrous suprascapular foramen which is directly linked to suprascapular nerve entrapment. Possibly the nerve is compressed by the ligament. Chances of compression are more when the STSL is ossified. [12, 15] The ossified STSL can be a risk factor at surgical exploration during suprascapular nerve decompression. [4] Therefore it should be assessed correctly. The electrophysiological studies and MRI should always be used when clinical findings suggest entrapment of the suprascapular nerve. [10] The patient of suprascapular nerve dysfunction without muscle atrophy or evidence of a space-occupying lesion is usually prescribed non-operative treatment consisting of pain-management, relative rest, followed by physiotherapy. After three-four months, if the symptoms persist, operative decompression of the nerve is advocated. [10, 11]

There are some limitations to this study. Because of the use of dry bones, the effects of other soft tissue structures on suprascapular nerve could not be evaluated as well as clinical history of patients was not available. Therefore the person with ossified STSL might have suprascapular nerve entrapment neuropathy but without these details, it is hard to say that person had suprascapular nerve entrapment neuropathy. Since the present study was performed with a limited number of dry scapulae, more clinical, radiological, histological and cadaveric studies need to be done.

CONCLUSION

Incidence of ossification of STSL varies in different populations and may be influenced by age, mechanical load on ligament, sex and genetic factors. The ossification of STSL can be one of the risk factors for suprascapular entrapment neuropathy. So these facts should be in the mind of clinicians, radiologists and surgeons while dealing with a case of painful shoulder**.**

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