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Associated Findings of Non-Traumatic Supraspinatus Tear an MRI Analysis

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Abstract: Supraspinatus muscle is usually the first and the most common rotator cuff muscle encountered in traumatic and non-traumatic rotator cuff tears, representing more than 95% of rotator cuff injuries. The aim of our study is to assess findings associated with non-traumatic supraspinatus muscle tears using magnetic resonance imaging and its relationship to different demographic factors. Shoulder magnetic resonance imaging were reviewed for a total of 321 patients referred from outpatient clinics aged between 18-80 years to analyze those having non-traumatic tear of the supraspinatus tendon during the period from January 2016 till April 2018. Patients with no tear status of the supraspinatus tendon and those with history of shoulder surgery or trauma have been excluded. A total number of 129 patients have fulfilled our inclusion criteria. There were 60 (46.5%) male and 69 (53.5%) female patients with a mean age of 55.25 (±12.96) and 49.98 (±15.4), respectively. A difference that was not statistically significant ($p = 0.107$). We found a significant difference ($p = 0.002$) in the frequency of complete and partial supraspinatus tears where 112 patients (86.8%) have partial supraspinatus involvement compared with 17 patients (13.2%) with complete rupture. Several associated factors with supraspinatus non-traumatic injury have been studied; degenerative changes of the acromioclavicular joint showed most significant association 89.8%, joint effusion 77.5%, abnormal bone marrow signal at the superior facet of the greater tubercle 46.5%, curved type of acromion 44.1% and subacromial-subdeltoid bursitis 53.5%. Three patients with tear status showed osacromiale and one patient had calcific tendinitis. Among other rotator cuff tendons the infraspinatus was the most commonly associated one representing 17.2% and long head biceps tendon was involved in 12.4%. Non-traumatic supraspinatus tear has multiple associations that can be detected using magnetic resonance imaging including osseous and muscular structures. Acromioclavicular joint degenerative changes showed the most significant association. This study provides an overview analysis of structural associations related to non-traumatic supraspinatus injury in our sample cohort. Several structural injuries are associated with non-traumatic supraspinatus tear. Degenerative changes of acromioclavicular joint is the most common structural association. MRI is the modality of choice in assessing supraspinatus and its associated injuries.

Key words: Supraspinatus, rotator cuff tear, shoulder magnetic resonance imaging, non-traumatic injuries, degenerative, associated

INTRODUCTION

Rotator cuff tear is a common condition affecting the shoulder; its incidence increases with advancing age (Milgrom *et al*., 1995; Tempelhof *et al*., 1999). The supraspinatus tendon is the structure most frequently and usually the first to be involved among rotator cuff tendons (Sharma *et al*., 2017). Diagnosis of tears is often delayed, since, early stages are asymptomatic (Cofield *et al*., 2001; Fukuda *et al*., 1996).

Magnetic Resonance Imaging (MRI) can reliably identify rotator cuff tendon tear and further characterization of the abnormality including its size, shape, involved thickness, presence of retraction and associated muscular atrophic changes which could influence treatment options and help determining the prognosis (Zanetti *et al*., 1999; Morag *et al*., 2006). Previous studies have described magnetic resonance findings of rotator cuff tears particularly supraspinatus tendon. The aim of our study is to assess non-traumatic supraspinatus tear among our patient cohort, moreover, its relationship to different structural and demographic factors. To best of our knowledge, the current analysis is the first national and regional retrospective study evaluated those factors as well as compared our results with global figures.

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Table 1: Shoulder magnetic resonance imaging protocol

Variables	Oblique coronal PD fat sat	Oblique coronal STIR	Oblique coronal T1WI	Oblique sagittal PD fat sat	Axial T1WI	Axial STIR
Average	2	2	2	2	1	2
Time to repeat (msec)	3000	4000	583	3000	700	3700
Time to echo (msec)	9.7	32	23	8.3	23	30
Receiver band width, hertz/pixel	241	220	250	240	260	219
FA, degrees	136	140	150	136	150	140
Field of view (mm)	160	160	160	160	160	160
Matrix size	342*384	282*320	342*384	265*320	288*384	192*256
Slice thickness (mm)	3	3	3	3	3	3
Distance factor	10%	10%	10%	10%	23%	23%

MATERIALS AND METHODS

The current retrospective study has been approved by our institution review board and conducted in accordance with Helsinki declaration. We reviewed shoulder magnetic resonance imaging for all patients referred form orthopedic, rheumatology and family medicine outpatient clinics to evaluate supraspinatus tendon tear during the period from January 2016 to April 2018. A retrospective picture archiving and communication system search of shoulder magnetic resonance imaging scans were reviewed for a total of 321 patients. Selection criteria included patients aged between 18 and 80 years with non-traumatic tendinous supraspinatus tear. Exclusion criteria included those with normal supraspinatus tendon, patients with history of shoulder surgery or trauma as well as magnetic resonance artifacts that interfere with proper evaluation of the supraspinatus tendon. A total number of (129) patients have fulfilled our criteria.

Imaging technique: Shoulder magnetic resonance imaging was performed using 3 Tesla superconducting magnetic resonance imaging unit (MagnetomVario, Siemens, Erlangen, Germany). A predesigned protocol was implemented using shoulder coil. The shoulder joint was imaged using T1weighted images (oblique coronal and axial), proton density with fat saturation (oblique coronal and oblique sagittal) and short tau inversion recovery sequence (oblique coronal and axial). Imaging parameters included a field of view of 16 cm, matrix size ranged from 192*256-342*384 and slice thickness of 3 mm Table 1.

Images were reviewed by five radiology consultants experienced in magnetic resonance imaging and four radiology senior residents with no significant inter-rater discrepancy reached above 91%, followed by a consensus to resolve any difference in interpretation. Shoulder magnetic resonance images were evaluated thoroughly for supraspinatus tendon partial versus complete tear; acromioclavicular joint degenerative changes, joint fluid (we classified the degree of joint fluid by measuring the thickness of fluid at the inferior aspect of the glenohumeral joint as mild: 1-2 mm; moderate: 2-3 mm; and severe: ≥4 mm), type of acromion shape, subacromial-subdeltoid bursitis, presence of OS acromiale, other rotator cuff tears, biceps tendon injury, abnormal bone marrow signal and calcific tendinitis.

Statistical analysis: We applied SPSS Version 22.0 (Chicago, USA) in our analysis. We used mean (±standard deviation) to describe continuous variables (i.e., age). We used count (frequency) to describe other nominal variables.

We employed independent sample t-test to analyze mean age difference with different dichotomous variables and used one-way ANOVA to analyze mean age difference with joint fluid. We applied Tukey post-hoc test to analyze sub-group differences. We used Chi-square test to analyze the dichotomous and multinominal variables, followed by post-hoc Z-test for proportions. All underlying assumptions were met, unless otherwise indicated. We adopted a p-value of 0.05 as a significant threshold.

RESULTS AND DISCUSSION

A total of 129 patients were included in this study with a mean age of 52.8 (±14.3), aged between 18 and 80 years. There were 60 (46.5%) male with a mean age of 49.98 (±15.4) and 69 (53.5%) female with a mean age of 55.25 (±12.96) with a non-statistically significant difference ($p = 0.107$). No significant gender or age differences for other studied variables.

A significant difference ($p = 0.002$) in the frequency of complete and partial supraspinatus tears has been noticed as 112 patients (86.8%) having partial tear compared with 17 patients (13.2%) demonstrating complete supraspinatus involvement. The studied factors that associated with development of the supraspinatus tear included: degenerative changes of the acromioclavicular joint, shoulder joint effusion, shape of the acromion process, subacromial-subdeltoid bursitis, osacromiale, calcific tendinitis, rest of rotator cuff and long head biceps tendon injuries and bone marrow signal edematous changes at the superior facet of the greater tubercle of the humerus at the insertion site of supraspinatus Table 2.

Acromioclavicular joint degenerative changes showed the most significant association with non-traumatic injuries of the supraspinatus tendon seen in 114 patients (89.8%). About 100 patients (77.5%) with supraspinatus tears showed joint fluid of different degrees; 64 patients (64%) mild, 14 patients (14%) moderate, 22 patients (22%) severe. Significant difference between acromion shape and tear (partial vs. complete) ($p = 0.022$) was found. Post-hoc test showed that curved shape was associated with the highest percentage of complete tear 56 patients (44.1%), compared to two patients (35.4%), 14 patients (11%), 12 patients (9.4%) for flat, hooked and convex shapes, respectively.

Table 2: Characteristics of the included sample

Studied criteria/Classification	No. of patients	Percentage
Supraspinatus tear types		
Complete	17	13.2
Partial	112	86.8
Acromioclavicular joint degeneration		
No	13	10.2
Yes	114	89.8
Joint fluid		
None	29	22.5
Mild	64	49.6
Moderate	14	10.9
Severe	22	17.1
Acromion shape		
Flat	45	35.4
Curved	56	44.1
Hooked	14	11.0
Convex	12	9.4
Subacromial-subdeltoid bursitis		
No	59	46.5
Yes	68	53.5
OS acromiale		
No	126	97.7
Yes	3	2.3
Subscapularis tear		
No	104	81.3
Yes	24	18.8
Teres minor tear		
No	129	100.0
Yes	0	0.0
Infraspinatus tear		
No	106	82.8
Yes	22	17.2
Biceps injury		
No	113	87.6
Yes	16	12.4
Abnormal bone marrow		
No	69	53.5
Yes	60	46.5
Calcific tendinitis		
No	126	99.2
Yes	1	0.8

Our study also showed a non-significant association of subacromial-subdeltoid bursitis with supraspinatus tear representing 53.5% compared with those having no concomitant subacromial-subdeltoid bursitis 46.5%. Os acromiale (3 patients, 2.3%) and calcific tendinitis (1 patient, 0.8%) showed no major associations with increased risk of supraspinatus tear.

Among rotator cuff muscles, infraspinatus was the most commonly associated one (22 patients, 17.2%) compared to subscapularis (24 patients, 18.8%) and teres minor (0 patients, 0.0%). About 16 patients (12.4%) had a concomitant long head of biceps injury. About 60 patients (46.5%) showed abnormal bone marrow signal at the superior facet of the greater tubercle of the humerus. Mean age and gender percentages for each of the four muscle tears are shown in Table 3.

The shoulder joint is a synovial multi-axial spheroidal (ball-and-socket) joint. Supraspinatus muscle is attached to the medial two thirds of the supraspinatus fossa and supraspinatus fascia then converges and passes under the acromion forming its tendon which crosses above the glenohumeral joint to attach at the highest facet of the greater tubercle of humerus; the tendon is adherent to the articular capsule. Its entheses organ is considered fibrocartilagenous type. Sub acromial-subdeltiodbursa separate the tendon from the coracoacromial ligament, acromion and deltoid; the tendon of the supraspinatus muscle is known to be the most commonly affected tendon among the rotator cuff (Williams *et al*., 1989).

In the current analysis we have found a significant difference in the incidence of ($p = 0.002$) complete and partial supraspinatus tears accounting for

Table 3: Mean age and gender percentages for each of the four muscle tears

	Age		Sex			
			Male		Female	
Muscles/Involvement	Mean	SD	No. of patients	Percentage	No. of patients	Percentage
Subscapularis tear						
No	52	14	47	45.2	57	54.8
Yes	57	14	13	54.2	11	45.8
Teres minor tear						
No	53	14	60	46.5	69	53.5
Yes	0	0	0	0.0	0	0.0
Infraspinatus tear						
No	52	14	48	45.3	58	54.7
Yes	58	13	11	50.0	11	50.0
Biceps injury						
No	53	14	52	46.0	61	54.0
Yes	51	17	8	50.0	8	50.0

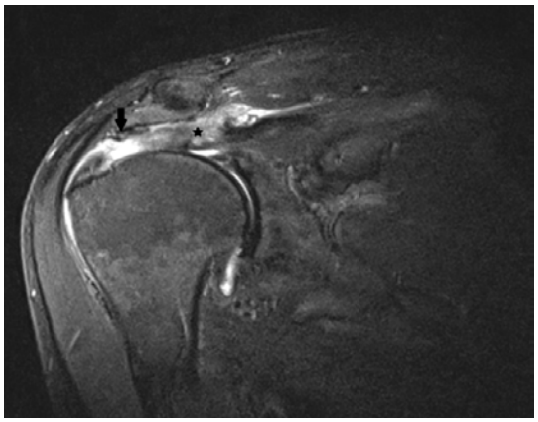

Fig. 1: Coronal STIR MR scan of the right shoulder joint shows complete supraspinatus tendon. Abnormal signal with thickening at the retracted supraspinatus tendon (star) and defect filled with fluid signal (black arrow)

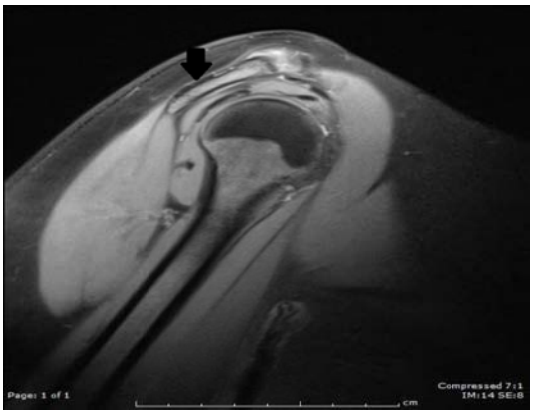

Fig. 2: Sagittal PD image showed curved configuration of the acromion (Type 2)

13.2% and 86.8%, respectively which is concordant with the literature figures (Freygant *et al*., 2014). Complete tear has been defined as the one that extends from the bursal surface to the articular surface on at least one slice while the partial counterpart partially involves the tendon Fig. 1.

In a study done on 586 patients with a history of arthroscopic tear repair the reported mean-age of patients with supraspinatus tear is 59 years (Gumina and Carbone, 2017). Patients older than 60 were twice as likely to develop tear compared with younger age-group (Gumina and Carbone, 2017). Also, cadaveric studies showed increased incidence of rotator cuff tears with advancing age (Gumina and Carbone, 2017; Cotton and Rideout, 1964). Both genders have otherwise been quoted as being equally predisposed to the development of rotator cuff tears (Moosmayer *et al*., 2009; Lehman *et al*., 1995), however, one study on premenopausal and postmenopausal women revealed significantly higher prevalence of asymptomatic full-thickness tears in the postmenopausal period (Abate *et al*., 2014). Gururaj *et al*. has reported that rotator cuff tear was more common in males than females with a ratio of 1.5:1 (Sharma *et al*., 2017). In the current analysis no significant gender or age difference has been revealed.

The acromioclavicular joint is a diarthrodial joint with a fibro-cartilaginous disc that has been shown to involute with age by the age of 40 years (Sharma *et al*., 2017; Williams *et al*., 1989). In the presence of a rotator cuff tear, fluid can escape from the glenohumeral joint into a subacromial-subdeltoid bursa and into acromioclavicular joint. Presence of fluid in the subcoracoid bursa should alert physicians to carefully check the rotator cuff tendons for tear formation (Sharma *et al*., 2017).

Presence of glenohumeral joint effusion has been significantly correlated with supraspinatus tear accounting for 77.5%. Joint effusion has been classified into four degrees from which mild degree shows the maximum association of 49.6% which is consistent with the internationally published data (Sharma *et al*., 2017).

There is strong association between degenerative changes of the acromioclavicular joint and supraspinatus tears (Sharma *et al*., 2017). The frequency of acromioclavicular joint degenerative changes is significantly higher (89.9%) in our study compared to the reported frequency (40-65%) in the literature (Teunis *et al*., 2014;Cotton and Rideout, 1964; Kim *et al*., 2009).

Previous studies found that anatomical variation in the acromion shape (hooked shape) are associated with increased incidence of supraspinatus tear (Freygant *et al*., 2014) which is disconcordant with our study finding which revealed that the non-traumatic supraspinatus tears are more likely to occur in curved acromion shape Fig. 2 and are more likely to be complete tear which could be explained by lack of control group.

Moreover previous studies also described that rotator cuff injuries occur more frequently with acromioclavicular osteoarthritis with osteophyte formation and chronic subacromial bursitis (Milgrom *et al*., 1995; Abate *et al*, 2014; McCauley *et al*., 2000), a that is concordant with our study in which we found that patients with non-traumatic supraspinatus tears are more likely to have subacromial-subdeltoid bursitis 53.5% compared to those without bursal involvement 46.5%. Non-traumatic supraspinatus tear has also higher percentage of subacromial-subdeltoid bursitis (Fig. 3) compared to other types of rotator cuff tear (Sharma *et al*., 2017).

In our study, there was no significant association between non-traumatic supraspinatus tears and the presence of os acromiale as well as calcific tendinitis

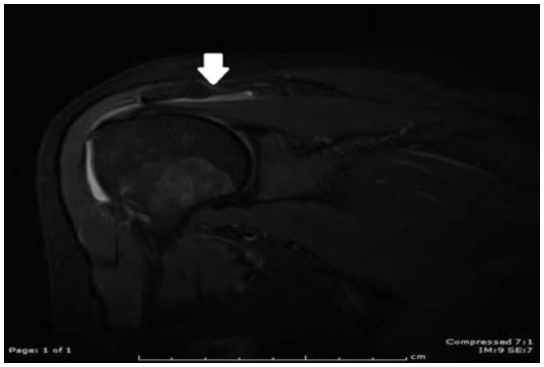

Fig. 3: Coronal STIR MRI scan of the right shoulder shows subacromial-subdeltoid bursitis manifested by abnormal collection of fluid deep to the acromion and deltoid muscle (white arrow)

which might be the result of small sample size. Previous studies found that os acromiale and calcific tendinitis are co-conditions in patients with supraspinatus tears. The prevalence in the current study of both conditions in patients with supraspinatus tears is similar to that in a standard population with unknown integrity status of supraspinatus muscle. Thus, it could be debatable whether osacromiale and calcific tendinitis are pathological conditions associated with supraspinatus tears (Boehm *et al*., 2005).

The infraspinatus tendon is the most frequently associated tendon among other muscles surrounding the shoulder joint encompasses 17.2% which highlights the important relationship of both muscle actions (Milgrom *et al*., 1995).

Bone marrow edematous changes at the greater tubercle are known to be associated with traumatic supraspinatus tear (McCauley *et al*., 2000), though in non-traumatic tear presented in 46.5% of our sample which could represent a concomitant findings as part of the degenerative changes that is seen, for example, in association with the cartilaginous loss and the prediction of its development (Boehm *et al*., 2005; Tuite, 2012).

Clinical relevance: Non-traumatic supraspinatus tear is a commonly encountered finding on shoulder MRI scan. Non-traumatic supraspinatus tear is associated with several structural injuries affecting muscle, bones and joints. Awareness of the these associated structural injuries is crucial for radiologists in order to assess shoulder MRI scans

CONCLUSION

The current study has studied many factors associated with non-traumatic supraspinatus tear these factors include muscles, bones and joints that reflects the functional integrity of the shoulder joint. Besides studying several factors associated with supraspinatus tear, the current analysis is the first, national study in this regard that could reflect demographic changes in our population and its similarities in the world.

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