“DIAGNOSTIC ACCURACY OF HISTORY AND CLINICAL TESTS FOR DETECTING SUPRASPINATUS TENDON TEARS IN PEOPLE WITH SHOULDER PAIN”

Thesis Submitted to

KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH, BELAGAVI
(Formerly known as KLE University)

(Deemed-to-be University established u/s 3 of the UGC Act, 1956)
Accredited ‘A’ Grade by NAAC (2nd Cycle)
Placed in Category ‘A’ by MHRD (GoI)

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For the award of the degree of
Doctor of Philosophy in the Faculty of Medicine

By

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(Registration No: KLEU/Ph.D./2014-15/DO1214004)

Under the Guidance of

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ACKNOWLEDGMENT

***L**ife offers only few chances to concede the cordial gratitude and appreciation to all those persons without whom we could not imagine to complete our task in an organized manner. I do not want to slack the opportunity, which give me immense pleasure to acknowledge the help, support, encouragement, and guidance that I received in the course of completion of this thesis. First and foremost, I thank my Dad and Mom for all their sacrifice for me throughout my educational life.*

*At the outset, I owe a deep sense of gratitude and profound indebtedness to my present research guide **Dr. Kiran Patil,** Professor, Department of Orthopaedics, KAHER, JN Medical College, Belagavi, for the valuable guidance; continued support and encouragement throughout the study. He showed me ways of approaching to any research problem and further the way of achieving it in different manner. He not only facilitated my research and encouraged my entire endeavor, but also provided me constant moral support.*

*I also express my sincere thanks to my previous guides, **Dr. B B Putti** and **Dr.R B Uppin,** Professor, Department of Orthopaedics, KAHER, JN Medical College, Belagavi, whose guidance and useful advice helped me at different stages of this research work.*

Humble Pranams to our Honorable former Vice Chancellor, Prof. (Dr.) Chandrakant K. Kokate Sir, respected Vice Chancellor Prof. (Dr.) Vivek A. Saoji and respected Ph.D. expert committee, Dr. P.A. Patil, Dr. B.S. Kodkany, Dr. Alka Kale, Dr Sunil Jalalpure and Dr. Subarna Roy for their constructive criticism which helped for the successful completion of my research.

*I would extend my acknowledgement to the Former Registrar **Dr. V.D. Patil** and present Registrar **Dr. V.A. Kothiwale**, KAHER, our beloved Principal JNMC **Dr. N S Mahantshetti**, for their support during my course of Ph.D.*

I appreciate the generous support from the KLE Academy of Higher Education and Research, Belagavi and my deep sense of gratitude to entire staffs at J N Medical College , Belagavi and KLE Dr. Prabhakar Kore Hospital & MRC, Belagavi for providing all necessary support required during the course of study.

I am obliged to ***Dr. Daksha Dixit****, former Director of Academic Affair, KAHER and* ***Dr. Roopa Bellad,*** *present Director of Academic Affair, KAHER, for providing all the necessary resources in completion of this thesis. I thank* ***Dr. S V Udapudi, Dr Ravi Jatti, and Dr Dinesh Kale*** *of Department of Orthopaedics for all the help and support during this course.*

I am very much thankful to my wife ***Dr.Farhana Tahseen Taj,*** *and my kids* ***Ayaan*** *and* ***Sofia*** *for supporting and giving positive energy throughout the project.*

I would like to acknowledge the assistance received from **Mr., Librarian**, *I am very much thankful to* ***Mr. Ravi Hullur,*** *in charge, Digital Computer laboratory, KLE University, Belagavi.*

I cannot afford to forget the immense support, encouragement and the vital discussion made by my friend to nourish the study. I feel loss of words to express my thanks to my friends; Mr. Arun C, Dr. Sudheergouda Patil, and Dr Satveer.

Eventually, the study was made possible due to the cooperation of those patients who provided information on various aspects of their complaints. I thank all those patients and their relatives for their participation and cooperation in this study.

Date: ***Dr. Sameer Haveri***

Place:

LIST OF ABBREVIATIONS

AHD	=	Acromio-Humeral Distance
AIC	=	Akaike Information Criterion
ADL	=	Activities of Daily Living
BP	=	Blood Pressure
BMI	=	Body Mass Index
CNS	=	Central Nervous System
CVS	=	Cardio Vascular System
CT Scan	=	Computer Tomography Scan
Ext.rot.lag/Ext.rot.zeroT	=	External Rotation Lag Test at Zero degrees Test
H/O	=	History of
Inf.strengthT	=	Infraspinatus Strength Test
IPD	=	In Patient Department
k	=	Kappa
+ LR	=	Positive Likelihood Ratio
- LR	=	Negative Likelihood Ratio
MRA	=	Magnetic Resonance Arthrogram
MRI	=	Magnetic Resonance Imaging
n	=	Number
NPV	=	Negative Predictive Value
OPD	=	Out Patient Department
p-value	=	Probability
PA	=	Per Abdomen examination
PAT	=	Painful Arc Test
PPV	=	Positive Predictive Value

PR	=	Pulse Rate
RS	=	Respiratory System examination
SD	=	Standard Deviation
Sup.strengthT	=	Supraspinatus Strength Test
USG/US	=	Ultrasonography
VAS	=	Visual Analogue Scale

ABSTRACT

Background and Aim: Shoulder pain and dysfunction are often caused by rotator cuff disease. Knowing the warning signs for progression of a supraspinatus tendon tear is critical for identifying the patients in the higher-risk group. The purpose of the study was to assess the diagnostic accuracy of history, patient characters and clinical tests in detecting supraspinatus tendon tear. Also to develop a prediction model for the same.

Methods: A total of 100 patients with symptomatic rotator cuf tear, aged>18 years, of either gender, presenting to the outpatient department were included in this cross-sectional study. Magnetic resonance imaging was done and based on its results; patients were identifed for the type of tear. Demographic, clinical, and biochemical factors afecting the tears were assessed using logistic regression analysis.

Results: Factors such as age, gender, pain radiation, night pain, and analgesic intake had signifcant association with supraspinatus tendon tears. Best individual and combination clinical tests were identified based on various statistical methods. 3 Prediction models were developed based on logistic regression.

Conclusion: “Pain radiation” and “Analgesic intake” were two new parameters found associated with the supraspinatus tendon tears. New parameters that have been assessed as risk factors will help in better understanding of supraspinatus tendon tears. The full can test was the single most effective clinical test for any type of tendon tear, including partial tears. The palpation test had the highest diagnostic precision for full-thickness/complete tears. Combining clinical tests did not increase diagnostic accuracy over individual tests. Prediction models combine patient characteristics, history, and clinical testing to help in diagnosis.

Keywords: Magnetic resonance imaging; Shoulder pain; Rotator cuff; Analgesics; Partial tear; Diagnosis.

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1. INTRODUCTION

1.1 BACKGROUND

Shoulder pain and dysfunction are often caused by Rotator cuff tears. Rotator cuff tears are prevalent in the old people, affecting 5-39 percent of the population. Munro was the first to characterize Rotator cuff disease in the literature in 1788. Codman's article on Rotator cuff and Supraspinatus tendon tears was published in 1934. Despite its years of experience and the fact that it is a standard clinical disorder, the etiology, and finest strategies for diagnosing this condition are still ongoing. (1)

Research question: Do history and clinical tests accurately diagnose supraspinatus tendon tears?

1.2 LITERATURE REVIEW

Anatomy (2)

“The Supraspinatus, Infraspinatus, Teres Minor, and Subscapularis tendons and muscles, as well as the capsular covering between the supraspinatus and subscapularis known as the rotator interval, make up the **Rotator cuff complex**. The supraspinatus is superior, the infraspinatus is posterosuperior, and the teres minor is posteroinferior when it comes to musculotendinous positioning in relation to the humeral head. The glenohumeral joint's dynamic stabilizers are the rotator cuff muscles. In the mid- and end-ranges of motion, they offer anterior support to the glenohumeral joint. During extension, the supraspinatus and subscapularis muscles stabilize; during flexion, the infraspinatus, subscapularis, and latissimus dorsi muscles stabilize; and during external rotation, the subscapularis muscle stabilizes.

The **Supraspinatus** is made up of two muscle bellies and three longitudinal tendon bands. The anterior section of the muscle is a bigger, more fusiform muscle that originates from the supraspinatus fossa and attaches to the superior facet of the greater tuberosity just behind the biceps groove as a thick tendon. The anterior segment of the tendon is stronger than the posterior half and is the principal functional component of the tendon. The anterior supraspinatus muscle produces higher stress on the anterior tendon than the middle and posterior supraspinatus muscles. The posterior tendon extends as a flat, thin tendon from the scapular spine and glenoid neck, making up the posterior 60% of the tendon. In comparison to the anterior and middle thirds, it is smaller, unipennate and thinner in cross-section. The **"footprint"** refers to the extensive attachment of the entire supraspinatus tendon complex to the greater tuberosity. The lesser tuberosity is attached to another anterior and minor section of the supraspinatus tendon. Internal rotation of shoulder is possible with this attachment. The alignment of both supraspinatus tendons to the coronal plane of the shoulder is roughly 50 degrees. The coraco-humeral ligament joins with the anterior section of the supraspinatus tendon. The infraspinatus tendon joins the posterior part. The **"Posterior rotator interval"** is the area just medial to the convergence of the posterior fibers of the supraspinatus and anterior fibers of the infraspinatus tendons. The supraspinatus tendon and muscle rotate and abduct the humerus. The suprascapular nerve provides innervation to this muscle.

The **Subacromial–subdeltoid (SA-SD) bursa** covers the superior and front surfaces of the Rotator cuff muscles and is located above the supraspinatus muscle and tendon. In some asymptomatic shoulders, it can contain a few milliliters of fluid, but it is rarely visible. A rim of fat can be detected around the inferior aspect of the bursa in both symptomatic and unaffected shoulders. It serves as a buffer between the rotator cuff and coracoacromial arch.

The **Infraspinatus muscle** originates from the scapula's infraspinatus fossa, and the bipennate tendon attaches to the middle facet of the larger tuberosity, just behind the supraspinatus tendon. It rotates and centers the humerus externally. It also depresses the humeral head. It prevents the humeral head from sub-luxating posteriorly during internal rotation. The distal suprascapular (subscapular) nerve innervates the infraspinatus muscle.

Local anatomic characteristics influence the likelihood and severity of tendon retraction. In the region of the critical zone, roughly 1 to 2 cm of the footprint, both the supra- and infraspinatus tendons may have a distinct ligament running along the articular surface anteroposterior to the main course of the tendon in a perpendicular fashion. This structure is a ligament known as the "ligamentum semicirculare humeri," however it is also known as the **Rotator cable**. Along with the biceps pulley, it is thought to play a role in anchoring the biceps at the rotator interval. Some people have larger cables than others, and these are known as "Cable dominant" tendons.

The **Rotator crescent** is the narrower portion of the tendon that runs from the cable to the footprint. Ultrasound can also reveal the cable. The cable and crescent are considered to serve as a suspension bridge. In cable-dominant tendons, most rotator cuff failure occurs in the crescent, with minor tearing and retraction beyond the cable. Because they have less retraction, the cable-dominant tendons are easier to heal. The cable will appear on MRI as a typical, minor thickening of the tendon's articular surface in the crucial zone, around 1.5 cm medial to the greater tuberosity.

The **Teres minor muscle** originates from the upper two-thirds of the scapula's lateral border, and its tendon attaches onto the greater tuberosity's inferior (vertical) facet. The posterior glenohumeral capsule adheres to the muscle. This muscle externally rotates the humerus. The axillary nerve provides innervation to the teres minor muscle.

The **Subscapularis muscle** has nine muscular bellies and several tendon slips that attach to the superior aspect of the lesser tuberosity, with 40% of the attachment on the humeral neck below the lesser tuberosity. It originates from the subscapular fossa on the anterior part of the scapula. The tendons of the subscapularis adhere to the anterior glenohumeral capsule. The humeral head is internally rotated by the subscapularis muscle. The glenohumeral joint is also flexed, extended, depressed, and adducted. The upper and lower subscapular nerves innervate the subscapularis muscle.

The **Rotator interval** is the space that exists between the supraspinatus and subscapularis tendons. In the rotator interval, the biceps tendon is found anterior and superior. The superior glenohumeral ligament and the coracohumeral ligament, which create a sling around the Biceps before it dips into the intertubercular groove laterally in the rotator interval, are also found in the rotator interval, in addition to the intra-articular section of the biceps tendon.

There are multiple layers to this capsular area. Fibro-fatty tissue makes up the most superficial layer. The Coraco-humeral ligament makes up the following layer. The Coracohumeral ligament is a triangular structure with two fascicles that arise from the coracoid's lateral face and attach to the humerus' lesser tuberosity. The coracohumeral ligament prevents the humeral head and accompanying bones from moving anteriorly or superiorly. The superior glenohumeral ligament originates from the supraglenoid tubercle and joins the coracohumeral ligament to attach to the lesser tuberosity.

Within the **Coracoacromial outlet** are the supraspinatus tendon, subacromial bursa, and long head of the biceps tendon. The acromion, an anterolateral extension of the scapular spine, the anterior third of the coracoid, and the coracoacromial ligament make up the superior portion of this outlet, the coracoacromial arch. During abduction, this ligament prevents the humeral head from moving anteriorly and superiorly. Some experts suggest that impingement syndrome is caused by coracoacromial ligament thickening." (Figure 1A, 1B, 1C)

Figure 1 A: Anatomy of rotator cuff – Axial view (2)

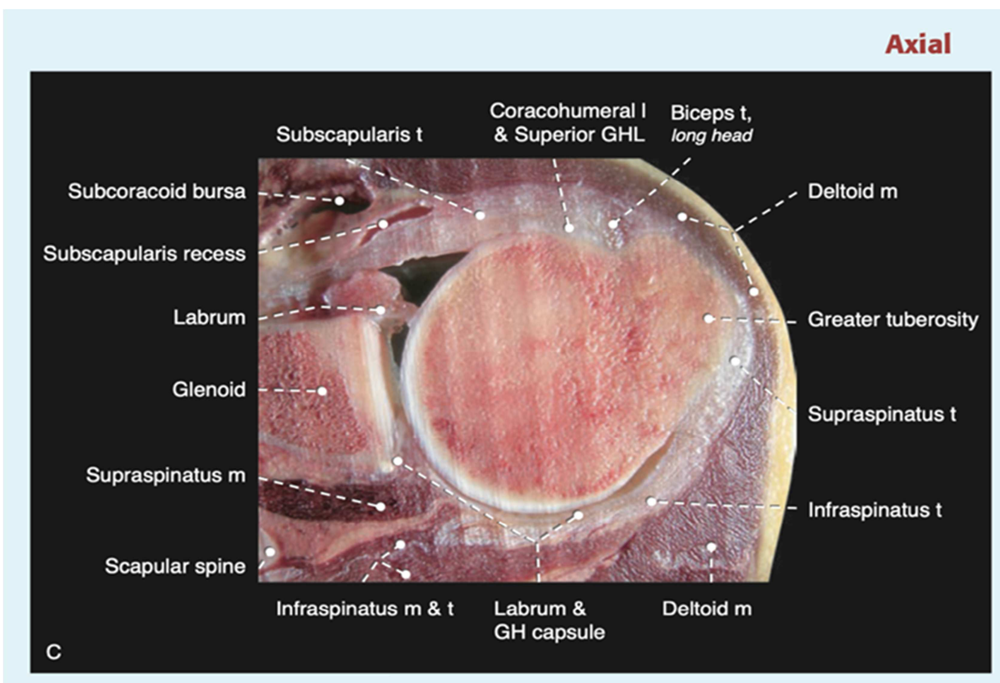


Figure 1 B: Anatomy of rotator cuff – Coronal view (2)

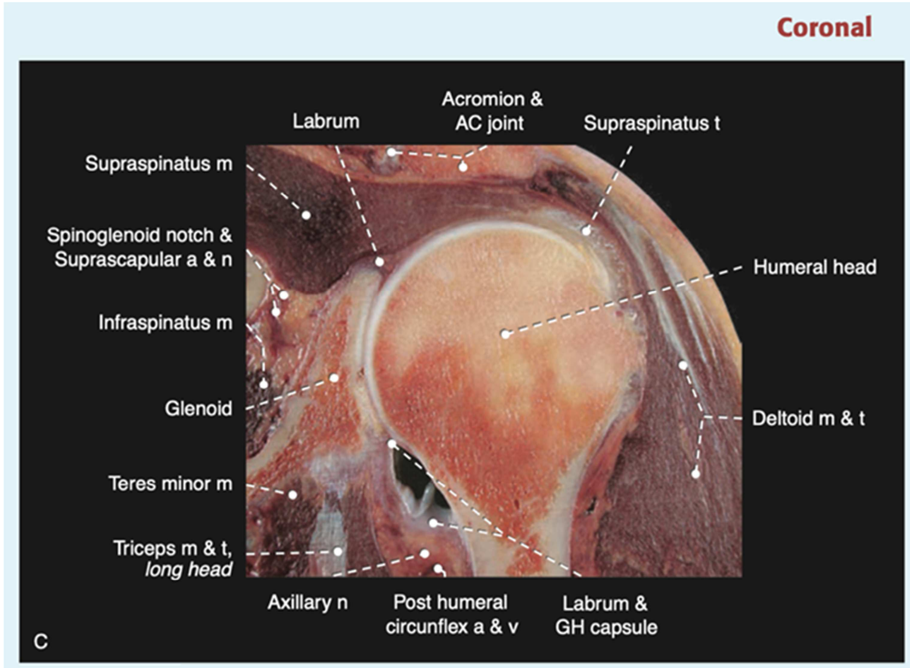
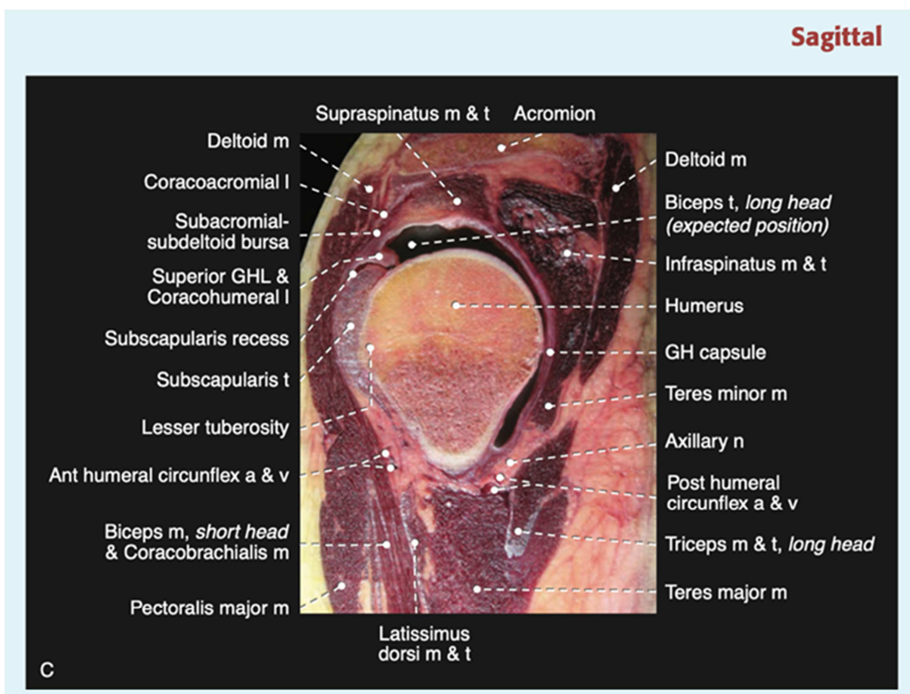


Figure 1 C: Anatomy of rotator cuff – Sagittal view (2)



Biomechanics

The rotator cuff muscles help keep the glenohumeral joint (shoulder joint) stable and allow for shoulder movements.

1. **Rotator Function:** (1,3) The subscapularis is an internal rotator muscle. The humerus is rotated externally by all rotator cuff muscles except subscapularis. Initial 30 degrees of shoulder abduction is contributed by supraspinatus.
2. **Maintaining glenohumeral joint stability**: (1,3) The Rotator cuff is responsible for maintaining dynamic shoulder stability while allowing a wide movement. The deltoid pulls the humerus upward during arm abduction, but the rotator cuff opposes this action by depressing the head of humerus and keeping it in the true location relative to the glenoid. Rotator cuff muscles are weak adductors of the shoulder joint, strong adductor being latissimus dorsi muscle.
3. **Force couples**: (4,5) "Another keyway through which the rotator cuff muscles stabilize the glenohumeral joint is through force coupling. When two opposing muscles create a moment of force around a stable fulcrum or axis of rotation, this is known as a force couple. In both the transverse and frontal planes, the rotator cuff muscles form a force couple around the glenohumeral joint. By resisting the forces caused by the surrounding muscles, this stabilizes the humeral head within the glenoid fossa through a variety of shoulder motions. The anterior subscapularis and the posterior infraspinatus/teres minor form the transverse plane force couple. The inferior rotator cuff muscles form the force couple in the frontal plane, counteracting the superiorly acting deltoid. For glenohumeral stability,

balanced force couples are required, which necessitate coordinated activation of agonist and antagonist muscles.” (Figure 2, Figure 3A & Figure 3B)

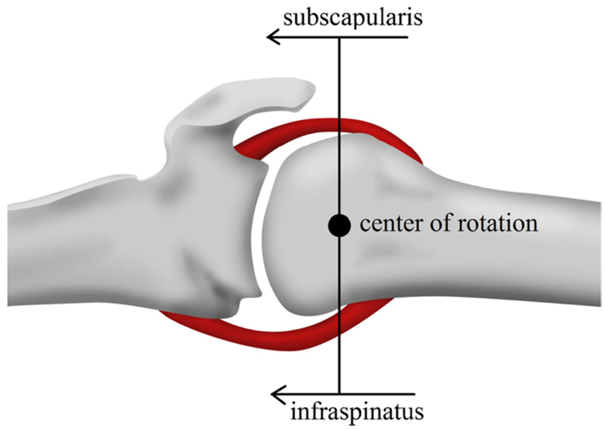


Figure 2: Transverse plane force couple. The infraspinatus tendon posteriorly balances against the supraspinatus tendon anteriorly (4)

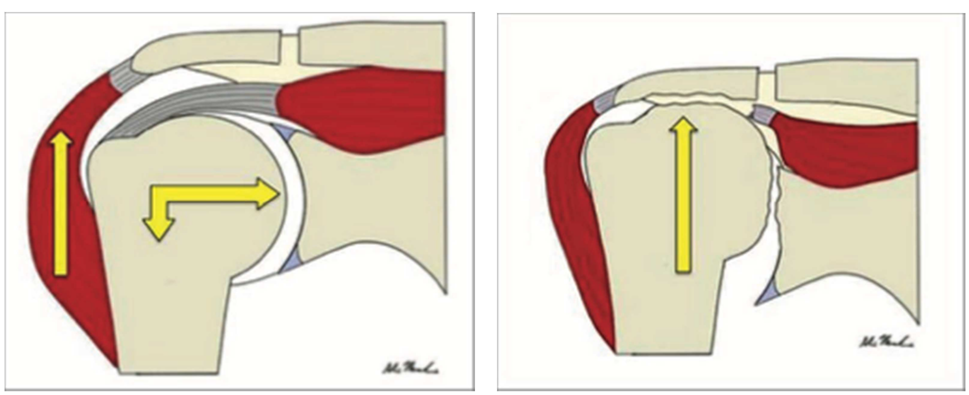


Figure 3A: Rotator cuff biomechanics. Drawing shows that net inferior and compressive force vector (*double-headed arrow*) of rotator cuff is balanced by net superiorly directed force vector of deltoid muscle (*single-headed arrow*).

Figure 3B: Rotator cuff insufficiency. Drawing shows superior migration of humeral head and degenerative changes of glenohumeral joint (*arrow*) that are suggestive of rotator cuff insufficiency. (5)

Pathophysiology

Rotator cuff tears has many causes, partly because it involves a wide variety of pathology, from early tendinitis to complete cuff tears.

1. Patients in their 20s - 30s that participate in a variety of physical exertion, like athletes or divers, are more likely to develop impingement. (1,6)
2. Rotator cuff injuries occurs more often as people get older. Before the age of 40, it is relatively rare, but after that, the incidence rises with each decade. The actual incidence of rotator cuff tears is unknown because the condition is asymptomatic. In a study of asymptomatic participants with rotator cuff tears, MRI revealed partial thickness tears in 20% of all participants, and 26% of those over 60 years old. Full thickness tears of the tendons were seen in fourteen percent of all participants and twenty-eight percent of those over the age of sixty. One of the predictors of rotator cuff tear was being age more than 60 years. (7)
3. Tendon avascularity: This is a disputable hypothesis. With detailed histologic studies of the tendon, they find no avascular zones, and doppler studies concerning rotator cuff have failed to discover an avascular region. (1,6)
4. Trauma: Tear of Rotator cuff muscle occurs in 14% to 63% of subjects following a fall, according to various reports. On the other hand, many individuals with a torn rotator cuff have no memory of ever suffering a shoulder injury. Elderly people frequently experience tendon tears following trauma, suggesting that tendons in advanced age are fragile and easily ruptured. (1,6)
5. Os acromiole may result in cuff tears. (1,6)
6. Sub-acromial spurs/acromial hooks: Their cause-and-effect relationship is yet to be established.(1,6)

7. Risk factors include thyroid disease, diabetes mellitus, hypertension, high cholesterol, and genetic rotator cuff tears (7), repetitive overhead work (7), handheld vibration work (7), and smoking. (8)

Natural History of Degenerative Rotator Cuff Tears (9)

"These researches, which frequently rely on problems in the asymptomatic shoulder, imply that atraumatic rotator cuff tears are a natural component of ageing for many people. Degenerative cuff tears can start anywhere between 13 and 17 mm behind the biceps tendon. Tears spread from this point as the disease advances.

Asymptomatic full-thickness rotator cuff injuries become more common as individuals get older. These tears start at the rotator crescent's junction of the posterior supraspinatus and anterior infraspinatus and spread from there. The amount of fatty degenerative changes increases as the tear size grows, as does the number of muscles affected.

Proximal humeral migration is observed after the tear size reaches a critical tear threshold. Recent research has focused on continuing to define and understand the natural history of atraumatic rotator cuff disease, including symptom progression, tear growth, and the development of arthritis, over the last 3–5 years.

Progression of Tears and Pain: The risk of tear growth in shoulders with degenerative rotator cuff tears has long been known to be time-dependent. At a median age of 2.8 years, tear enlargement was noted in 49% of shoulders. Full-thickness tears grew in size, became symptomatic, and showed more muscle degeneration than partial-thickness tears and normal controls. Tear enlargement was similarly linked to hand dominance, implying that activity levels may influence tear advancement. In all tear types, the presence of tear elongation was linked to new pain. Although tear elongation and pain were more common in the dominant shoulder, shoulder activity level and occupational demand were not linked to the likelihood of tear progression.

According to Dr Marcus Chia (10)- At two years, the possibility of tear enlargement is about 20%, and at five years, it's about 50%. The mechanisms that influence the development of pain in asymptomatic tears are less well known, yet around 50% of persons experience pain within 5 years. It's also worth noting that disease severity does not always correlate with pain levels, implying that variables other than tear enlargement are at play.

Fatty Muscle Degeneration: Full-thickness tears are almost often associated with fatty muscle degeneration. When muscle degeneration was observed, it progressed faster in bigger tears than in stable tears. The supraspinatus took 1.0 year and the infraspinatus took 1.1 year to progress muscle changes in proportion to tear size.

Arthritis Progression: Chalmers et al. found that glenohumeral arthritic changes in shoulders with a wide range of cuff tear severity progressed significantly over an average 8-year period, while these changes remained minor. Following a supraspinatus full thickness tear, the tear progresses to the infraspinatus, then biceps tendon ruptures. Rotator tendons are unable to maintain normal joint biomechanics, resulting in more abrasions, cartilage wear and joint arthritis. (1,6)

Non-operative Management: In partial thickness tears and patients over the age of 70 with chronic and retracted full-thickness tears with muscle degeneration, as well as tears with fixed proximal humeral migration, nonoperative treatment should be followed. The surgical benefit was clinically insignificant.

Healing Data: The age of the patient, the magnitude of the rupture, and the severity of fatty muscle degeneration/infiltration are the most crucial variables impacting the rate of tendon recovery. People over 65, tears larger than 2 cm, tendon retraction to the glenoid, and infraspinatus fatty muscle atrophy had decreased healing rates. (10)

Limited rotator cuff tears, particularly in the aged, have a minimal ability to heal due to a variety of factors. Torn tendon fibers resorb, and healing does not occur without closure of the defect. Another explanation is that the fibrin clot containing healing factors is washed away by synovial fluid. Finally, they have tendons that have degenerated." (1,6)

Natural history of Acute traumatic rotator cuff tears (11)

"Traumatic rotator cuff tears are less common than degenerative rotator cuff tears, although they do happen. Traumatic rotator cuff injuries affect patients who are **younger**. **Male sex** is the only other demographic risk factor for catastrophic rotator cuff injury, other from age. It's unclear if this is due to higher-risk behaviors or differences in seeking care. Srensen et al. observed that five patients (10%) had a full-thickness tear of several tendons, 28 (60%) had a full-thickness tear of a single tendon, and 14 (30%) had a partial-thickness tear among 47 patients with traumatic rotator cuff tears. Robinson et al. reported that 14.2 percent of patients with a rotator cuff tear secondary to a glenohumeral dislocation (about 10% of dislocations) had a tear less than 1 cm. Meanwhile, 48.2 percent of patients had a tear of 1 to 3 cm, 25% had a tear of 3 to 5 cm, and 12.3 percent had a rotator cuff avulsion. The supraspinatus was involved in all the tears, more than half involved the infraspinatus, and 15.3 percent were acute-on-chronic injuries with fatty infiltration.

Rotator cuff tears caused by acute injuries are expected to **heal faster** than degenerative rotator cuff tears after surgical treatment. Those who had surgery within four months of their injuries appear to have better outcomes.” (10)

Classification of rotator cuff tears (12)

- Based on duration- Acute, Chronic
- Based on etiology- Traumatic, Degenerative
- Based on size of tear- Partial-thickness, Full-Thickness
- Based on shape- Crescent shape, L-shape/reverse L-shape, Massive retracted
- Partial-thickness tears are sub-divided as (13)
    - Articular surface partial,
    - Bursal surface partial and
    - Intra-substance partial.

The size of the tear is described by radiologists in metric units. Treatment decisions are influenced by every single variable (time duration, etiology, and size).

Prevalence of acute complete Rotator cuff tears is less than ten percent. Subjects with short-term full-thickness cuff injuries frequently have a history of falls or Accidents, as well as abrupt pain and weakness. The best course of action is to have surgery as soon as possible, preferably within six weeks.

Clinical symptoms (1,12)

1. Many tears of the rotator cuff are asymptomatic (even full thickness tears).
2. There is pain, stiffness, and weakness in the shoulder area.

   The pain can radiate from the shoulder to the elbow joint. Overhead work and lying on the affected shoulder aggravate the pain. Acute, traumatic full thickness cuff tear patients are unable to actively abduct the shoulder. Chronic degenerative cuff defects can cause pain and weakness over time, as well as an absence of functional movements.

Night pain (14)

"Only 11% of people with symptomatic rotator cuff tear claim to have a normal sleep. Shoulder pain typically gets worse at night. These patients' sleep is of low quality. An increase in the production of inflammatory cytokines has been identified as a possible reason.

Patients may experience sleep disturbances even though rotator cuff repair improves psychological status, physical function, and overall health. Functional impairments, maintaining a forced position, and shoulder stiffness are some of the factors that can contribute to poor sleep quality. Conservative treatment, such as physiotherapy or medication, may be beneficial.

Lower back pain, diabetes mellitus, sling use, shoulder stiffness, an obligatory posture throughout the night and preoperative and prolonged postoperative narcotic use are all factors that can affect sleep quality in patients with RC tears. Sleep disturbance was not related to the size of the lesion."

Pseudoparalysis (15)

"Peudoparalysis was defined as - shoulder elevation limited to 45 degrees, the rotator cuff tear is massive (>5cm full thickness) and with at least grade II to III fatty infiltration. Otherwise, the situation is merely a massive, repairable cuff tear, as demonstrated by Burkhart et al. If the pseudoparalysis is caused by arthritic conditions, arthroplasty is required, and this is a more specialised category. Patients with acute pseudoparalysis are treated with rotator cuff repair, whereas those with chronic pseudoparalysis require reverse shoulder arthroplasty."

Physical examination (1,16)

Inspection:

- In chronic cases, the Supraspinatus and Infraspinatus muscles are wasted.
- Asymmetry of Biceps muscle suggests tear of the biceps tendon.
- Examine the position of Scapula on the thorax. Downward rotation, depression, adduction, and abduction are the most common Scapula alignment abnormalities. Muscle dysfunction is the cause of this.

Palpation:

- Tenderness is located at the Greater tuberosity. With the arm extended, palpation is easy.
- A full thickness tendon tear can be identified by a Palpable rent in the tendon.

Movement:

- Test active movements first. Full-thickness tears are known to reduce active abduction while maintaining regular passive abduction.
- The Apley scratch test can be used to assess functional range of motion.
- Rotation is accurately measured in a supine position with 90-degree shoulder abduction, because the scapula is stabilized in this position,
- Abduction and flexion are to be measured in standing posture.

Strength testing:

- Supraspinatus muscle strength is measured at 90 degrees abduction in scapular axis & internal rotation.
- Resisted external shoulder rotation is used to measure Infraspinatus and Teres minor muscle strengths.
- The strength of the Subscapularis muscle is measured by Belly press test.
- Examine Trapezius, Rhomboids & Serratus anterior muscles
- Muscle examination of the Pectoralis major and minor
- In the background, the patient could have
  1. Tendinosis - pain without weakness
  2. Partial thickness tear - pain and mild weakness
  3. Full thickness tear – weakness without pain

Special tests: (17)

<u>Advantages:</u>

- Clinical testing is non-invasive, simple, and quick, and the findings are available right away.
- Because they are designed to replicate pain or functional limitations, they have a unique relevance to patients' complaints, whereas tears discovered through imaging or open surgery may be asymptomatic.
- Furthermore, they are free of charge in addition to a specialist consultation.

<u>Disadvantages:</u>

- Physical examinations necessitate clinical and analytic abilities, and outcomes have been shown to vary depending on the examiners level of expertise.

A) Tests for Impingement (Table 1)

1. Neers' test
2. Hawkins' Kennedy Test

Table 1: Diagnostic accuracy of clinical tests in other studies (18–21)

Test	Study	Reference standard	Age in yrs.	n (Shoulders)	Benchmark	Stage of tear	Sensitivity (%)	Specificity (%)	+ LR	-LR
Neer's Test	Calis et al 2000	MRI	51.6	87	Pain	Stage 1	71.4	30.7	1.03	0.93
				87	Pain	Stage 2	91.6	26.9	1.25	0.31
				87	Pain	Stage 3	90.0	28.5	1.26	0.35
	Park et al 2005 (20)	Arthroscopy	Not reported	552	Pain	Any severity	68	68.7	2.19	0.47
				552	Pain	Partial thickness tear	75.4	47.5	1.44	0.52
				552	Pain	Full Tear	59.3	47.2	1.12	0.86
Hawkins Kennedy test	Calis et al 2000	MRI	51.6	87	Pain	Stage 1	95.2	30.7	1.37	0.16
				87	Pain	Stage 2	87.5	23.0	1.14	0.54
				87	Pain	Stage 3	100	35.7	1.56	0.00
	Park et al 2005 (20)	Arthroscopy	Not reported	552	Pain	Any severity	71.5	66.3	2.12	0.43
				552	Pain	Partial thickness tear	75.4	44.4	1.36	0.55
				552	Pain	Full Tear	68.7	48.3	1.33	0.65

+LR = positive likelihood ratio, –LR = negative likelihood ratio; Stage 1 = high signal amplitude with no shrinkage or unevenness in the tendon, Stage 2 = MRI signal amplitude in the tendon with shrinkage or unevenness is raised., Stage 3 = full tear of tendon; PARTIAL THICKNESS TEAR = partial thickness tear; FULL TEAR = full thickness tear

B) Tests for Supraspinatus (Table 2)

Table 2: Diagnostic accuracy of individual clinical tests in other studies (18–21)

Test	Study	Reference standard	Age in years	n (Shoulders)	Benchmark	Stage of tear	Sensitivity (%)	Specificity (%)	+ LR	-LR
Drop arm test	Calis et al 2000	MRI	51.6	87	Pain & Weakness	Phase 1	4.4	100	infinity	0.96
					Pain & Weakness	Phase 2	6.2	96.1	1.59	0.98
					Pain & Weakness	Phase 3	15.0	100	infinity	0.85
	Murrel &Walton 2001 [19]	Operation	Not reported	400	Not specified	Any severity	26.9	88.4	2.32	0.83
	Park et al 2005 [20]	Arthroscopy	Not reported	552	Instant fall of arm or intense pain	Any severity	26.9	88.4	2.32	0.83
					Instant fall of arm or intense pain	Partial thickness tear	14.3	77.5	0.64	1.11
					Instant fall of arm or intense pain	Full Tear	34.9	87.5	2.79	0.74

Full can test	Itio et al 1999	MRI	43	136 (143 Shoulders)	Pain	Full Tear	66	64	1.82	0.54
					Weakness (grade <5)	Full Tear	77	74	2.98	0.31
					Pain/weakness/ both	Full Tear	86	57	2.01	0.25
	Itio et al 2006	Arthroscopy	53	149 (160 Shoulders)	Pain	Not stated	80	50	1.60	0.40
					Weakness (grade <5)	Not stated	83	53	1.78	0.32
	Kim et al 2006	MRI	59.5	200	Pain	Full Tear	55.5	77.8	2.50	0.57
					Pain	Partial thickness tear/Full Tear	71.2	67.9	2.22	0.42
					Weakness	Full Tear	59.9	81	3.15	0.50
					Weakness	Partial thickness tear/Full Tear	77.3	67.9	2.41	0.33
					Pain & Weakness	Full Tear	41.6	90.5	4.38	0.65
					Pain & Weakness	Partial thickness tear/Full Tear	59.1	82.1	3.30	0.50
					Pain / Weakness	Full Tear	73.7	68.3	2.32	0.39
					Pain / Weakness	Partial thickness tear/Full Tear	89.4	53.7	1.93	0.20
Painful arc test	Calis et al 2000	MRI	51.6	87	Pain	Phase 1	9.5	88.4	0.82	1.02
					Pain	Phase 2	37.5	73.0	1.39	0.86
					Pain	Phase 3	45	78.5	2.09	0.70

	Park et al 2005 [20]	Arthroscopy	Not reported	552	Pain	Any severity	73.5	81.1	3.89	0.33
					Pain	Partial thickness tear	67.4	47.0	1.27	0.69
					Pain	Full Tear	75.8	61.8	1.98	0.39
Empty can test	Kim et al 2006	MRI	59.5	200	Pain	Full Tear	79.6	60.3	2.01	0.34
					Pain	Partial thickness tear/Full Tear	93.9	46.3	1.75	0.13
					Weakness	Full Tear	59.9	88.9	5.40	0.45
					Weakness	Partial thickness tear/full tear	75.8	70.9	2.60	0.34
					Pain & Weakness	Full Tear	83.9	58.7	2.03	0.27
					Pain & Weakness	Partial thickness tear/Full Tear	98.5	43.3	1.74	0.03
					Pain / Weakness	Full tear	55.5	90.5	5.84	0.49
					Pain / Weakness	Partial thickness tear/full tear	71.2	73.9	2.73	0.39
	Park et al 2005 [20]	Arthroscopy	Not reported	552	Weakness	Any severity	44.1	89.9	4.37	0.62
					Weakness	Partial thickness tear	32.1	67.8	1.00	1.00
					Weakness	Full Tear	52.6	82.4	2.99	0.58

Palapation test	Lyons & Tomilson	Operation	Not reported	42	Feel the rent in the tendon	No rent to rent	91	75	3.64	0.12
	Wolf & Agarwal [14]	Arthroscopy	51.2	109	Feel the rent in the tendon	Full tear	95.7	96.8	29.91	0.04
External rotation lag sign [13]	Castoidi 2009	Arthroscopy or open surgery	50	395	Pain	Full tear	56	98		
					Pain	Partial thickness tear	12	98		

+LR = positive likelihood ratio, –LR = negative likelihood ratio; Phase 1 = high signal amplitude with no shrinkage or unevenness in the tendon, Phase 2 = MRI signal amplitude in the tendon with shrinkage or unevenness is raised., Phase 3 = full tear of tendon; PARTIAL THICKNESS TEAR = partial thickness tear; FULL TEAR = full thickness tear

1. Drop Arm Test(22) (Codman's sign)
2. Full can test(23)
3. Painful arc test(24)
4. Empty can test (Jobe test)(24)
5. Palpation of tendon defect(25)
6. External Rotation Lag test at zero Degrees(22) (test’s both supraspinatus & infraspinatus)
7. Supraspinatus strength test
8. Infraspinatus strength test

Positive painful arc test as well as external rotation lag test were most effective tests able to diagnose a rotator cuff tear, as per a systematic review by Hermans J et al.(18) and possibly the lateral Jobe test was the most effective test for diagnosing a rotator cuff tear, according to Hegedus EJ et al. (19) A positive lag test was the most effective way of detecting full-thickness tears. (18)

The Jobe test (empty can test) was found to be the most effective for diagnosin g Supraspinatus tears by Gismervik et al. (20) and Beaudreuil et al. (26)

Combination of clinical tests (Table 3)

Table 3: Diagnostic accuracy of combination of clinical tests in other studies (18–21)

Test	Study	Reference standard	Age in yrs	n (Shoulders)	Benchmark	Stage of tear	Sensitivity (%)	Specificity (%)	+ LR	- LR
Hawkins-Kennedy & Neer Test	MacDonald et al 2000	Arthroscopy	40	85	Pain	Stage of tear not mentioned	87.5	37.7	1.35	0.42
	Ardic et al 2006	MRI	55.5	59	Pain	Stage of tear not mentioned	78.3	50	1.57	0.43
	Mac Donald et al 2000	Arthroscopy	40	85	Pain	Stage of tear not mentioned	83.3	55.7	1.88	0.30
Hawkins-Kennedy or painful arc or infraspinatus test	Park et al 2005 [20]	Arthroscopy	Not reported	552	3/3 tests positive	Full Tear	32.7	98	16.35	0.69
					2/3 tests positive		34.6	90.3	3.57	0.72
					1/3 positive		23.5	70.3	0.79	1.09

+LR = positive likelihood ratio, –LR = negative likelihood ratio; FULL TEAR = full thickness tear

In two trials, it was found that combining multiple tests was the most promising strategy to diagnose patients with Rotator-cuff tears. (27,28) As per Murrell and Walton (27), when a patient is above 60 years of age, shows weakness in abduction, and has a significant impingement test, the Rotator cuff is likely to be affected in 98 percent cases. According to Park et al. (28), any patient above 60 years of age with a significant painful arc test, abduction weakness, and external rotation weakness has a 90% chance of having a Full-thicknes Rotator cuff tear.

Even though the combined results of positive clinical tests did not significantly exceed those of individual tests, several analysts assert that Rotator cuff tears are increasingly likely as the success rate increases.(18)

To examine the shoulder, many clinical tests are available, and we can't use all of them every time. We have to choose a proper clinical test. (23)

Imaging (12)

X-Ray:

Simple X-ray films can rule out other causes of shoulder pain, like Arthritis and Calcific tendonitis. Anteroposterior view and Scapular Y views are often advised. (Figure 4)

Figure 4: X-ray showing normal Acromio-Humeral distance of 6-15 mm (29)

"Weiner and Macnab proposed that an AHD (acromio-humeral distance) of less than 6 mm can be used as a cuff tear diagnostic measure. On AP shoulder radiographs, **the Gothic arch** is the line that connects the lateral border of the scapula and the medial border of the humerus along the glenoid labrum. (29)

Based on the Gothic arch concept, the **C-line** was described as the line that goes from the medial margin of the proximal humeral head to the inferior margin of the articular glenoid and then to the lateral border of the scapula. The humeral head migrates superiorly after a rotator cuff injury, causing a break in the C-line. The C-line changed independently of the acromion in AHD, which is easily altered by acromial deformity or bony spurs. (29) (Figure 5)

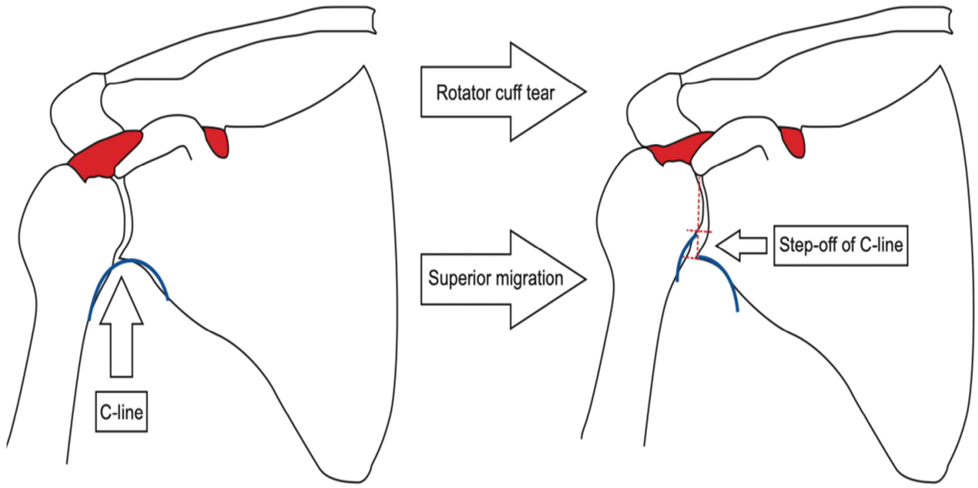


Figure 5: Showing C-line/ Gothic arch and step-off C-line (29)

In acute rotator cuff injuries, standard shoulder radiographs are frequently normal. A type III acromion can be visible on a supraspinatus outlet view (a modified Y view) and has been linked to a higher rate of rotator cuff tears. An active abduction view, in which the patient abducts the shoulder to 90° or the highest degree possible, can be acquired to look for a decreased acromiohumeral distance (less than 2 mm). The shortened acromiohumeral distance is related to the unopposed action of the deltoid muscle actively drawing the humerus superiorly and the lack of the supraspinatus as a physical barrier due to tendon tear and retraction. Repetitive contact between the humeral head and the acromion can occur in chronic rotator cuff tears, leading in remodelling and irregularity of these structures, notably the greater tuberosity. Sclerosis, subchondral cysts, osteolysis, and notching or pitting of the greater tuberosity, generally with matching sclerosis and faceting or concavity in the inferolateral portion of the acromion, are all signs of cuff arthropathy **(Acetabularisation of acromion).”** (30) (Figure 6 & 7)

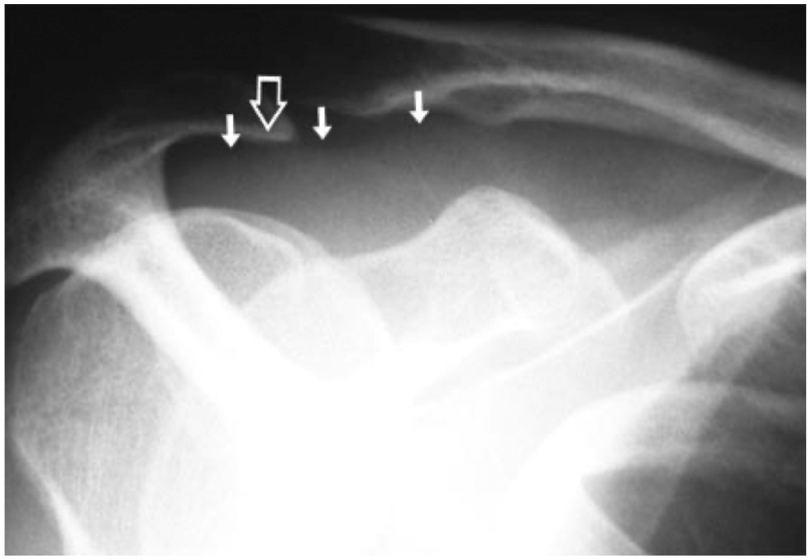


Figure 6: Supraspinatus outlet view showing normal supraspinatus as bulging homogenous appearance (solid arrows) and type III acromion (open arrow) (30)

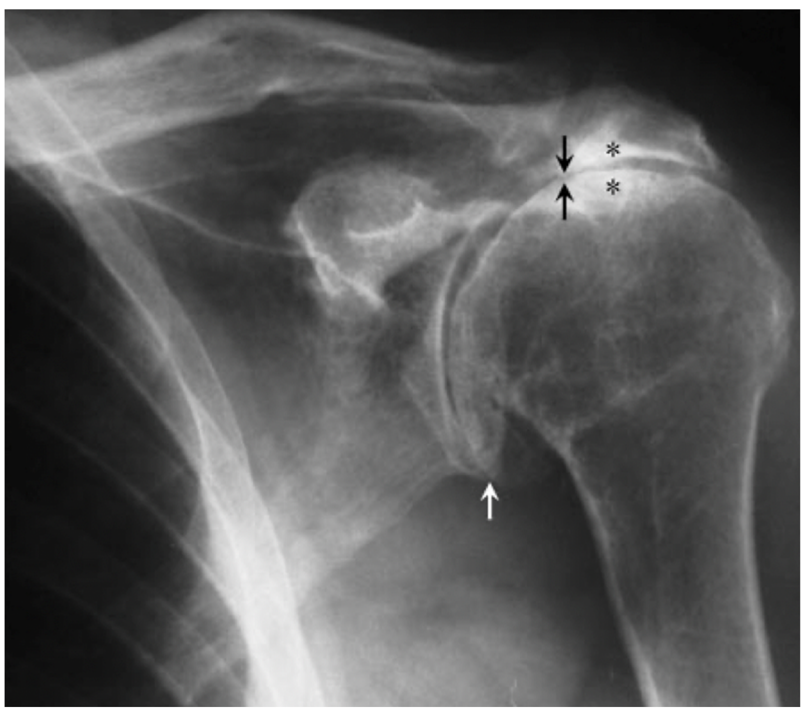


Figure 7: AP X-ray of chronic rotator cuff tear. Black arrows show decreased acromio-humeral distance suggesting upward migration of humerus. * Shows sclerosis, subchondral cysts in greater tuberosity and acromion. White arrow shows osteophytes. (30)

Ultrasonography (US): (12)

The Ultra-sonographic evaluation of rotator cuff diseases was first described by Seltzer in 1979. The US of the shoulder is used to assess the rotator cuffs in various health care settings. It consists of a non-invasive test with almost no side effects and enables dynamic analysis of the Rotator cuff. According to Le Corroller, it is operator dependant and requires experience to interpret, especially in the case of partial-thickness tears, which have a significant inter-observer variation.

Two meta-analyses (31,32) reports of Ultrasound for diagnosing Rotator cuff tears:

1. For Partial thickness tears - sensitivity range from 72%-84% & specificity range from 89% -93%
2. For Full-thickness tears - sensitivity range from 95%-96% & specificity range from 93% -96%

Ultrasound was more effective in diagnosing full thickness Rotator cuff tears according to Baombe JP. (33)

Magnetic Resonance Imaging (MRI): (12,34)

MRI is the benchmark for evaluating Rotator cuff tears because it gives a great deal of structural information. However, MRI is more costly than ultrasound. (1)

<u>MRI Principles and Procedures:</u>

- A typical 1.5 Tesla MRI device (in our centre) consists of a long cylinder-shaped tube encircled by a circular magnet.
- OPD or IPD MRI tests are available.
- The patient is asked to wear a gown and remove all jewelry, watches etc.

- The patient is asked to lie down in a gantry
- To increase picture quality, wear a small gadget around your arm that contains coils capable of transmitting and receiving radio waves.
- The Radiology expert will analyze the films.
- It takes about twenty minutes to complete the process.

Absolute contraindications: aneurysmal clips in brain, heart pacemakers, automated defibrillators, bio stimulators, embedded infusion systems, cochlear implants, and eye implants.

Advantages:

- MRI does not depend on ionizing radiation.
- MRI is a noninvasive imaging technique
- MRI has been shown to be helpful in diagnosing a wide variety of disorders, including muscle and bone defects, and in determining which patients with shoulder injuries need surgery.

Disadvantages/Risks:

- Absolute nil except when patient carries metal objects inside his body

Limitations of shoulder MRI:

- Avoided in first trimester of pregnancy
- An obese person may not be able to fit through the opening of an MRI machine, and a very erratic heart-rhythm may impair image quality.

MRI Reporting: (13,35)

- On T1 and T2-weighted pictures, the usual rotator cuff tendon has a low signal.
- The Supraspinatus tendon can be detected superiorly on axial MR images right below the acromion and clavicle. The supraspinatus musculotendinous junction is commonly found in the 12 o'clock position above the humeral head, much lateral to the glenoid edge on coronal MR images. The subacromial–subdeltoid (SA-SD) bursa encompasses the cranial and anterior sides of the Rotator cuff muscles and is located above the Supraspinatus muscle and tendon. In some asymptomatic shoulders, it can contain a few millilitres of fluid, but it is rarely visible. The inferior part of the bursa may have a rim of fat that can be visible in both symptomatic and asymptomatic shoulders. (2) (Figure 8-11)
- Partial thickness tear in Rotator cuffs most often occur as a break in the natural cuff shape, as a result, a cuffs aberration loaded with fluid signals is produced.
- Full thickness tears have a fluid signals and tendon retraction is possible.

According to a meta-analysis of 44 reports (36) MRI had greater sensitivity and specificity for identifying partial thickness tears (sensitivity 80%, specificity 95% percent) and full thickness (sensitivity 91%, specificity 97%) rotator cuff tears. Furthermore, higher the field intensity of MRI better the diagnosis.

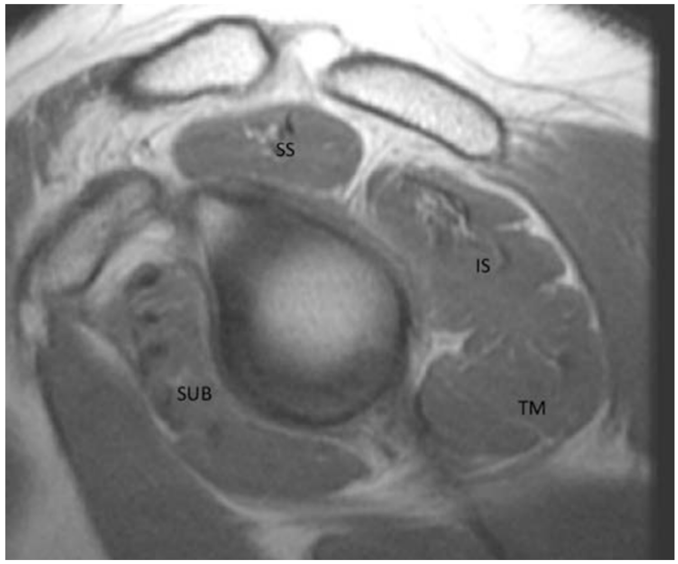


Figure 8: Normal rotator cuff muscles in cross section on a sagittal T1-weighted MRI image at the level of the coracoid. SS- supraspinatus, IS – infraspinatus, TM – teres minor, SUB – subscapularis (2)

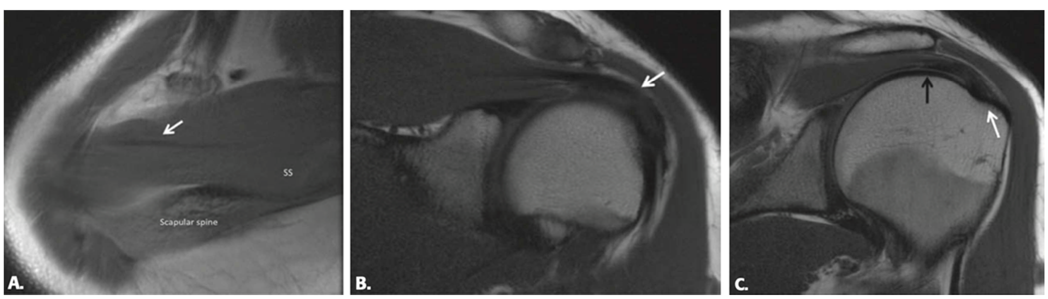


Figure 9: T1-weighted MRI pictures of the normal supraspinatus muscle and tendon (SS).

A. The multipennate supraspinatus tendon with the thicker anterior central tendon is seen in this axial view (arrow). Supraspinatus fossa, scapular spine, and glenoid neck are the origins of the supraspinatus muscle.Supraspinatus fossa, scapular spine, and glenoid neck are the origins of the supraspinatus muscle.

B: The stronger, more fusiform anterior muscle and tendon may be seen in this oblique coronal anterior view (arrow).

C: The posterior part of the supraspinatus muscle and tendon attaches to the superior aspect of the greater tuberosity's "footprint" (arrow). (2)

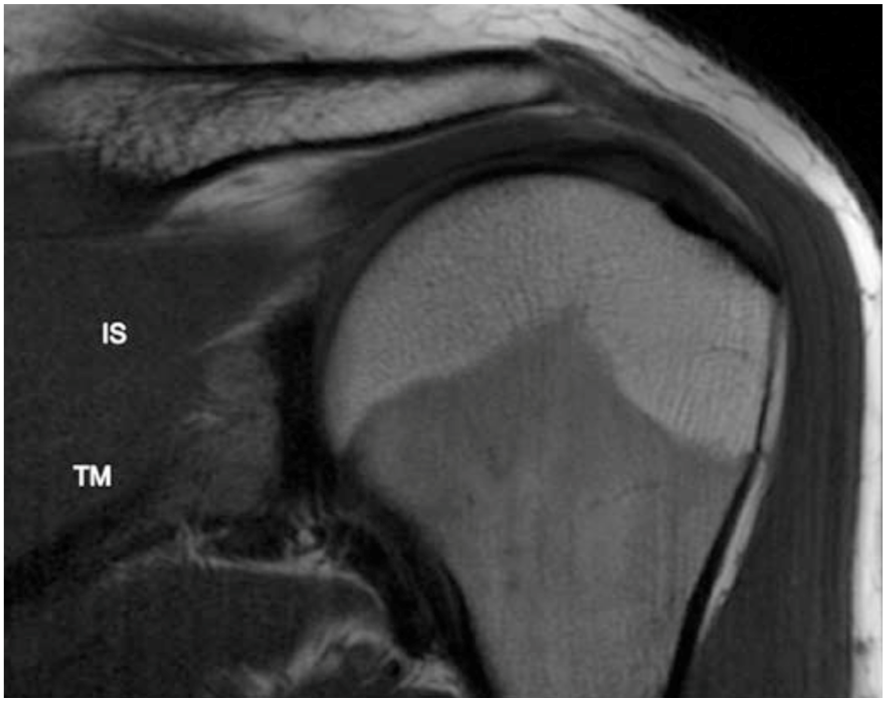


Figure 10: On this oblique coronal T1-weighted MRI picture, the normal infraspinatus muscle and tendon (IS) as well as the teres minor muscle (TM) lies under the scapular spine. (2)

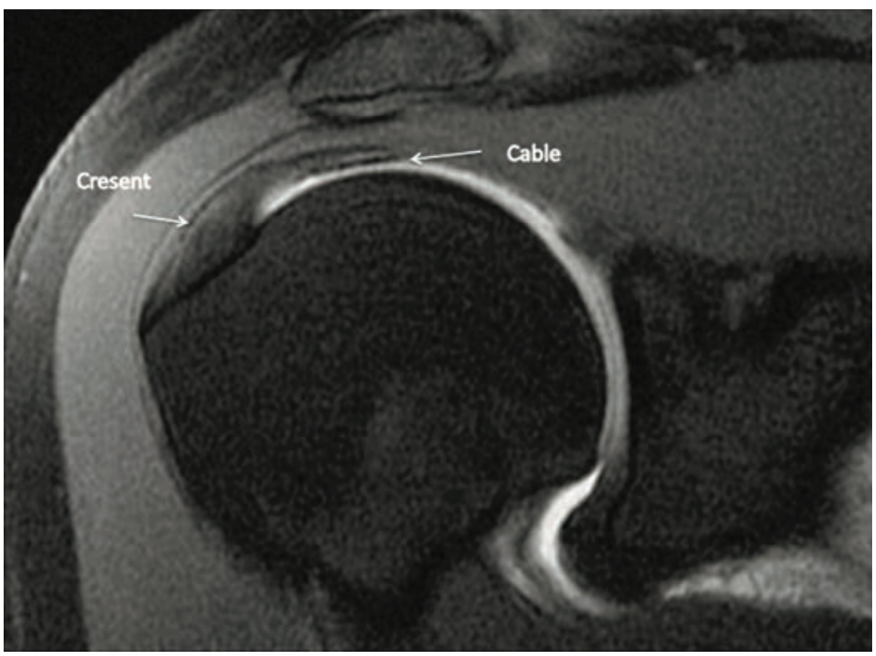


Figure 11: An oblique coronal fat suppressed T1-weighted imaging from an MR arthrogram shows a normal supraspinatus cable and crescent. (2)

MRI Classification (37)

"**Grade 0** was defined as a tendon that was normal in signal intensity and morphology. **Grade I** was defined as a tendon with increased signal intensity but normal morphology. **Grade II** was defined as a tendon with both abnormal signal intensity and morphology. Abnormal morphology was defined as obvious tendon thinning or irregularity. A **grade III** tendon was defined as one with a definite large area of discontinuity in the normal signal void of the tendon. Acromio-Humeral distance less than 0.5 cm was defined as an extensive rotator cuff tear, 0.5-1.0 cm as acromion stenosis, and 1.0-1.5cm as normal acromion.

Fatty infiltration of the rotator cuff muscles was graded according to the **Goutallier classification** with sagittal proton density images. Based on this classification system, **Grade 0** represents no fat, **Grade I** represents trace fatty streaks, **Grade II** represents less than 50% fat, **Grade III** represents 50% fat, and **Grade IV** represents more than 50% fat. The global fatty degeneration index (GFDI) of each patient was calculated and classi- fied into <1, 1-1.5, and >1.5.

Rotator cuff tears can be **classified according to size. Full thickness rotator cuff tears** were classed as mild (less than 1 cm), medium (1–3 cm), large (3–5 cm), or massive (more than 5 cm) by DeOrio and Cofield. Partial-thickness articular surface Rotator cuff tears are more common than partial-thickness tears on the bursal surface. **Partial-thickness tears** on the articular and bursal surfaces are rated as grade 1 (less than 3 mm), grade 2 (3–6 mm), or grade 3 (more than 6 mm) depending on their depth. Because the average rotator cuff thickness is 10–12 mm, grade 3 tears are considered significant tears affecting more than half of the cuff thickness." (38)

Magnetic Resonance Arthrography (MRA): (12)

Intra-articular injection of radiopaque dye may improve MRI performance. The Rotator cuff integrity can also be assessed using MRA of the shoulder. MRA can improve diagnostic efficiency in detecting shoulder diseases as compared to traditional MRI; however, it is an invasive procedure.

Three research evaluated the MRA accuracy in diagnosing Rotator cuff injuries, using 183 shoulders from 183 participants. The sample size was 58 people (range 50 to 75), with an 85 percent prevalence rate (range 62 percent to 90 percent) MRA had a sensitivity of 72 percent to 100 percent and a precision of 5 percent to 80 percent.

McGarvey et al (39) found that three tesla magnetic resonance imaging and three tesla magnetic resonance arthrogram (MRA) had superior prediction value for full thickness Supraspinatus tears. For diagnosing partial-thickness tears, three tesla two-D MRA had greater sensitivity (87 percent vs 81 percent, P=0.01) and lower specificity (95 percent vs 100 percent, P=0.001) when compared to three tesla magnetic resonance imaging.

Diagnostic Arthroscopy: (12)

Invasive reference tests are used to diagnose Rotator cuff tears. Diagnostic arthroscopy is the most common reference examination. Arthroscopy is a minimally invasive surgical technique that requires a small incision. However, diagnostic shoulder arthroscopy has some drawbacks, such as the need for anesthesia, hospitalization, and some inter-observer variance in the classification of tears.

Disadvantages: (17)

- The widely regarded benchmark of diagnoses. Visual inspection during open or arthroscopic surgery, isn't always correct since tears within the rotator cuff's substance are often not visible and visible tears can be asymptomatic.
- There is a probability that surgery will cause complications.
- Furthermore, while about 70percent of total of patients with shoulder impingement recover with non-surgical management, those who receive surgical treatment cannot be representative (spectrum bias).
- Surgery is also operator dependent.

Surgery: (12)

It has diagnostic and therapeutic value. However, open surgery is less efficient than arthroscopy in diagnosing partial rotator cuff injuries.

1.3 JUSTIFICATION

- To examine the shoulder, a variety of special tests have been identified. It's not possible to use all of them at every study.
- Evidence is insufficient regarding clinical tests to diagnose Rotator cuff tears; additionally, to assess the prediction accuracy, strong research is needed of medical history and physical examination parameters.(18,19,21)
- It's unclear what is best for Rotator cuff tear diagnosis. As a result, diagnosing them is difficult, leading to an increase in the use of other diagnostic methods such as Magnetic Resonance Image scan (MRI), Ultrasonography, and diagnostic Arthroscopic examination. Nevertheless, these investigations are laborious, costly, or indeed invasive, they must be kept to a minimum.(18)
- A prediction model that considered individual characteristics, clinical records, and it would be highly valuable to have the results of some clinical research that could forecast the possibility of a rotator cuff tear in specific patients.

1.4 OBJECTIVES OF THE STUDY

- Primary objective: To see how accurate history and clinical testing were at detecting Supraspinatus tendon tears.
- Secondary objective: To develop a methodology for predicting the possibility of a supraspinatus tear in patients using patient characteristics, history, and clinical tests.

2. MATERIALS AND METHODS

- **Selection criteria**

➢ All New patients over the age of 18 with a symptomatic supraspinatus tendon tear, including males and females, were included.

➢ Previously diagnosed shoulder injuries, fractures, frozen shoulder, arthritis, previous dislocations of the shoulder and shoulder instability were excluded.

- Symptom duration of more than one month will be included.
- **Previous treatments:** Patients who have taken previous treatment will be excluded.
- **Study period:** June 2015 and June 2017
- **Study center:** KLE'S Dr Prabhakar Kore Hospital & MRC, Belagavi, Karnataka, India.
- **Type of Study center:** Tertiary care center
- **Study Design:** Hospital-based Diagnostic Test Accuracy Study, Prospective study with consecutive recruitment.
- **Sample size:** All patients who meet the inclusion criteria and are not rejected by one or more of the exclusion criteria make up the intended study population. A series of patients who presented at the study center were included in the study. There is no randomization.

Sample size formula: (40) (41)

$$n = \frac{(Z_{(1-\alpha/2)} + Z_{1-\beta})^2}{(p_1 - p_0)^2} * [\frac{p_0(1 - p_0)}{1 - \pi} + \frac{p_1(1 - p_1)}{\pi}]$$

Where $p_0 = p(y = 1/x = 0)$;$p_1 = p(y = 1/x = 1)$; π indicates the portion of the sample where x=1.

Since there is more than one independent variable, correction is used as

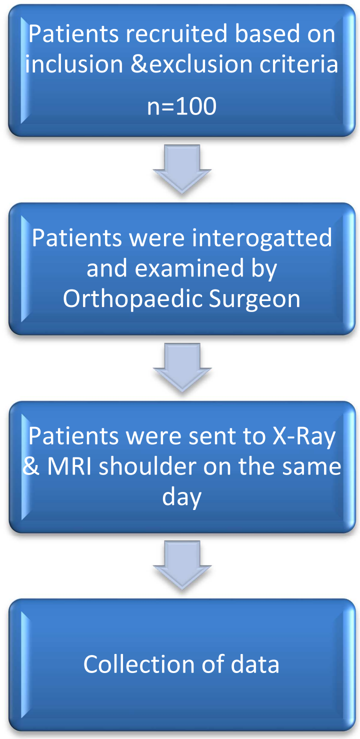
$$n^* = \frac{n}{1 - R^2}$$

R2 is calculated by regressing the independent variable of prime interest on all other independent variables. (Nagelkerke's R2 used). Using G-power software by assuming π =0.7, p_0=0.45, p_1=0.8, R^2=0.3, **sample size is 96.33≈96**

Note: taking analgesic is considered as the independent variable of prime interest.

For author: p_0=probability of event tear in subjects without taking analgesics, p_1= probability of event tear in subjects who are taking analgesics.

- **Data Collection:** Recruited patients are examined by orthopedic expert consultant clinically after taking a thorough history. Any patient underwent ten clinical tests. Following that, patients had an affected shoulder MRI for the last conclusion, which was completed the same day.
- Clinically relevant data: Appropriate demographical and historical information will be collected.



History

- Duration of pain?
- Duration of weakness?
- Range of Shoulder movements and Stiffness?
- Pain:
  - Pain severity? VAS (Visual Analogue Scale)
  - Pain Localization- anterior/lateral?
  - Radiation?
  - Aggravating factors?
  - Relieving factors?
  - Analgesic intake?
  - Night pain?
  - Rest pain?

- Are activities of daily living restricted?
- Is Lifting weight to shoulder level without bending elbow difficult?
- H/O Trauma?
- H/O Smoking?
- H/O Co-morbidities?
  - Diabetes mellitus
  - Hypertension
  - Thyroid disease
  - Hypercholesterolemia
  - Any other

<u>Clinical examination</u>

- **General Physical Examination:** PR/BP/Height/Weight/BMI
- **Systemic Examination:** CVS/RS/PA/CNS
- **Local Examination of Shoulder**

Inspection:

- Wasting of Supraspinatus and Infraspinatus
- Asymmetry of the Biceps muscle
- Observe the shoulder symmetry
- Observe the position of the Scapula on the thorax

Palpation:

- Tenderness is at the anterior aspect of humerus
- Palpable rent in the cuff tendon

Movements:

- Test active movements first. Full-thickness tears are known to reduce active abduction while maintaining regular passive abduction.
- The Apley scratch test can be used to assess functional range of motion.
- Since the Scapula is stabilized in this position, rotation is determined reliably in the supine posture with 90-degree shoulder abduction.
- Abduction and flexion are to be measured in standing posture.

Strength testing:

- Supraspinatus strength is measured at ninety degrees abduction and internal rotation. Resisted outward shoulder movement is used to measure Infraspinatus and Teres minor muscles strength.
- The strength of the Subscapularis is measured in internal rotation by pressing the belly or lifting the hand from back.
- Muscle testing of Trapezius, Rhomboids, Serratus Anterior, Pectoralis Major and Minor.

Special Tests - Table 4: Clinical tests (18–21)

Sl.No	Clinical Tests	Method to Perform	Inference
1	Neer's Test	Patient is sitting and examiner stands behind. Examiner stabilises the scapula and passively flexes the shoulder.	This manoeuvre causes greater tubercle impingement against acromion producing pain over the anterolateral shoulder of supraspinatus tear patient.
2	Hawkin's Kennedy Test	Patient is sitting and examiner stands behind. Examiner flexes the shoulder to 90^0 and internally rotate the shoulder when elbow is flexed.	Pain over the anterolateral shoulder with this manoeuvre is considered positive for impingement.
3	Drop Arm Test (Codman's sign)	Patient is standing. Ask the patient to slowly lower the arm to zero degrees from 180 degrees of abduction.	The test will be positive when the arm falls to the side.
4	Full can Test	Patient is sitting and examiner standing in the front. With elbow extended and thumb pointing to the ceiling, the arm is lifted to 90 degrees in the scapular plane.	Pain over the anterolateral shoulder or weakness when the investigator applies downside force, the test is accurate.
5	Painful arc Test	The patient is in standing position. The patient was told to raise his arm in the scapular plane until it was entirely raised, then descend it in the same arc.	If the patient complained of discomfort over the anterolateral shoulder or an uncomfortable trapping between 60° and 120° elevation, the result was deemed positive.
6	Empty can Test (Jobe Test)	Patient is sitting and examiner standing in the front. With elbow extended and thumb pointing to the floor, the arm is lifted to 90 degrees in the scapular plane.	Pain over the anterolateral shoulder or weakness when the investigator applies downside force, the test is accurate.

Table 4: Clinical tests (continued)			
7	Palpation of tendon defect	Full thickness rotator cuff tears were first palpated by Codman. He mentioned being able to palpate a "sulcus" caused by a supraspinatus tendon tear. The elbow on the affected side is bent to ninety degrees and held there. The humerus head is palpated by twisting the arm inside and outside and then taking it backward. An anterior supraspinatus tear can be detected in outward rotation.	The test was considered positive when the defect is felt.
8	External rotation lag sign (ERLS) at zero degrees	With his or her back to the practitioner, the individual is sitting. The physician holds the elbow at 90 degrees passive flexion and the shoulder at 20 degrees elevation (in the scapular plane) and close to full outward rotation (i.e., maximum outward rotation minus 5 degrees to prevent elasticity in the shoulder). The person is then instructed to consciously retain the outward rotation posture while the doctor removes the wrist support and maintains limb assistance at the elbow.	When a lag, or angle decrease, occurs, the test is favorable. The lag's degree is measured to the closest 5°. A positive test suggests a defect in the postero-superior cuff (supraspinatus and infraspinatus).
9	Supraspinatus strength test	The test is performed with the arm in internal rotation and lifted to 90 degrees.	It is rated on a scale of 0 to 5. Grade 0: There is no muscle contraction or movement. Grade 2: Movement at the joint with gravity removed Grade 3: Movement in opposition to gravity, but not against additional resistance. Grade 4: Movement with little strength than normal over external force. Grade 5: Regular
10	Infraspinatus strength test	Outward rotation strength against resistance is examined with the elbow flexed to 90 degrees and the arm held by the side of the body.	It is graded from 0-5 as above.

- **Target condition:** Supraspinatus tendon tear
- **Reference standard:** MRI (Magnetic Resonance Imaging) for all patients. To determine the diagnosis, every new patient with a shoulder problem should have an arthroscopy performed in the outpatient clinic. This method is not ethically justified for diagnosis because it is invasive. Therefore, MRI (Magnetic Resonance Imaging) is the reference standard used in our study.

Magnetic Resonance Imaging (MRI):

MRI Procedure:

- A typical 1.5 Tesla MRI device (in our center) consists of a long cylinder-shaped tube encircled by a circular magnet.
- OPD or IPD MRI tests are available.
- The patient is asked to wear a gown and remove all jewellery, watches etc.
- The patient is asked to recline in a gantry
- To increase picture quality, wear a small gadget around your arm that contains coils capable of transmitting and receiving radio waves.
- The Radiology expert will analyze the films.
- The procedure requires around twenty minutes.

Absolute contraindications: aneurysmal clips in brain, heart pacemakers, automated defibrillators, bio stimulators, embedded infusion systems, cochlear implants, and metallic orbital foreign bodies.

MRI Reporting:

- On T1 and T2-weighted pictures, the usual Rotator cuff tendon has a low signal.
- Partially torn Rotator cuffs most often occur as a break in the natural cuff shape, as a result, a cuffs aberration loaded with fluid signals is produced.
- Full thickness tears have a fluid signals and tendon retraction is possible.

- **Tester:** Clinical examination will be done by experienced Orthopedic consultant and MRI shoulder will be read by experienced Radiologist.
- **Blinding in a study:**
  - Index test results will be blinded: Radiologist will be blinded for all clinical study results.
  - The results of the reference test will be blinded: Because the clinical tests will always be conducted and decoded earlier to the reference standard.
- The time between the clinical test and the MRI shoulder was same day
- **Follow-up:** No follow-up done
- **Is treatment given to patients in the same setting?** Yes
- **Un interpretable test results:** will be reported
- **Patient withdrawal:** will be reported and explained.

3. STATISTICAL ANALYSES

The statistical programme R i386.3.5.1 was used to analyze the data. The frequency table represents both continuous data as average, standard deviation, and categorical data in the form of a categorical variable. To study the association between categorical variables, the chi-square test/fisher test is utilized. To compare continuous findings, the t-test/Mann Whitney U-test was utilized. A Cochran Armitage test is used to determine trends. The factors influencing tear stages were studied using logistic regression and ordinal logistic regression. A P-value of less than 0.05 was selected as a statistically significant threshold.

4. RESULTS

Descriptive statistics: Here totally of 100 subjects of mean age 53.59±12.56 were considered for the study consisting of 67 male and 33 female subjects. Descriptive statistics of data is shown in **Figure 12, 13, 14** and **Table 5.**

Figure 12: Subjects are distributed according to their age categories.

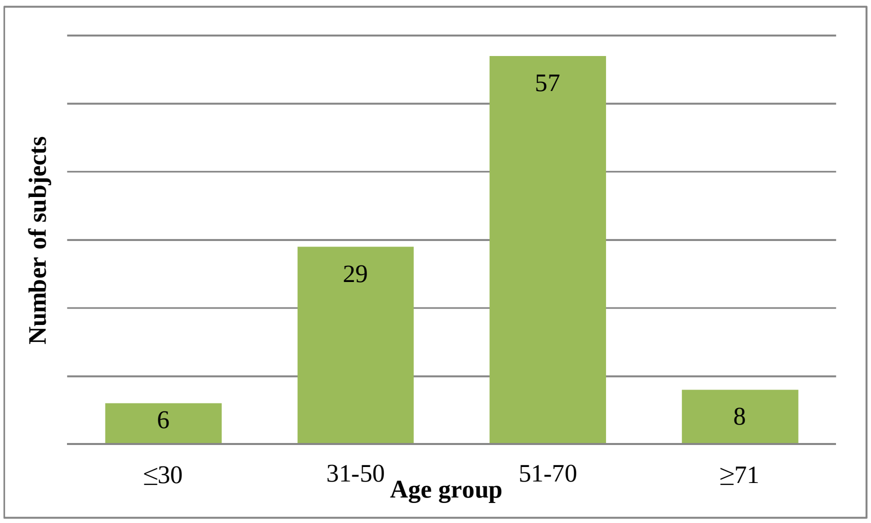


Figure 13: Subjects are distributed according to their sex

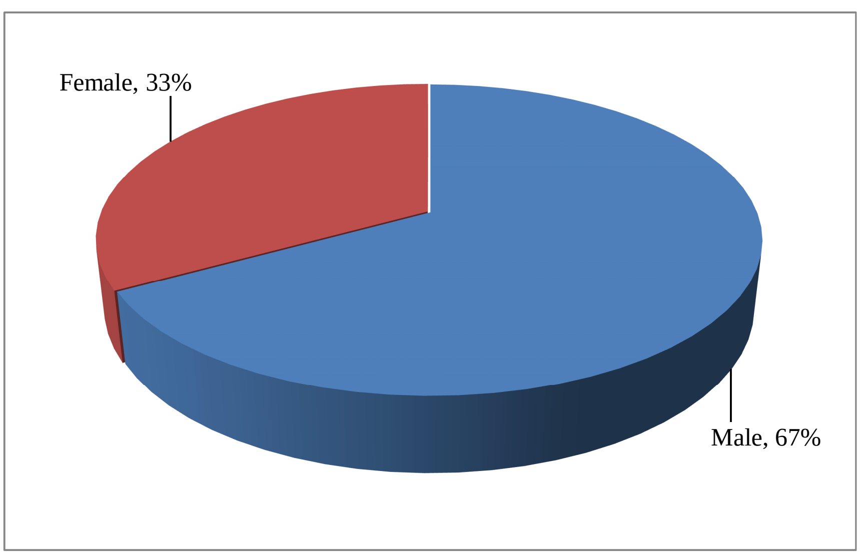


Figure 14: Subjects are distributed according to their occupation

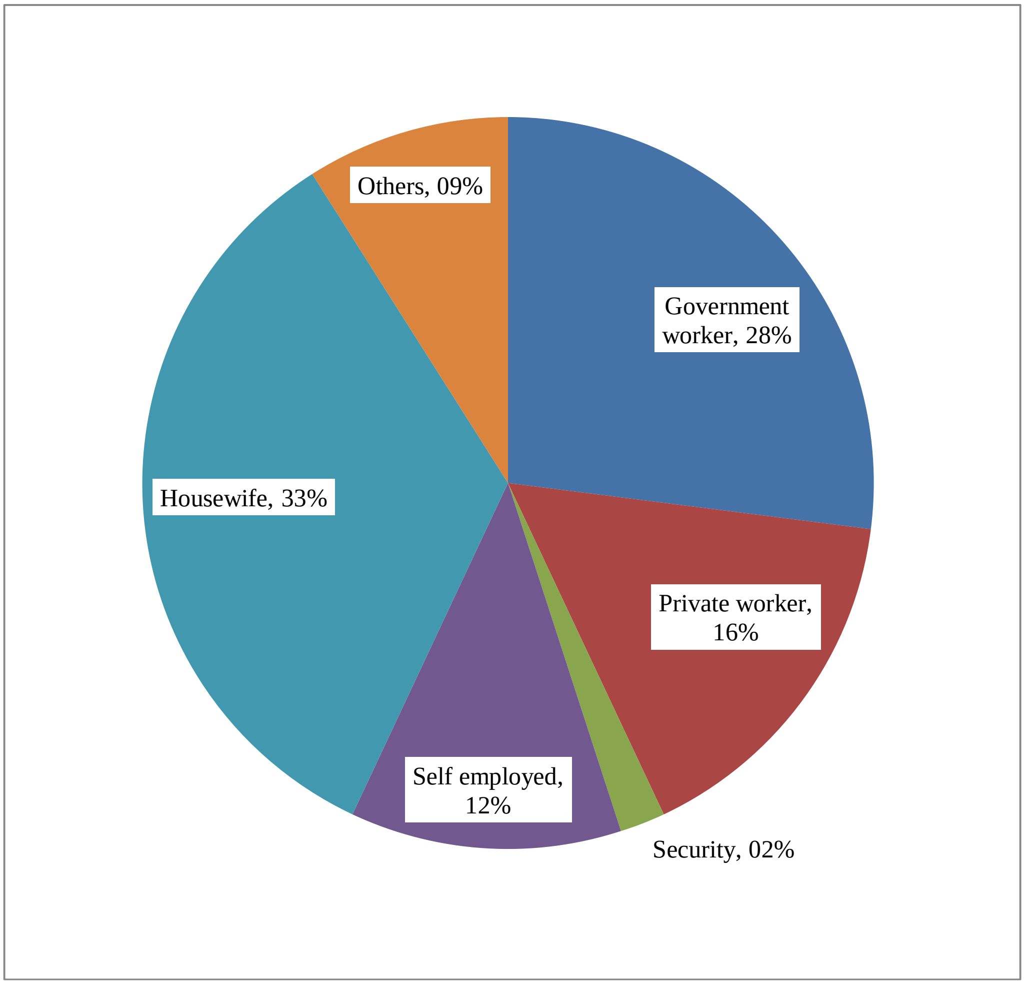


Table 5: Descriptive statistics of data

Item	Group	Overall tested	Any type of tear	No tear	Partial thickness tear	Full thickness tear
Age Category	≤30	6	1(16.67%)	5(83.33%)	1(100%)	0(0%)
	31-50	29	17(58.62%)	12(41.38%)	14(82.35%)	3(17.65%)
	51-70	57	44(77.19%)	13(22.81%)	32(72.73%)	12(27.27%)
	≥71	8	7(87.5%)	1(12.5%)	3(42.86%)	4(57.14%)
Age	Mean ± SD	53.59±12.56	56.20±11.37	47.77±13.29	54.26±11.16	61.32±10.55
Sex	Men	67	41(61.19%)	26(38.81%)	30(73.17%)	11(26.83%)
	Women	33	28(84.85%)	5(15.15%)	20(71.43%)	8(28.57%)
Duration of pain	<1mnth	7	4(57.14%)	3(42.86%)	2(50%)	2(50%)
	1-<3mnths	33	19(57.58%)	14(42.42%)	10(52.63%)	9(47.37%)
	3-<1Yr	45	32(71.11%)	13(28.89%)	26(81.25%)	6(18.75%)
	≥1yr	15	14(93.33%)	1(6.67%)	12(85.71%)	2(14.29%)
Occupation	Govt.worker	28	20(74.07%)	7(25.93%)	16(80%)	4(20%)
	Private worker	16	9(56.25%)	7(43.75%)	8(88.89%)	1(11.11%)
	Security	2	0	2(100%)	-	-
	Self-employed	12	7(58.33%)	5(41.67%)	4(57.14%)	3(42.86%)
	Housewife	33	27(79.41%)	7(20.59%)	18(66.67%)	9(33.33%)
	Others	9	6(66.67%)	3(33.33%)	4(66.67%)	2(33.33%)
Affected side	Right	66	46(69.7%)	20(30.3%)	31(67.39%)	15(32.61%)
	Left	34	23(67.65%)	11(32.35%)	19(82.61%)	4(17.39%)
Occupation	Fine work	78	56(71.79%)	22(28.21%)	42(75%)	14(25%)
	Laborious work	22	13(59.09%)	9(40.91%)	8(61.54%)	5(38.46%)
Dominant side	Right	98	67(68.37%)	31(31.63%)	48(71.64%)	19(28.36%)
	Left	2	2(100%)	0(0%)	2(100%)	0(0%)
Weakness	Present	31	28(90.32%)	3(9.68%)	13(46.43%)	15(53.57%)
	Absent	69	41(59.42%)	28(40.58%)	37(90.24%)	4(9.76%)
Decreased movements	Absent	86	59(68.6%)	27(31.4%)	44(74.58%)	15(25.42%)
	Present	14	10(71.43%)	4(28.57%)	6(60%)	4(40%)
VAS	Mean ± sd	5.48±1.31	5.54±1.29	5.35±1.38	5.42±1.34	5.84±1.12
	Median [range]	5.5[3,10]	5 [3,10]	6 [3,10]	5 [3,10]	6[4,8]
Localisation of pain	Anterior	35	23(65.71%)	12(34.29%)	14(60.87%)	9(39.13%)
	Lateral	60	43(71.67%)	17(28.33%)	34(79.07%)	9(20.93%)
	Posterior	1	0	1(100%)	-	-
	Others	4	3(75%)	1(25%)	2(66.67%)	1(33.33%)
Radiation of pain	No	35	19(54.29%)	16(45.71%)	14(73.68%)	5(26.32%)
	Yes	65	50(76.92%)	15(23.08%)	36(72%)	14(28%)

Table 5: Descriptive statistics of data (Continued)

Item	Group	Overall tested	Any type of tear	No Tear	Partial thickness tear	Full thickness tear
Night pain	**Yes**	77	62(80.52%)	15(19.48%)	45(72.58%)	17(27.42%)
	No	23	7(30.43%)	16(69.57%)	5(71.43%)	2(28.57%)
Analgesic intake	**Yes**	67	54(80.6%)	13(19.4%)	37(68.52%)	17(31.48%)
	No	33	15(45.45%)	18(54.55%)	13(86.67%)	2(13.33%)
Is Shoulder relaxed with arm at your side?	**Yes**	95	64(67.37%)	31(32.63%)	46(71.88%)	18(28.13%)
	No	5	5(100%)	0(0%)	4(80%)	1(20%)
Is the range of ADL restricted?	**Yes**	43	31(72.09%)	12(27.91%)	16(51.61%)	15(48.39%)
	No	57	38(66.67%)	19(33.33%)	34(89.47%)	4(10.53%)
Lifting heavy weight	**Yes**	58	35(60.34%)	23(39.66%)	32(91.43%)	3(8.57%)
	No	42	34(80.95%)	8(19.05%)	18(52.94%)	16(47.06%)
H/O Trauma?	**No**	73	50(68.49%)	23(31.51%)	37(74%)	13(26%)
	Yes	27	19(70.37%)	8(29.63%)	13(68.42%)	6(31.58%)
Smoking	**No**	80	53(66.25%)	27(33.75%)	39(73.58%)	14(26.42%)
	Yes	20	16(80%)	4(20%)	11(68.75%)	5(31.25%)
Comorbidities?	**No**	52	33(63.46%)	19(36.54%)	25(75.76%)	8(24.24%)
	Yes	48	36(75%)	12(25%)	25(69.44%)	11(30.56%)
Body mass index	**Mean ± SD**	26.16±3.27	26.33±3.56	25.77±2.50	26.10±3.59	26.95±3.52

From the above table number 5 of descriptive statistics, we observe that

- Most of the subjects in the study were between the ages of 51 and 70, followed by 31 and 50.
- The average age of subjects in the sample was 53 years.
- The percentage of tears (partial thickness+ full thickness) by age category followed a straight pattern, using the Cochran Armitage test (p=0.0188).
- We observed the average age of patients was significantly different with full thickness tear and partial thickness tear using the t-test.
- 67% of total subjects in the sample were male.
- The proportion of male subjects who were substantially higher than the proportion of female subjects in the Supraspinatus tear group, according to the proportion survey.
- There was also a straight pattern in the proportion in “Any type” of tear through pain levels. (p=0.0155).

Diagnostic values of various clinical tests: Full can test showed 83 % accuracy in diagnosing “Any type” of Supraspinatus tendon tears and the same test showed 68% accuracy in diagnosing the “Partial type” of Supraspinatus tendon tears. The palpation test showed 91% accuracy in diagnosing full thickness tears of Supraspinatus tendon tears. The diagnosing reliability of individual clinical tests and a combination of clinical tests is shown in **Tables 6 and 7**.

Table 6: Diagnostic accuracy of individual clinical tests

	Any type of tear					Full thickness tear					Partial thickness tear				
	Sensitivity	Specificity	Accuracy	Precision (PPV)	NPV	Sensitivity	Specificity	Accuracy	Precision (PPV)	NPV	Sensitivity	Specificity	Accuracy	Precision (PPV)	NPV
Neer's Test	89.86	19.35	68	71.26	46.15	89.47	13.58	28	19.54	84.62	90	16	53	51.72	61.54
Hawkins's Test	75.36	32.26	62	71.23	37.04	78.95	28.4	38	20.55	85.19	74	28	51	50.68	51.85
Drop Arm Test	33.33	96.77	53	95.83	39.47	63.16	85.19	81	50	90.79	22	74	48	45.83	48.68
Full can Test	91.3	64.52	83	85.14	76.92	89.47	29.63	41	22.97	92.31	92	44	68	62.16	84.62
Painful Arc Test	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5
Empty can Test	76.81	74.19	76	86.89	58.97	84.21	44.44	52	26.23	92.31	74	52	63	60.66	66.67
Palpation Test	28.99	100	51	100	38.75	78.95	93.83	91	75	95	10	70	40	25	43.75
Sup. Strength T	84.06	41.94	71	76.32	54.17	100	29.63	43	25	100	78	26	52	51.32	54.17
Inf. Strength T	31.88	93.55	51	91.67	38.16	63.16	85.19	81	50	90.79	20	72	46	41.67	47.37
Ext Rot Lag Test	5.8	100	35	100	32.29	5.26	96.3	79	25	81.25	6	98	52	75	51.04

Table 7: Diagnostic accuracy of combination of clinical tests

	Any type of tear					Full thickness tear					Partial thickness tear				
	Sensitivity	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**	**Sensitivity**	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**	**Sensitivity**	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**
Neers+ Hawkins Test	92.75	12.9	68	70.33	44.44	89.47	8.64	24	18.68	77.78	94	12	53	51.65	66.67
Neers+ Drop Arm Test	92.75	19.35	70	71.91	54.55	94.74	12.35	28	20.22	90.91	92	14	53	51.69	63.64
Neers+ Full can Test	95.65	12.9	70	70.97	57.14	94.74	7.41	24	19.35	85.71	96	10	53	51.61	71.43
Neers+ Painful Arc Test	98.55	6.45	70	70.1	66.67	100	3.7	22	19.59	100	98	4	51	50.52	66.67
Neers+ Empty can Test	97.1	16.13	72	72.04	71.43	94.74	7.41	24	19.35	85.71	98	12	55	52.69	85.71
Nees+ Palpation Test	92.75	19.35	70	71.91	54.55	94.74	12.35	28	20.22	90.91	92	14	53	51.69	63.64
Neers+ Sup. StrengthT	95.65	12.9	70	70.97	57.14	100	8.64	26	20.43	100	94	8	51	50.54	57.14
Neerss + Inf. StrengthT	91.3	19.35	69	71.59	50	94.74	13.58	29	20.45	91.67	90	14	52	51.14	58.33
Neers + Ext. rot. ZeroT	89.86	19.35	68	71.26	46.15	89.47	13.58	28	19.54	84.62	90	16	53	51.72	61.54
Hawkins+ Drop Arm Test	81.16	32.26	66	72.73	43.48	89.47	25.93	38	22.08	91.3	78	24	51	50.65	52.17
Hawkins + Full can Test	94.2	32.26	75	75.58	71.43	94.74	16.05	31	20.93	92.86	94	22	58	54.65	78.57
Hawkins + Painful Arc Test	98.55	12.9	72	71.58	80	100	6.17	24	20	100	98	8	53	51.58	80
Hawkins + Empty can Test	88.41	32.26	71	74.39	55.56	89.47	19.75	33	20.73	88.89	88	24	56	53.66	66.67
Hawkins + Palpation Test	81.16	32.26	66	72.73	43.48	94.74	27.16	40	23.38	95.65	76	22	49	49.35	47.83
Hawkins+ Sup. StrengthT	94.2	29.03	74	74.71	69.23	100	16.05	32	21.84	100	92	18	55	52.87	69.23
Hawkins + Inf. StrengthT	82.61	32.26	67	73.08	45.45	94.74	25.93	39	23.08	95.45	78	22	50	50	50
Hawkins + Ext. rot. ZeroT	76.81	32.26	63	71.62	38.46	78.95	27.16	37	20.27	84.62	76	28	52	51.35	53.85
Drop arm+ Full can Test	92.75	64.52	84	85.33	80	94.74	29.63	42	24	96	92	42	67	61.33	84
Drop arm+ Painful Arc Test	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5
Drop arm+ Empty can Test	76.81	74.19	76	86.89	58.97	84.21	44.44	52	26.23	92.31	74	52	63	60.66	66.67
Drop arm+ Palpation Test	42.03	96.77	59	96.67	42.86	84.21	82.72	83	53.33	95.71	26	66	46	43.33	47.14

Table 7: Diagnostic accuracy of combination of clinical tests

	Any type of tear					Full thickness tear					Partial thickness tear				
	Sensitivity	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**	**Sensitivity**	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**	**Sensitivity**	**Specificity**	**Accuracy**	**Precision (PPV)**	**NPV**
Drop arm+Sup.strngth.T	86.96	41.94	73	76.92	59.09	100	27.16	41	24.36	100	82	26	54	52.56	59.09
Drop arm+Inf.strngth T	47.83	90.32	61	91.67	43.75	73.68	72.84	73	38.89	92.19	38	66	52	52.78	51.56
Drop arm+ Ext. rot. ZeroT	34.78	96.77	54	96	40	63.16	83.95	80	48	90.67	24	74	49	48	49.33
Full can + Painful Arc Test	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5
Full can + Empty can Test	94.2	58.06	83	83.33	81.82	94.74	25.93	39	23.08	95.45	94	38	66	60.26	86.36
Full can + Palpation Test	92.75	64.52	84	85.33	80	94.74	29.63	42	24	96	92	42	67	61.33	84
Full can + Sup. StrengthT	94.2	38.71	77	77.38	75	100	19.75	35	22.62	100	92	24	58	54.76	75
Full can + Inf. Strength T	92.75	58.06	82	83.12	78.26	94.74	27.16	40	23.38	95.65	92	38	65	59.74	82.61
Full can + Ext. rot. ZeroT	91.3	64.52	83	85.14	76.92	89.47	29.63	41	22.97	92.31	92	44	68	62.16	84.62
PAT+ Empty can Test	100	19.35	75	73.4	100	100	7.41	25	20.21	100	100	12	56	53.19	100
PAT+ Palpation Test	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5
PAT+ Sup. StrengthT	98.55	19.35	74	73.12	85.71	100	8.64	26	20.43	100	98	12	55	52.69	85.71
PAT+ Inf. StrengthT	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5

PAT+ Ext. rot. Zero T	98.55	22.58	75	73.91	87.5	100	9.88	27	20.65	100	98	14	56	53.26	87.5
Empty can+ Palpation Test	79.71	74.19	78	87.3	62.16	89.47	43.21	52	26.98	94.59	76	50	63	60.32	67.57
Empty can + Sup. StrengthT	92.75	38.71	76	77.11	70.59	100	20.99	36	22.89	100	90	24	57	54.22	70.59
Empty can + Inf. StrengthT	79.71	70.97	77	85.94	61.11	89.47	41.98	51	26.56	94.44	76	48	62	59.38	66.67
Empty can + Ext. rot. ZeroT	76.81	74.19	76	86.89	58.97	84.21	44.44	52	26.23	92.31	74	52	63	60.66	66.67
Palpation Test+ Sup. strengthT	85.51	41.94	72	76.62	56.52	100	28.4	42	24.68	100	80	26	53	51.95	56.52
Palpation Test+ Inf. strengthT	43.48	93.55	59	93.75	42.65	84.21	80.25	81	50	95.59	28	64	46	43.75	47.06
Palpation Test+ Ext. rot. zeroT	31.88	100	53	100	39.74	78.95	91.36	89	68.18	94.87	14	70	42	31.82	44.87
Sup. strength +Inf. Strength	84.06	41.94	71	76.32	54.17	100	29.63	43	25	100	78	26	52	51.32	54.17
Sup. strength+ Ext. rot. zeroT	84.06	41.94	71	76.32	54.17	100	29.63	43	25	100	78	26	52	51.32	54.17
Inf. Strength + Ext. rot. ZeroT	34.78	93.55	53	92.31	39.19	68.42	83.95	81	50	91.89	22	70	46	42.31	47.3

According to Fleiss e al. (2003) (42,43)**classification of Cohen's kappa, (Table 8),** it has been concluded <u>for individual clinical tests</u> that

- Full can test and Empty can test has fair to good agreement beyond chance with MRI **any type of tear** (i.e., calculated agreement between any type of tear and test).
- Palpation test, Drop arm test and Infraspinatus strength test has fair to good agreement beyond chance with MRI for **full thickness tear**.
- All tests had poor agreement beyond chance with MRI for **partial thickness tear**.

Table 8: Percentage agreement of clinical tests calculated using Cochen Kappa

	Any type of tear		**Full thickness tear**		**Partial thickness tear**	
	Kappa	P-value	Kappa	P-value	Kappa	P-value
Neer 's Test	0.11	0.205	0.01	0.722	0.06	0.372
Hawkins's Test	0.08	0.427	0.04	0.516	0.02	0.822
Drop Arm Test	0.22	0.0011	0.44	<0.0001	0	0.64
Full can Test	0.58	<0.0001	0.09	0.0875	0.36	<0.0001
Painful Arc Test	0.27	0.0003	0.04	0.153	0.12	0.0270
Empty can Test	0.48	<0.0001	0.16	0.0212	0.26	0.0077
Palpation Test	0.20	0.0008	0.71	<0.0001	0.02	0.788
Sup. Strength T	0.28	0.0050	0.14	0.0065	0.04	0.64
Inf. Strength T	0.18	0.0059	0.44	<0.0001	0.08	0.349
Ext Rot Lag Test	0.04	0.1710	0.02	0.7550	0.04	0.307
Fleiss classififcation, K<0.40- Poor agreement, 0.40≤K≥0.75 Fair to good agreement, K>0.75 Excellent agreement.						

According to Fleiss e al. (2003) classification of Cohen's kappa, it has been concluded for a combination of clinical tests that

- **For any type of Supraspinatus tear** –
  - Drop arm test combining with Full can test/Empty can test had fair to good agreement with MRI for any type of supraspinatus tear (k=0.61,k=0.48 respectively).
  - Full can test when combined with Empty can test/Palpation test/Infraspinatus strength test/External rotation lag test at zero degrees had fair to good agreement with MRI for any type of tear (k=0.57,0.61,0.55,0.58 respectively).
  - Empty can test when combined with Palpation test/Infraspinatus strength test/External rotation lag test at zero degrees had fair to good agreement with MRI for any type of tear (k=0.49,0.48 respectively).
- **For full thickness Supraspinatus tear -**
  - Drop arm test with Palpation Test/External rotation lag test at zero degrees had fair to good agreement with MRI for the full thickness tear (k=0.55,0.42 respectively).
  - Palpation test with Infraspinatus strength test/External rotation lag test at zero degrees had fair to good agreement with MRI for the full thickness tear (k=0.51, k=0.66) respectively.
- **For partial thickness Supraspinatus tear-** None of the combinations has at least fair to good agreement with MRI for partial thickness tear.

PREDICTION MODELS

<u>Prediction model in any type of tear</u>- (Table 9) Using logistic regression, we conclude that Gender, Radiation of pain, Night pain, Status of taking Analgesics, results from Full can test significantly affecting any type of tear. To find the Accuracy of the model, 50 times sequentially run the model with different sets of training data and we found the average 83% Accuracy.

Table 9: **Prediction model in any type of Supraspinatus tear**

	Sub-category	Estimated	Odds ratio [95 percent confidence interval]	P-value
Age category	≥50	0.8383	2.31[0.8116-6.7376	0.1168
	<50	Reference		
Sex	Men	-1.7640	0.1714[0.0515-0.5140]	0.0024*
	Women	Reference		
Radiation pain	Present	-1.4182	0.2421[0.0658-0.7636]	0.0221*
	Absent	Reference		
Night pain	Present	2.0221	7.5542[2.3177-28.2386]	0.0014*
	Absent	Reference		
Taking Analgesics	Yes	2.7460	15.5803[5.4615-52.9067]	<0.0001*
	No	Reference		
Full can test	Positive	2.9250	18.634[4.0856-117.2905]	0.0005*
	Negative	Reference		
Painful Arc test	positive	17.2148	$2.99\ e^{7}[7.53e\wedge^{-20}$-$3.24\wedge^{e194}$	0.9899
	Negative	Reference		
Empty can test	positive	0.9507	2.59[0.9172-7.3368]	0.0708
	Negative	Reference		
Residual deviance: 116.47 AIC:134.47				
Using logistic regression, we conclude that Gender, Radiation of pain, Night pain, status of taking Analgesics, Results from Full can test significantly affecting the any type tear. To find the Accuracy of the model, 50 times sequentially run the model different sets of training data and we found the average 83% Accuracy.				

<u>Prediction model in full thickness tear</u> – **(Table 10)** Using logistic regression, we conclude that age >50, taking analgesics, lifting weight, Neer test positive, significantly affecting full thickness tear. To find the Accuracy of the model, 50 times sequentially run the model with different sets of training data and we found the average 85% Accuracy.

Table 10: **Prediction model in full thickness type of Supraspinatus tear**

		Estimated	Odds ratio [95 percent confidence interval]	P-value
Age category	≥50	2.6512	14.17[2.8188-108.9120]	0.0030
	<50	Reference		
Weakness	Present	0.9594	2.6102[0.8059-8.5672]	0.1070
	Absent	Reference		
Taking Analgesics	Yes	1.9609	7.11[1.5329-42.2799]	0.0179*
	No	Reference		
Able to Lift weight	Yes	-2.6544	0.0703[0.0148-0.2634]	0.0002*
	No	Reference		
Neer test	Positive	-2.2459	0.1058[0.0106-0.6430]	0.0274*
	Negative	Reference		
Sup strength	Positive	18.5425	1.12e^8[8.81e^-30-NA]	0.9890
	Negative	Reference		
Empty can test	Positive	-1.4258	0.2403[0.0409-1.1836]	0.0935
	Negative	Reference		
Residual Deviance :83.01 AIC=99.01; Accuracy=0.8547				
Using logistic regression, we conclude that age >50, taking analgesics, lifting weight, Neer test positive, significantly affecting full thickness tear. To find the Accuracy of the model, 50 times sequentially run the model different sets of training data and we found the average 85% Accuracy. **Note**: before doing this model, Oversampling is done and only associated factors and top 4 tests which has maximum accuracy were included in the model and final model after stepwise regression was reported.				

<u>Prediction model in partial thickness tear</u> – **(Table 11)** Using logistic regression, we conclude that night pain, activities of daily living limited, Full can test positive, significantly affecting partial thickness tear. To find the Accuracy of the model, 50 times sequentially run the model with different sets of training data, and we found the average 75% Accuracy.

Table 11: **Prediction model in partial thickness type of Supraspinatus tear**

		Estimate	OR [95 % CI]	P-value
Duration of pain	<1 month	Reference		
	>1 month - Less than 3 months	-0.9699	0.3791[0.0358-4.6887]	0.4227
	>3 months -Less than 1 year	-0.4087	0.6645[0.0600-8.1472]	0.7377
	Greater than 1 year	1.1425	3.1347[0.2532-52.3346]	0.3902
Night pain	Present	1.5806	4.8581[1.1730-24.7443]	0.0381
	Absent	Reference		
ADL limited	Yes	-1.7701	0.1703[0.0445-0.5695]	0.0059
	No	Reference		
Full can test	Positive	2.3065	10.0394[2.2709-57.8308]	0.0043
	Negative	Reference		
Residual Deviance:82.032 AIC=96.032 Accuracy:75.20 ADL activities of daily living				

<u>MRI Results:</u> Various MRI diagnosis and other diagnosis are as shown in **Figure 15, Table no. 12 and Table 13** shows the different forms of Rotator cuff injuries and their frequency. Partial supraspinatus tendon tears are the commonest types of tear. Various other diagnoses on MRI are listed in **Table 14.**

Fig.15: Full thickness tear of Supraspinatus tendon on MRI

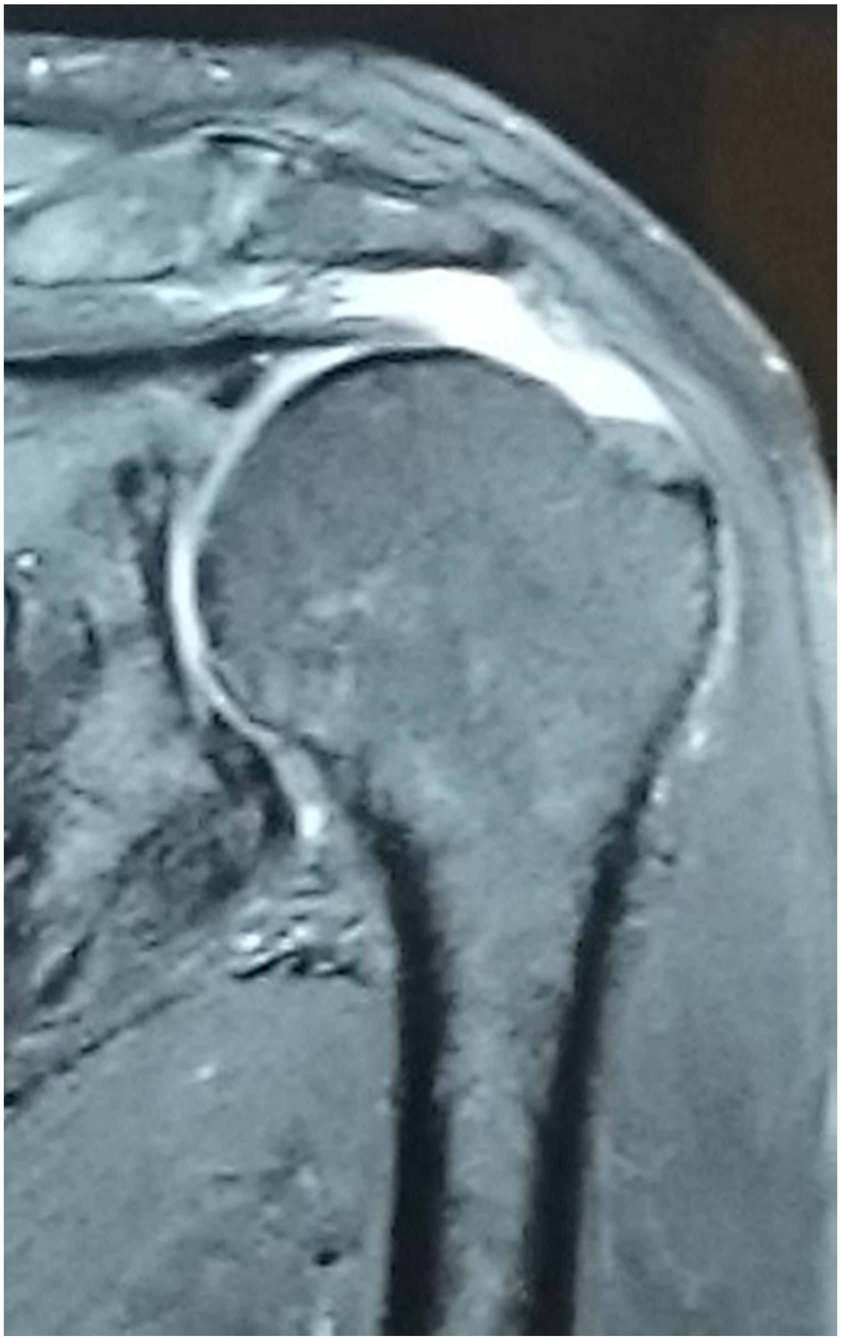


Table 12: Various MRI (Magnetic Resonance Imaging) diagnosis

MRI DIAGNOSIS	Frequency
Normal	**9**
Partial thickness tear of Supraspinatus Tendon	**49**
Full thickness tear of Supraspinatus Tendon	**18**
Other diagnosis	**24**
Total	**100**

Table 13: Types of Rotator cuff tears and their frequency

Tendon	Types of tears	Number	
Supraspinatus	Partial	49	Total 67 patients
	Complete	18	
Infraspinatus	Partial	03 [a]	
	Complete	00	
Subscapularis	Partial	01 [b]	
	Complete	00	

a =1 case was associated with partial supraspinatus tear; 2nd case was associated with complete supraspinatus tear & 3rd case was associated with complete supraspinatus tear & partial subscapularis tear. b =1 case was associated with complete supraspinatus tear & partial infraspinatus tear

Table 14: MRI reports showed variable insignificant features

Diagnosis	**Number of patients**
Acromioclavicular joint arthritis	7
SLAP Tear	6
Subacromial bursitis	3
Biceps tendinitis	2
Calcific tendinitis	1
Type 2 Acromion	1
Bankart's lesion	1

5. DISCUSSION

The Shoulder is ball and socket type of a synovial joint, which is formed by Scapular glenoid and Humeral head. The Shoulder joint has highest mobility as compared to its stability. The Rotator cuff is a group of muscles and tendons that help to stabilize the shoulder. Sub-acromial bursa supports and cushions the Rotator cuff tendons. (2,44)

A Supraspinatus tear is a rupture or tear of the Supraspinatus muscle's tendon. It's a part of the shoulder's Rotator cuff, and it's usually followed by another Rotator cuff muscle tear. Some of the most common causes of the tear are trauma or repetitive micro-trauma. It may be in the form of a partial or full thickness tear. Incomplete disruption of muscle fibers is linked to partial thickness. It has the potential to transform into a full thickness tear. Muscle fibers are completely disrupted when term full thickness is used. Large tears progress at a faster pace than small tears. (45)

A Supraspinatus tendon tear may result from a variety of causes, including demographic and biochemical factors. Age(46), gender (46,47), smoking (46,48,49) , and alcohol (48) are some of the demographic variables that can trigger a Supraspinatus tendon tear. There are also biochemical factors such as genetics(46,48,50), hormonal influence (48), and hypercholesterolemia (46,51); clinical factors related to increase the risk of rotator cuff injury are repetitive stress from carrying heavy items (46), history of trauma (46), lack of blood supply(46,52), rotator cuff ageing (53), impingement lesions (54), diabetes (55,56); and sports. (57) Increased BMI, diabetes, and heavy work activity are all risk factors for a partial thickness tear, which can eventually lead to a full thickness tear. (58)

Supraspinatus tendon tears can be diagnosed using a variety of clinical tests. (45) Special investigations, such as X-rays, Magnetic resonance imaging, CT scans, and Ultrasounds, can also be used. (45)

Rotator cuff tears are a common occurrence in developed countries, and they have a considerable impact on health-care expenses. This is by far the most common cause of shoulder pain and dysfunction. Rotator cuff tears have recently received a lot of attention. Because of the Rotator cuff's anatomic placement between the Coracoacromial arch and the Humeral head, the Supraspinatus tendon is frequently injured. Leading causes of the tear have been identified as attrition, trauma, and subacromial impingement. They trigger incomplete Rotator cuff tears on the bursal side, joint side, or intra-tendinous side, as well as full thickness rotator cuff tears. Rotator cuff tears were linked to attrition in one study. (59) Degeneration of the Rotator cuff is becoming more common as people get older, and it affects patients over the age of 40. One of the causes of Rotator cuff disease has been discovered to be subacromial impingement. (60)

Particularly if non-operative treatment is being considered, surgeons must be aware of the risk factors for tear progression. (61) Knowing the warning signs for progression of a Supraspinatus tendon tear is critical for identifying the patients in the higher-risk group who need further MRI diagnosis and evaluation, as well as preventing unnecessary MRI prescriptions and lowering patient costs.

This research looked at demography, medical, and biological variables. Factors including age above fifty years, males, radiating pain, weakness, night pain, and analgesic intake had a significant association with the prevalence of tears in the Supraspinatus tendon, according to the findings.

Age: Current research shows that symptomatic Supraspinatus tendon tears were found in 77% of patients aged 51 to 70 years old, while no tears were found in 83 percent of patients under the age of 30. The chances of developing a full thickness tear are 41 times greater in older subjects (age above fifty years) than in younger subjects (age below fifty years). Similar findings were found in a study by Van Kampen et al. (24) With a prevalence of 50% and 19%, respectively, partial-thickness tears over numbered full thickness tears, according to the current research, which was also stated by Fukuda et al. (62) Over 60 years of age, an increasing occurrence of asymptomatic Rotator cuff tears has been identified (63) indicating ageing has role in their tears.

Gender: Male patients outnumbered female patients in this study, which is close to one study.(24) Other study (64) found that the average age was 57.31 years and that females outnumbered males, which is not the case in ours.

Types of **occupation** had no statistically meaningful association with the incidence of tears in this study. Other research on occupation in France who are subjected to heavy tasks found that the incidence of Rotator cuff tears was much more common.(65)

In the current study, seventy-seven percent of subjects of Supraspinatus tear group had **radiation of pain** (p-value of 0.0064), suggesting a significant association between this factor and a tear. Even though this feature was listed in the literature (57,66), there was no statistically significant correlation between it and supraspinatus tear. The sensory distribution of 5th cervical and 6th cervical spinal nerves describes pain radiation on outer aspect of upper limb till the thumb; 5th cervical and 6th cervical spinal nerves as well innervate Supra-spinatus and Infra-spinatus muscles. (67)

Ninety percent of patients with a tear had **weakness** when lifting or rotating their arm, according to the current study. Which made a significant difference (p = 0.03). That's hard to tell if an individual has pain as well as weakness. After a sub-acromial anaesthetic injection, weakness can be measured using Neer's impingement test. In other studies, patients with Rotator cuff tears reported weakness in 41% of cases. (24)

In this study, eighty percent of Supraspinatus tear group had **night pain**. Statistically, this was highly significant (p = 0.0005). One study had comparable results to our study. (67) Reason for night pain - participants experienced pain while sleeping on the painful side, which disturbed their sleep.

In this study, we observed that 80 percent of patients with a tear had a history of **analgesic intake** for shoulder pain. P value of 0.0003 suggests statistically strong relation. The pain was light at the beginning with activities and relieved by taking analgesics. But later it is even present at rest and not relieved even with analgesics. (68) There was no mention of a statistically significant association between this and supraspinatus tear. This is the **first analysis** to show that this is the case.

The number of subjects with comorbid conditions was lower in this report, which is close to Cadogan et al study.(69)

Age (70,71), Gender (70,72), Occupation (70), a mixture of ageing and uncertain blood supply of the tendon of Supraspinatus at the critical zone, frequent overhead usage of the arm, fracture, and sub-acromial impaction in the predominant shoulder, and History of trauma (66), Rotator cuff fatty infiltration prior to surgery (72) have all been studied as risk factors for the tear progression. (71)

Genetics, Hypercholesterolemia, Duration of pain, Trauma, Alcohol consumption, Co-morbidities, Obesity, and Severity of pain (Visual Analogue Scale) not in any way display a significance in this study, as they had in previous studies. Differences in study samples and designs can account for the disparity in outcomes.

Clinical tests: Individual tests: For any type of tear, the Full can test and Empty can test had 83 percent and 76 percent accuracy, respectively, while the Palpation test and Infraspinatus strength test had 91 percent and 81 percent accuracy **for full thickness tear**. **For partial thickness tear,** the Full can test and Empty can test had 68 percent and 63 percent accuracy, respectively.

Hegedus et al (21) found that the Hawkins-Kennedy test was the only one that produced+ LR >10; -LR<0.1 in a systematic analysis. Other studies, however, did not show the same result. The Neer test has been shown to be ineffective in diagnosing rotator cuff impingement. The positive Painful arc test (18) and positive External rotation lag test (18) and possibly the lateral Jobe test, (19) are the most reliable tests for diagnosing a rotator cuff tear.

External rotation lag test at zero degrees was the most effective way to diagnose full-thickness tears. (20) The Jobe test (empty can test) was found to be the most effective for diagnosing Supraspinatus tears by Gismervik et al (20) and Beaudreuil et al. (26)

According to Bak K et al., the Hawkin's test, Neer's test, Jobe's test, and Painful arc test showed great sensitivity in acute full thickness Supraspinatus tears.(73)

Combination of clinical tests: For any type of tear, a combination of the Full can test and the Drop arm test has had an accuracy of 84 percent (with a sensitivity of 92 percent). For the full thickness tear, both the Drop arm test with Palpation test and the Drop arm test with External rotation lag test at zero degrees had fair to reasonable agreement with MRI (k=0.55,0.42, respectively). **For the full thickness tear** Palpation test with Infraspinatus strength test and Palpation test with External rotation lag test at zero degrees had fair to strong agreement with MRI (k=0.51, k=0.66). **For partial thickness tears**, none of the combinations has at least a fair to good agreement with MRI. The current study found that combining clinical tests does not improve diagnostic accuracy significantly.

The blend of the Hawkins-Kennedy test and the Neers test was found to be diagnostically ineffective in a report by McDonald et al. (74) The Hawkins-Kennedy test, Painful arc, and Infraspinatus tests were used in Park et al's (28) study.

Prediction model: The prediction model in van Kampen et al. (24) analysis consisted of two independent factors: Age and the Neer test. The model's discriminative ability was 73 percent. The type of Rotator cuff tear was not mentioned in this report.

The current study developed three prediction models for Supraspinatus tears of any type, full thickness tear type, and partial thickness tear type.

- Four variables were included in the prediction models for any type of tear: male sex, pain radiation, night pain, and Full can test. This model had an accuracy of 83 percent.

- Age > 50, analgesic intake, ability to lift weight, and the Neer test were all included in the full thickness tear prediction model. This model had an accuracy of 85 percent.
- A partial thickness tear prediction model involves three factors: night pain, activities of daily living (ADL), and a Full can test. This model had a 75 percent accuracy rate.

Instead of relying solely on clinical tests, prediction models aid in the diagnosis by blending patient characters, symptoms, and clinical tests.

The **uniqueness** of our research is that it examines the effect of parameters such as radiation of pain, night pain, weakness, and analgesic intake on tendon tears and shoulder pain. These parameters have rarely been linked to tendon tears before. Our research is also unique in that it established prediction models for different types of Supraspinatus tendon tears.

There were, however, some **drawbacks** to this analysis. One of the study's drawbacks was its limited sample size. The study's sample size was reduced due to time constraints and a small number of patients. Another drawback of the research is that it is a single-center study, which means that the findings cannot be extrapolated to a large population.

In the **future**, a broad sample size may be suggested for a better understanding of the subject. Studies to be conducted in several locations in addition to a large sample to obtain more precise results. This will aid in a better understanding of the subject, as well as the ability to generalize the findings.

6. CONCLUSION

Supraspinatus tendon tears may result from several factors. Supraspinatus tendon tears are affected by age-category, sex, radiating pain, night pain, taking analgesics, and weakness. Knowing the risk factors for progression of a Supraspinatus tendon tear is critical for identifying the patients in the higher-risk group who need further MRI diagnosis and evaluation, as well as preventing unnecessary MRI prescriptions and lowering patient costs, which will be helpful in low-income countries. The Full can test was the single most effective clinical test for any type of tendon tear, including partial thickness tears. The Palpation test had the highest diagnostic precision for full thickness tears. Combining clinical tests does not increase diagnostic accuracy over individual tests. Prediction models combine patient characteristics, history, and clinical testing to help in diagnosis. Limitations of the study were limited sample size and single center study. In the future, a broad sample size and multi-centric study may be suggested for a better understanding of the subject.

7. SUMMARY

- Primary objective of this study was to see how accurate history and clinical testing were at detecting Supraspinatus tendon injuries.
- Here totally of 100 subjects of mean age 53.59±12.56 were considered for the study consisting of 67 male and 33 female subjects.
- All new patients over the age of 18 with a symptomatic Supraspinatus tendon tear, including males and females, were included in this study.
- Current research shows that symptomatic Supraspinatus tendon tears were found in 77% of patients aged 51 to 70 years old, while no tears were found in 83 percent of patients under the age of 30.
- Male patients outnumbered female patients in this study.
- Types of occupation had no statistical significance with the incidence of tears in this sample.
- In the current research, 77% of subjects of Supraspinatus tear group had radiation pain (p-value of 0.0064), suggesting a significant association between this factor and a tear.
- 90% of patients with a tear had weakness when lifting or rotating their arm, according to the current study. Which made a significant difference ($p = 0.03$).
- In this research, 80% of Supraspinatus tear group had night pain. Statistically, this was highly significant ($p = 0.0005$).
- In this research, we discovered that 80 percent of patients with a tear had a history of taking analgesics for shoulder pain. P value of 0.0003 suggests statistically strong relation.
- The number of subjects with comorbid conditions was lower in this report.

- Genetics, Hypercholesterolemia, Duration Of Pain, H/O Trauma, Alcohol, Comorbidities, Obesity, and Severity of pain (Visual Analogue Scale) not in any way display a scientific significance in this study, as they had in previous studies.
- For any type of tear, the Full can test and Empty can test had 83 percent and 76 percent accuracy, respectively, while the Palpation test and Infraspinatus strength test had 91 percent and 81 percent accuracy for Full thickness tear.
- Combining clinical tests does not increase diagnostic accuracy over individual tests.
- The current study developed three prediction models for Supraspinatus tears of any tear type, full thickness tear type, and partial thickness tear type with accuracy ranging from 75% to 85%.
- One of the study's drawbacks was its limited sample size and single center study.
- In the **future**, a broad sample size and multicentric study may be suggested for a better understanding of the subject.

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9. ANNEXURES

ANNEXURE I: ETHICAL CLEARANCE LETTER

KLE UNIVERSITY

(Formerly known as KLE Academy of Higher Education & Research, Belagavi)

[Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956 vide Government of India Notification No.F.9-19/2000-U.3(A)]

'Accredited 'A' Grade by NAAC   Placed in Category 'A' by MHRD (GoI)

Director, Academic Affairs

JNMC Campus, Nehru Nagar, Belagavi-590 010, Karnataka State, India

☎: 0831-2444444/2493779 **FAX:** 0831-2493777 **Web:** http://www.kleuniversity.edu.in **E-mail:** info@kleuniversity.edu.in

Ref.No.KLEU/Ethic/2015-16/D- 70   Date: 21-5-2015.

To,
Dr. Sameer Haveri
Dept. of Orthopedics,
J.N.Medical College, Belagavi
Ph.D.Scholar 2014-15

Dear Research Scholar,

Sub:- Regarding Ethical Clearance.

The KLE University **Ethics Committee on Human Subjects** for Ph. D Research Project met on **23rd March 2015** to consider your application for approval of the research project **"Diagnostic accuracy of history and clinical tests for detecting supraspinatus tendon tears in people with shoulder pain".**

As there are no ethical issues involved in your proposed research project, the committee has provided approval for this research project.

You are requested to report to Ethical Committee in case of the following:

1. Any deviation from or change of the protocol.
2. All serious adverse events.
3. Any changes in study documents.

(Dr. Anita Dalal)
Member Secretary,
Ph.D. Ethical Committee(Human),
K.L.E. University,
Belagavi.

(Dr. Anil Hogade)
Chairman
Ph.D. Ethical Committee(Human),
K.L.E. University,
Belagavi.

CC to: - The Director Academic Affairs, KLE University, Belagavi.
- The Director Research Foundation, KLE University, Belagavi.
- The Registrar, KLE University, Belagavi

ANNEXURE II: PARTICIPANT INFORMATION SHEET

TITLE OF THE STUDY: DIAGNOSTIC ACCURACY OF HISTORY AND CLINICAL TESTS FOR DETECTING SUPRASPINATUS TENDON TEARS IN PEOPLE WITH SHOULDER PAIN

OBJECTIVES/PURPOSE OF THE STUDY

- **Primary Objectives:** To estimate the diagnostic accuracy of history and clinical tests, singly or in combination, in diagnosing supraspinatus tendon tears in patients with shoulder pain.
- **Secondary Objectives:** To develop a prediction model, which combined patient characteristics, history, and results from a few clinical tests, for predicting the probability of a supraspinatus tear in patients with shoulder pain.
- You are invited to participate in this research as you are suffering from shoulder pain.
- All patients with shoulder pain with age more than 18 years, both males and females are recruited in this study.
- Dr. Sameer Haveri is the principal investigator and the study will be conducted under the direct supervision of Dr Kiran Patil.
- Funding of the study: Investigations bill is paid by you.

PROCEDURES

- If you consent to be in this study, the relevant data is collected as per the proforma provided to you. You will undergo a history taking and clinical examination, blood investigations, X-Ray shouder and Magnetic Resonance Imaging of affected shoulder.

- This can be performed within 2 hours.
- You will be asked to undergo this procedure only once.
- Any of the procedures will not cause much pain or discomfort to you.
- Any of the procedures will not cause any temporary or lasting problems to you.

RISKS AND BENEFITS:

- Benefits to the patient in the study
  1. It will act as a diagnostic tool for the patients in the study by providing information regarding the presence of the disease.
  2. Will help to initiate therapy once the diagnosis is confirmed.
- Benefits to the community at large
  1. The data obtained from the study will help to provide information on the diagnosis of the supraspinatus tear which will be then a basis for initiation of treatment procedures.

RISKS: There are no risks associated with this study.

ALTERNATIVES

- Other options: Ultrasonography or Arthroscopy of shoulder may be needed to diagnose and treat your condition.
- If you decline to participate in the study, your decision will not change the present or future health care or other services that you will receive. The treatment given to you will be the standard treatment for your condition.
- You're told about the new information of this study.

WITHDRAWING / REMOVAL FROM THE STUDY:

- You can withdraw from the study during anytime you want
- You will not be penalized for the withdraw from the study
- You can be removed from the study if you do not fulfil the inclusion criteria.

PRIVACY AND CONFIDENTIALITY:

- All information about the subject during the course of the study will be kept confidential to the extent permitted by law. The code numbers will identify the subject in this research record.
- Information from this study may be published but the subject's identity will be confidential in any publication.

INSTITUTIONAL/SPONSORS POLICY

- Injury as a result of participation in study is very rare and if any such injuries occur, it will be treated free of cost.

FINANCIAL INCENTIVES FOR PARTICIPATION

- No incentives will be given for participation in the study.
- There will be no reimbursement for your expenses.

CONTACT DETAILS

If any enquiries in the future or in case of study related problems you may contact following person.

1. Dr. Kiran Patil, Professor **,**Department of Orthopaedics, KAHER J. N. Medical College, Belgavi
2. Dr. Sameer Haveri, Associate Professor, Department of Orthopaedics, KAHER J. N. Medical College, Belgavi. Mobile No. 9844333082

AUTHORIZATION TO PUBLISH RESULTS

- The results of the study are published in the indexed journals

Participants Name	Participants Signature
Investigators Name	Investigators Signature
Witness's Name	Witness's Signature
Date	
Place	

INFORMED CONSENT FORM

- The details of the research study in which I am expected to participate, for which I have to undergo history taking, clinical examination and Magnetic Resonance Imaging of my shoulder have been explained to me.
- I willingly, under no pressure from the researcher agree to take part in this study, and agree to participate in all investigations. I may withdraw at any time. I am not giving up any of my legal rights by signing this form.
- My signature below indicates that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form.

SIGNATURE OF THE PARTICIPANT OR LEGALLY AUTHORIZED REPRESENTATIVE

Participants Name	Participants Signature
Investigators Name	Investigators Signature
Witness’s Name	Witness’s Signature
Date	
Place	

ANNEXURE III: PROFORMA

TITLE: DIAGNOSTIC ACCURACY OF HISTORY AND CLINICAL TESTS FOR DETECTING SUPRASPINATUS TENDON TEARS IN PEOPLE WITH SHOULDER PAIN

- Hospital Name: KLE'S Dr Prabhakar Kore Hospital & MRC, Belagavi, Karnataka, India.

I.P/ OPD NO:

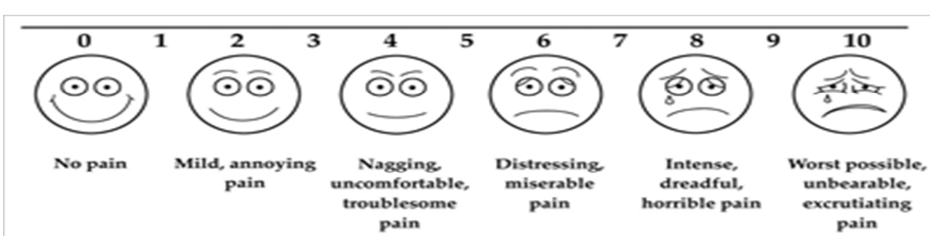
Name: Age/sex:

Address: Phone no:

Occupation

HISTORY

- Pain in which shoulder? Right /Left
- Dominant Arm? Right /Left
- Pain in shoulder since how long?
- Weakness in shoulder since how long?
- Range of motion of shoulder? Stiffness?
- **Pain :**
  - Severity of pain? VAS (Visual Analogue Scale)



  - Localisation- anterior/lateral?
  - Is pain worsening?
  - Radiation?
  - Aggravating factors?
  - Relieving factors?
  - Do you take pain medication?
  - Night pain?
  - Is your shoulder comfortable with your arm at rest by your side?
- Limitation in ADL (Activities of Daily Living)?
- Lift weight to shoulder level without bending elbow?
- H/O Trauma?
- H/O Smoking?
- H/O Co-morbidities?
  - Diabetes mellitus
  - Hypertension
  - Thyroid disease
  - Hypercholesterolemia
  - Others
- Is he taking treatment/ taken treatment?
- Any other, Family history of rotator cuff tears?

CLINICAL EXAMINATION

PR: BP:

HEIGHT: WEIGHT: BMI:

SYSTEMIC EXAMINATION

CVS/RS/PA/CNS

LOCAL EXAMINATION OF SHOULDER

Inspection:

- Wasting of suprspinatus and infraspinatus
- Asymmetry of biceps muscle
- Observe the alignment of the shoulder girdle
- Observe the position of the scapula on the thorax

Palpation:

- Tenderness is elicited at the insertion of the tendons to the humerus
- Palpation of rent in the tendon

Range of motion:

- Range of motion should be performed first actively and then passively.
- Active ROM
- Passive ROM
- **Apley scratch test**

  (Note: Internal and external rotation of the glenohumeral joint should be tested **with the arm abducted to 90** and **the patient supine.** Shoulder abduction and forward flexion should be tested with the **patient standing** to assess total active range of motion available and to assess the scapulohumeral rhythm.)

Strength testing:

Tests	**Right shoulder** (Affected/Control)	**Left shoulder** (Affected/Control)
Supraspinatus strength		
Infraspinatus and teres minor strength		
Thoracoscapular muscles – ➢ The upper, middle and lower trapezius, ➢ Rhomboids, ➢ Levator scapula, ➢ Serratus anterior		
Pectoralis major and minor strength		

CLINICAL TESTS:

Tests for supraspinatus	**Right shoulder** (Affected/Control)	**Left shoulder** (Affected/Control)
1. Neers Impingement Test		
2. Hawkins –Kennedy's Test		
3. Drop arm Test		
4. Full Can Test		
5. Painful Arc Test (Positive at how many degrees? Use goniometer)		
6. Empty Can Test (Jobe Test)		
7. Palpation Test		
8. External Rotation Lag Test at 0 degrees		
9. Supraspinatus strength test		
10. Infraspinatus strength test		

Note: Do tests on both shoulders / other shoulder is control

Tests	**Right shoulder** (Affected/Control)	**Left shoulder** (Affected/Control)
Subscapularis tests		
Infraspinatus tests		
Teres minor tests		
Biceps tests		
Acromioclavicular joint Tests		
Labral Tests		

NEUROVASCULAR EXAMINATION

CLINICAL DIAGNOSIS

BLOOD INVESTIGATIONS:

HB TC DC

ESR, CRP,

RBS, SR.CREATININE,

HIV, HBSAG

XRAY SHOULDER- AP view and Scapular Y view

MRI SHOULDER (reference standard)

- **Period between index test and reference standard:** Same day
- **Report:**
- **Size of tear in centimeters?**

FINAL DIAGNOSIS

Follow-up: No follow-up done

Is treatment given to patients in the same setting? Yes

What treatment given?

<u>ANNEXURE IV:</u> PUBLICATIONS

A Cross-Sectional Study on Novel-Risk Factors Associated with Supraspinatus Tendon Tear

Sameer Haveri, Kiran S. Patil, Rajendra B. Uppin, Santosh Patil & B. B. Putti

ONLINE FIRST

Indian Journal of Orthopaedics

ISSN 0019-5413

JOIO
DOI 10.1007/s43465-020-00222-3

Springer

Indian Journal of Orthopaedics
https://doi.org/10.1007/s43465-020-00222-3

ORIGINAL ARTICLE

A Cross-Sectional Study on Novel-Risk Factors Associated with Supraspinatus Tendon Tear

Sameer Haveri[1] · Kiran S. Patil[1] · Rajendra B. Uppin[1] · Santosh Patil[2] · B. B. Putti[3]

Received: 16 February 2020 / Accepted: 2 August 2020

Abstract

Background and Aim Several patient-related factors have been identified which are responsible for the development of rotator cuff tears. The purpose of the study was to assess various parameters which can be risk factors for the development of supraspinatus tendon tear.

Methods A total of 100 patients with symptomatic rotator cuff tear, aged > 18 years, of either gender, presenting to the outpatient department were included in this cross-sectional study. Magnetic resonance imaging was done and based on its results; patients were identified for the type of tear. Demographic, clinical, and biochemical factors affecting the tears were assessed using logistic regression analysis.

Results Factors such as age, gender, pain radiation, night pain, and analgesic intake had significant association with supraspinatus tendon tears.

Conclusion "Pain radiation" and "Analgesic intake" were two new parameters found associated with the supraspinatus tendon tears. New parameters that have been assessed as risk factors will help in better understanding of supraspinatus tendon tears.

Keywords Magnetic resonance imaging · Shoulder pain · Rotator cuff · Analgesics · Partial tear

Introduction

Shoulder disorders rank among the most prevalent musculoskeletal disorders. Shoulder pain can be a debilitating condition and is estimated to be the third most common cause of musculoskeletal consultation in primary care [1]. A supraspinatus tear is a tear or rupture of the tendon of the supraspinatus muscle. The supraspinatus is a part of the rotator cuff of the shoulder and is accompanied with another rotator cuff muscle tear in most cases. Trauma or repeated micro-trauma can cause such tears. It is present as a partial or full-thickness tear [2]. The incidence of partial tears in a study was found to be 28.7% and the incidence of complete rupture was found to be 30.3% [3].

There are a number of risk factors which can lead to supraspinatus tear; genetics [2, 4, 5], demographic factors such as age [4, 6], gender [4, 7], smoking [2, 4, 8], and alcohol [2]; biochemical factors such as hormonal influence [2], hypercholesterolemia [4, 9]; clinical factors including repetitive stress of lifting heavy objects [4], history of trauma [4], lack of blood supply [4, 10], ageing of rotator cuff [11], impingement lesions [12], diabetes [13, 14], and athletes have a greater risk of having a rotator cuff injury [15]. For partial tear, increased body mass density (BMI), diabetes, and practice of heavy work can be risk factors and may, eventually, lead to the development of complete/full-thickness tear [16].

It is important for surgeons to know the risk factors for tear progression, especially when non-surgical treatment

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Published online: 10 August 2020

is considered [17]. The knowledge of the risk factors concerning tear progression after clinical examination is important to identify the high-risk group of patients that needed further MRI diagnostic and assessment. The purpose of the study was to assess various parameters which can be risk factors for the development of supraspinatus tendon tear.

Methods

One hundred thirty-four consecutive patients with symptomatic rotator cuff tears visited our centre between June 2015 and August 2017. Of these, 100 new patients (100 shoulders) who underwent evaluation by history taking, clinical examination and magnetic resonance imaging (MRI) were enrolled. Patients aged more than 18 years, of either gender, were included. Patients with shoulder fractures, previously treated rotator cuff tears, frozen shoulder, arthritis, previous dislocation shoulder, and instability were excluded. The study was initiated after obtaining ethical approval by the Institutional ethical committee. After obtaining informed consent, all patients were evaluated by an orthopaedic surgeon. All patients underwent MRI of the shoulder, on the same day. Based on its findings, type of supraspinatus tear was identified as partial-thickness tear, complete/full-thickness tear, or no tear. The clinical examiners and MRI reporters were not the same and were blinded at each other's findings.

Variables were selected based on AIC (Akaike information criterion)/BIC (Bayesian information criterion) values [18]. Demographic details including age, gender, occupation, and clinical features such as night pain, reduced range of motion, weakness, duration of pain, and biochemical data(serum cholesterol level) of the patients were collected using a structured questionnaire.

Statistical Analysis

Data analysis was done using R i386.3.5.1. Continuous data were represented in the form of mean ± SD and the categorical variable was represented by the frequency table. Association between categorical variables was studied using Chi-square test/Fisher's test. Continuous data were compared using *t* test/Mann–Whitney *U* test. Trend test was done using Cochran–Armitage test. Logistic regression was used to study the factors affecting different stages of tear. p value of < 0.05 was considered statistically significant.

Results

Of the 100 subjects, 69 subjects were with supraspinatus tendinous tear which was either partial (50) or complete/full-thickness (19). Most of the subjects in the group were in the age group of 51–70 years. There was a linear trend in the proportion of tear (partial + complete) by age group ($p = 0.0188$). Mean age of subjects with complete/full-thickness tear and partial-thickness tear was significantly different ($p = 0.0199$). Out of 100 subjects, male predominance was observed. Type of occupation and trauma did not show any statistical significance in this study. Proportion of tear among male subjects was significantly ($p = 0.0296$) more than that of female subjects (Tables 1, 2).

Using logistic regression, age, gender, pain radiation, night pain, analgesics intake, and weakness was observed to significantly affect the total tear (Table 3).

VAS visual activity score, *ROM* range of motion, *BMI* body mass index, *ADL* activities of daily living.

Age, gender, pain radiation, night pain, analgesics intake, and weakness significantly affected the complete/full-thickness tear. While, for partial tear gender, radiation of pain, duration of pain, and night pain affected partial tear. For elder subjects (≥ 50 years), odds of having complete/full-thickness tear was 40.65 higher than in subjects of age < 50 years. Odds of having complete/full-thickness tear was 10 and partial tear was 4.34 times higher for female subjects, as compared to male subjects. Odds of having complete/full-thickness tear was 8.67 times higher for subjects with weakness. Subjects with night pain are 3.8 times more likely to have partial tear. Odds of being complete/full-thickness tear was 4.59 times higher for subjects with analgesics intake (Table 4).

Discussion

The knowledge of the risk factors concerning supraspinatus tendon tear progression is important to identify the high-risk group of patients that needed further MRI diagnostic and assessment, which also helps in avoiding unnecessary MRI prescriptions, and reducing the financial burden on the patients.

In the present study, demographic, clinical, and biochemical factors were evaluated. The most important findings of the present study were the factors such as age more than or equal to 50 years, male gender, radiation of pain, weakness,

Table 1 Demographic details of the participants

Factor	Sub-category	Total screened	With tear (partial tear + complete/full-thickness tear)	Without tear	With partial tear	With complete/full-thickness tear
Age group	≤30	6	1 (16.67%)	5 (83.33%)	1 (100%)	0 (0%)
	31–50	29	17 (58.62%)	12 (41.38%)	14 (82.35%)	3 (17.65%)
	51–70	57	44 (77.19%)	13 (22.81%)	32 (72.73%)	12 (27.27%)
	≥71	8	7 (87.5%)	1 (12.5%)	3 (42.86%)	4 (57.14%)
Age	Mean ± sd	53.59 ± 12.56	56.20 ± 11.37	47.77 ± 13.29	54.26 ± 11.16	61.32 ± 10.55
Gender	Male	67	41 (61.19%)	26 (38.81%)	30 (73.17%)	11 (26.83%)
	Female	33	28 (84.85%)	5 (15.15%)	20 (71.43%)	8 (28.57%)
Occupation	Govt. worker	27	20 (74.07%)	7 (25.93%)	16 (80%)	4 (20%)
	Private worker	16	9 (56.25%)	7 (43.75%)	8 (88.89%)	1 (11.11%)
	Security	2	0	2 (100%)	–	–
	Self employed	12	7 (58.33%)	5 (41.67%)	4 (57.14%)	3 (42.86%)
	Housewife	34	27 (79.41%)	7 (20.59%)	18 (66.67%)	9 (33.33%)
	Others	9	6 (66.67%)	3 (33.33%)	4 (66.67%)	2 (33.33%)
Occupation	Light jobs	78	56 (71.79%)	22 (28.21%)	42 (75%)	14 (25%)
	Heavy jobs	22	13 (59.09%)	9 (40.91%)	8 (61.54%)	5 (38.46%)

VAS visual activity score, *ROM* range of motion, *BMI* body mass index, *ADL* activities of daily living

night pain, and analgesic intake had statistically significant relationship with the presence of supraspinatus tendon tears.

In the present study, 77% of patients aged between 51 and 70 years had symptomatic supraspinatus tendon tears and 83% of patients aged less than 30 years had no tears. For elder subjects (≥ 50 years), odds of having complete/full-thickness tear was 40.65 higher than in subjects of age < 50 years. Van Kampen et al. [19] study found similar results. Present study also reveals that partial-thickness tears were more common than full-thickness tears with the prevalence of 50% and 19%, respectively, which was also reported by Fukuda et al. [20]. Increasing incidence of asymptomatic rotator cuff tears, as high as 54%, above 60 years of age has been reported [21] suggesting rotator cuff lesions as natural correlate of aging.

In the present study, male patients were more in number than females which shows similarity with Van Kampen et al.'s [19] study. In the study conducted by Sgroi et al. [22], mean age was found to be 57.3 ± 12.0 years and females were more in number in their study which is in contrast with our study.

In the present study, types of occupation did not show any statistically significant correlation with the presence of tears. The prevalence rate of rotator cuff tears reported in other studies on French workers exposed to repetitive work was even higher, ranging between 29% in highly exposed workers and 16% in weakly exposed workers [23].

Radiation of pain in this study was seen in 77% of patients with tear, and its p value was 0.0064, suggesting highly significant association of this factor with tear. Though this feature was mentioned in various literature [15, 24], its statistical significant association with supraspinatus tear was not reported. This is the first study to report the same. Pain radiation to lateral part of arm, elbow, forearm and thumb side of the hand is explained by the C5 and C6 nerve supply of the dermatomes; C5 and C6 nerves also supply supraspinatus and infraspinatus muscles [25].

In the present study, weakness when lifting or rotating the arm was seen in 90% of patients with tear. This was statistically significant ($p = 0.03$). It is difficult to assess if the patient has both pain and weakness. In such cases, weakness can be assessed after giving sub-acromial anaesthetic injection as explained in Neer' s impingement test. 41% of patients of rotator cuff tear experienced weakness in other studies [19].

In this study, we found that night pain was present in 80% of patients with tear. This was strongly statistically significant ($p = 0.0005$). Similar results were seen by Holtby et al. [25]. The cause for the pain at night was when patients lie on the painful side at night, they experience pain and which disturbs their sleep.

In this study, we found that the history of analgesic intake for shoulder pain was present in 80% of patients with tear. This was strongly statistically significant

Table 2 Clinical features of the participants

Factor	Sub-category	Total screened	With tear (partial tear + complete/full-thickness tear)	Without tear	With partial tear	With complete/full-thickness tear
Dominant arm	Right	98	67 (68.37%)	31 (31.63%)	48 (71.64%)	19 (28.36%)
	Left	2	2 (100%)	0 (0%)	2 (100%)	0 (0%)
Weakness	Present	31	28 (90.32%)	3 (9.68%)	13 (46.43%)	15 (53.57%)
	Absent	69	41 (59.42%)	28 (40.58%)	37 (90.24%)	4 (9.76%)
Reduced ROM	Absent	86	59 (68.6%)	27 (31.4%)	44 (74.58%)	15 (25.42%)
	Present	14	10 (71.43%)	4 (28.57%)	6 (60%)	4 (40%)
VAS	Mean ± sd	5.48 ± 1.31	5.54 ± 1.29	5.35 ± 1.38	5.42 ± 1.34	5.84 ± 1.12
	Median[range]	5.5 [3, 9]	5 [3, 9]	6 [3, 9]	5 [3, 9]	6 [4, 8]
Pain location in shoulder	Anterior	35	23 (65.71%)	12 (34.29%)	14 (60.87%)	9 (39.13%)
	Lateral	60	43 (71.67%)	17 (28.33%)	34 (79.07%)	9 (20.93%)
	Posterior	1	0	1 (100%)	–	–
	Others	4	3 (75%)	1 (25%)	2 (66.67%)	1 (33.33%)
Radiation of pain	No	35	19 (54.29%)	16 (45.71%)	14 (73.68%)	5 (26.32%)
	Yes	65	50 (76.92%)	15 (23.08%)	36 (72%)	14 (28%)
Night pain	Present	77	62 (80.52%)	15 (19.48%)	45 (72.58%)	17 (27.42%)
	Absent	23	7 (30.43%)	16 (69.57%)	5 (71.43%)	2 (28.57%)
Pain in which shoulder	Right	66	46 (69.7%)	20 (30.3%)	31 (67.39%)	15 (32.61%)
	Left	34	23 (67.65%)	11 (32.35%)	19 (82.61%)	4 (17.39%)
Duration of pain	< 1 month	7	4 (57.14%)	3 (42.86%)	2 (50%)	2 (50%)
	1– < 3 months	33	19 (57.58%)	14 (42.42%)	10 (52.63%)	9 (47.37%)
	3– < 1 year	45	32 (71.11%)	13 (28.89%)	26 (81.25%)	6 (18.75%)
	≥ 1 year	15	14 (93.33%)	1 (6.67%)	12 (85.71%)	2 (14.29%)
Are you taking analgesic?	Yes	67	54 (80.6%)	13 (19.4%)	37 (68.52%)	17 (31.48%)
	No	33	15 (45.45%)	18 (54.55%)	13 (86.67%)	2 (13.33%)
Is shoulder comfortable with arm at your side?	Yes	95	64 (67.37%)	31 (32.63%)	46 (71.88%)	18 (28.13%)
	No	5	5 (100%)	0 (0%)	4 (80%)	1 (20%)
Is ADL (activities of daily living) limited?	Yes	43	31 (72.09%)	12 (27.91%)	16 (51.61%)	15 (48.39%)
	No	57	38 (66.67%)	19 (33.33%)	34 (89.47%)	4 (10.53%)
Do you lifting weight to shoulder level without bending elbow?	Yes	58	35 (60.34%)	23 (39.66%)	32 (91.43%)	3 (8.57%)
	No	42	34 (80.95%)	8 (19.05%)	18 (52.94%)	16 (47.06%)
History of trauma?	No	73	50 (68.49%)	23 (31.51%)	37 (74%)	13 (26%)
	Yes	27	19 (70.37%)	8 (29.63%)	13 (68.42%)	6 (31.58%)
History of smoking?	No	80	53 (66.25%)	27 (33.75%)	39 (73.58%)	14 (26.42%)
	Yes	20	16 (80%)	4 (20%)	11 (68.75%)	5 (31.25%)
Comorbidities?	No	52	33 (63.46%)	19 (36.54%)	25 (75.76%)	8 (24.24%)
	Yes	48	36 (75%)	12 (25%)	25 (69.44%)	11 (30.56%)
BMI	Mean ± sd	26.16 ± 3.27	26.33 ± 3.56	25.77 ± 2.50	26.10 ± 3.59	26.95 ± 3.52

VAS visual activity score, *ROM* range of motion, *BMI* body mass index, *ADL* activities of daily living

Table 3 Factors affecting the overall tear

Factors	Complete/full-thickness tear		
	Estimate	OR [95% CI]	*p* value
Age (years)			
≥50	1.4667	4.3349 [1.6777–11.9818]	0.0032*
<50	Reference		
Gender			
Male	− 0.9410	0.3903 [0.1550–0.9468]	0. 0402*
Female	Reference		
Radiation of pain			
Yes	− 1.3699	0.2541 [0.0.0900–0.6550]	0.0064*
No	Reference		
Duration of pain (months)			
<1 month	Reference		
1–3 months	− 0.7811	0.4579 [0.0424,4.3079]	0.5090
3 months–<1 year	− 1.0364	0.3547 [0.0325,3.1835]	0.3779
≥1 year	1.4866	4.4221 [0.2510,153.9441]	0.3434
Weakness			
Present	1.1246	3.0846 [1.1340,8.8177]	0.0300*
Absent	Reference		
Night pain			
Present	2.5964	13.4150 [3.5601,72.2582]	0.0005*
Absent	Reference		
Analgesic intake			
Yes	1.7346	5.6667 [2.2890,15.1494]	0.0003*
No	Reference		

Residual deviance is 149.62 AIC: 169.62

($p = 0.0003$). Initially, the pain may be mild and only present when lifting the arm over the head, such as reaching into a cupboard. Over-the-counter medication, such as aspirin or ibuprofen, may relieve the pain initially. Over time, the pain may become more noticeable at rest, and does not reduce even with medications [26]. Its statistically significant association with supraspinatus tear was not reported. This is the first study to report the same.

In the current study, subjects with comorbid conditions were less in number which is similar to the study done by Cadogan et al. [27].

Number of studies have investigated risk factors associated with the progression of asymptomatic tears into symptomatic tears like age [28, 29], gender [28, 30], occupation [28], dominant arm, and history of trauma, combination of aging, and precarious vascularity of the supraspinatus tendon at the critical portion, repeated use of the arm above the horizontal level, injury, and subacromial impingement [24] preoperative fatty infiltration of the rotator cuff [30] which have shown significant effect on rotator cuff tear [29]

In the current study, risk factors such as genetics, hypercholesterolemia, duration of pain, trauma, smoking, comorbidities, obesity, pain severity (VAS) did not show any statistically significant correlation as seen in other studies. Difference in the results can be due to the difference in study types and designs.

Assessing the effect of parameters like radiation of pain, night pain, weakness, analgesic intake on the tendon tears, and shoulder pain is the novelty of our study as these parameters have not been correlated with the tendon tear before. However, some limitations are small sample size and a single-centre study. Future prospective is a study with a large number of patients in multiple centres for better understanding.

Conclusion

There are various risk factors that affect the supraspinatus tendon tears. Factors like age, gender, radiation of pain, night pain, analgesics intake and weakness significantly affect supraspinatus tendon tear. Insight into these risk factors is essential to identify the "high-risk group" of patients that needed further MRI diagnostic and assessment. This knowledge of risk factors will reduce unnecessary prescription of MRI and thus are helpful in low-economy countries.

Table 4 Factors affecting the complete/full-thickness tear and partial tear

Factors	Complete/full-thickness tear			Partial tear		
	Estimate	OR [95% CI]	*p* value	Estimate	OR [95% CI]	*p* value
Age (years)						
≥50	3.7050	40.6523 [8.7214,189.4895]	<0.0001*	0.6070	1.8349 [0.6167,5.4589]	0.2752
<50	Reference					
Gender						
Male	− 2.2351	0.1070 [0.0239,0.4787]	0.0035*	− 1.4693	0.2301 [0.0591,0.8962]	0.0342*
Female	Reference					
Radiation of pain						
Yes	− 1.6136	0.1992 [0.064,0.6570]	0.0081*	− 0.3659	0.6936 [0.2377,2.0243]	0.0532*
No	Reference					
Duration of pain (months)						
≥12	0.5560	1.7437 [0.1089,27.9109]	0.6943	2.5751	13.1330 [0.9620,179.2966]	0.0535*
3– <12	− 1.4801	0.2276 [0.0341,1.5212]	0.1267	0.2444	1.2769 [0.2236,7.2919]	0.7833
1–3	− 0.6083	0.5443 [0.0824,3.5934]	0.5276	− 1.2735	0.2799 [0.0444,1.7648]	0.1753
<1	Reference					
Weakness						
Present	2.1595	8.6672 [2.5190,29.8211]	0.0006*	0.6164	1.8522 [0.5854,5.8605]	0.2942
Absent	Reference					
Night pain						
Present	− 0.0737	0.9290 [2511,3.4364]	0.9121	1.3374	3.8091 [1.0981,13.2132]	0.0351*
Absent	Reference					
Analgesic intake						
Yes	1.5249	4.5946 [1.3619,15.5004]	0.0139*	0.8479	2.3347 [0.8001,6.8131]	0.1207
No	Reference					

Residual deviance 263.11 Aic:303.11 Accuracy = 75.76%; No tear is taken as reference

Author contributions All the authors have contributed equally in developing the manuscript.

Compliance with ethical standards

Conflict of interest No potential conflicts of interest relevant to this article were reported.

Ethical standard statement Ethical approval was granted by the KLE University Ethics Committee on Human Subjects (KLEU/Ethic/2015-16/D-70). Signed written consent was obtained from all participants.

Informed consent The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Original Article

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Quick Response Code:
Website:
www.ijournalhs.org
DOI:
10.4103/kleuhsj.kleuhsj_168_18

The diagnostic value of the combination of clinical tests for the diagnosis of supraspinatus tendon tears

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Abstract:

CONTEXT: A large number of special tests have been described to examine the shoulder. It is unknown which combination of clinical tests might be optimal for the diagnosis of rotator cuff tears.

AIMS OF OUR STUDY: To estimate the diagnostic accuracy of history and clinical tests and to find out which combination of clinical tests is best in diagnosing supraspinatus tendon tears.

SETTINGS AND DESIGN: Diagnostic test accuracy study.

METHODOLOGY: One hundred and thirty-four patients with shoulder pain were evaluated with history-taking and clinical tests and magnetic resonance imaging of the shoulder.

STATISTICAL ANALYSES: Sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratios were calculated with a 2 × 2 table.

RESULTS: The combination of Neer test, painful arc test, and full can test yielded 100% sensitivity and 100% specificity in diagnosing supraspinatus tears of any type.

CONCLUSIONS: Our study shows that individual clinical tests have moderate diagnostic value for the diagnosis of supraspinatus tears. Diagnostic value improves significantly when clinical tests are combined together. Neer test, painful arc test, and full can test form the best combination in diagnosing supraspinatus tears of any type.

Keywords:

Clinical tests, diagnostic accuracy, magnetic resonance imaging, supraspinatus tendon tears

Introduction

Rotator cuff tears are the common cause of shoulder pain and dysfunction.[1,2] The prevalence of rotator cuff tears is 5%–39%.[1] Clinical tests should be used selectively and tailored to the clinical condition suspected.[3,4] Recent meta-analysis showed that data were lacking to support most clinical tests used for diagnosing rotator cuff tears, and there is a need for high-quality studies to test the diagnostic performance of parameters from patient history and physical examinations.[5-7] The study was done to estimate the diagnostic accuracy of clinical tests and to find out which combination of clinical tests is best in diagnosing supraspinatus tendon tears.

Methodology

This prospective study was conducted in the orthopedic department of our hospital from June 2015 to August 2017.

Patient selection

Patients presenting with shoulder pain of age above 18 years of either sex was included in the study. Patients with shoulder fractures, frozen shoulder, arthritis, bilateral shoulder pain, previous dislocation shoulder, and instability were excluded. Ethical clearance has been taken from ethical committee before conducting the study.

How to cite this article: Haveri S, Uppin RB, Patil K. The diagnostic value of the combination of clinical tests for the diagnosis of supraspinatus tendon tears. Indian J Health Sci Biomed Res 2019;12:91-6.

Control

Unaffected opposite shoulder joint was taken as control in our study.

Study design

Diagnostic test acuuracy study design.

Calculating the sample size

The targeted study population consists of all patients who satisfy the criteria for inclusion and are not disqualified by one or more of the exclusion criteria. The included patients were a consecutive series of patients presenting at the study center. No randomization was done. The sample size was calculated assuming a sensitivity and specificity of at least 0.85, the confidence interval of 95% with a width of 0.1 and an effect size of 0.5, leading to sample size of 70 patients with the power of 0.9.[8]

Data collection

The patients of shoulder pain were evaluated by history and clinical examination. The examiner was blinded to the imaging analyses. Subsequently, all patients underwent X-ray of the shoulder and magnetic resonance imaging (MRI) of the involved shoulder as a reference standard for the final diagnosis, which was done on the same day [Figure 1].

Relevant clinical information

Appropriate demographical and historical data were recorded.

Intervention

Routine clinical examination of the shoulder was performed, and then, clinical tests were selected for evaluation in the study [Table 1].[2,3,7] Blood tests and other investigations were done.

Plain X-ray films of the shoulder were useful to rule out other causes of shoulder pain, such as osteoarthritis (of glenohumeral joint and acromioclavicular joint) and calcific tendinitis. Changes seen on plain films that are consistent with rotator cuff disease include acromial spurs, decreased space between the humerus and acromion, and sclerosis and cystic changes in the greater tuberosity.

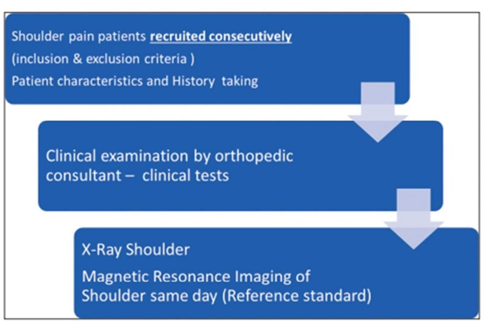

Figure 1: Methodology-data collection

Reference standard–magnetic resonance imaging

Experienced radiologist who was blinded from clinical test results reported the MRI. MRI gives a great deal of anatomic information and usually is considered the gold standard for imaging cuff disease. The normal rotator cuff tendon is of low signal on T1- and T2-weighted images. Partial-thickness rotator cuff tears most commonly appear as interruption of the normal cuff contour, resulting in a cuff defect filled with fluid signal. Full-thickness tears were seen as defect has fluid-like signal and might also see tendon retraction.[9-11]

Data analyses/statistical analyses

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio, and negative likelihood ratios were calculated with a 2 × 2 table.

Results

One hundred and thirty-four (134) patients were collected. Thirty-four patients were excluded as per inclusion and exclusion criteria. Effective sample size was (134–34) 100. Table 2 shows patient's demographic characteristics. Sixty-seven patients were diagnosed with supraspinatus tendon tears. Males were affected more commonly. Right shoulder has higher incidence of supraspinatus tendon tears. Table 3 shows different types of rotator cuff tears and their frequency. Incidence of supraspinatus tears was higher as compared to other tendons and partial tears were more common. Tables 4 and 5 show various MRI diagnoses and their frequencies. Partial tear of supraspinatus tendon was the most common diagnosis. Twenty-four patients had other diagnosis [Table 5] and nine patients had normal shoulder on MRI.

History

The highest incidence of supraspinatus tendon tears was seen in the age group above 50–60 years, which was clinically significant ($P = 0.009$). Night pain has showed the highest sensitivity. Weakness and smoking have highest specificities [Table 6].

Clinical tests

Painful arc test has highest sensitivity of 96%. Palpation test, external rotation at 0°, and drop arm test have highest specificity of 100%, 100%, and 97%, respectively.

Table 1: Clinical tests

Clinical tests	Method to perform	Inference
Neer test	The impingement sign is elicited with the patient seated and the examiner standing. Scapular rotation is prevented with one hand while the other hand raises the arm in forced forward elevation, causing the greater tuberosity to impinge against the acromion	A positive test is if the maneuver produces pain over the anterolateral shoulder
Hawkins-Kennedy test	The examiner forward flexes the humerus to 90° and forcibly internally rotates the shoulder. This maneuver drives the greater tuberosity farther under the coracoacromial ligament	Pain over the anterolateral shoulder with this maneuver is considered positive for impingement
Drop arm test (Codman's sign)	It and is performed by passively abducting the patient's shoulder to 180° and then observing as the patient slowly lowers the arm to the waist. The patient may be able to lower the arm slowly to 90° (because this is a function mostly of the deltoid muscle as opposed to the supraspinatus) but will be unable to continue the maneuver as far as the waist	This test is positive when the arm drops to the side
Full can test	The full can test is performed with patient's arms abducted in 90° in the scapular plane and rotated 45° externally, with the thumb pointing upward	The sign is positive when there is pain over the anterolateral shoulder or weakness at the downward pressure applied by the examiner
Painful arc test	The painful arc test was performed with the patient standing. The patient was asked to elevate the arm actively in the scapular plane, until the arm was fully elevated and then to let the arm down in the same arc	The test was considered positive when the patient demonstrated pain over the anterolateral shoulder or reported a painful catching between 60° and 120° elevation
Empty can test (Jobe test)	Test was performed with the patient standing, the shoulder in 90° abduction in the scapular plane and with full internal rotation. The thumbs were pointing toward the floor. The patient maintained this position against downward resistance applied by the examiner	The test was considered positive when the patient demonstrated weakness or pain over the anterolateral shoulder during the applied resistance
Palpation of tendon defect	Codman first described the palpation of full thickness rotator cuff tears. He described the ability to palpate a "sulcus" produced by a rent in the supraspinatus tendon. The elbow on the affected side is flexed to 90° and held in that position. The top of the humeral head is palpated with the arm rotated into internal and external rotation and then hyper extended. In external rotation, an anterior supraspinatus tear can be felt	The test was considered positive when the defect is felt
External rotation lag sign at 0°	The patient is seated with his or her back to the physician. The elbow is passively flexed to 90°, and the shoulder is held at 20° elevation (in the scapular plane) and near-maximum external rotation (i.e., maximum external rotation–5° to avoid elastic recoil in the shoulder) by the physician. The patient is then asked to actively maintain the position of external rotation as the physician releases the wrist while maintaining support of the limb at the elbow	The sign is positive when a lag, or angular drop, occurs. The magnitude of the lag is recorded to the nearest 5°. A positive test indicates posterosuperior cuff (supraspinatus and infraspinatus) deficiency
Supraspinatus strength test	It is tested with the arm in internal rotation and elevated to 90° in the plane of the scapula	It is graded from 0-5 Grade 0: No contraction or muscle movement Grade 2: Movement at the joint with gravity eliminated Grade 3: Movement against gravity, but not against added resistance Grade 4: Movement against external resistance with less strength than usual Grade 5: Normal
Infraspinatus strength test	It is measured by testing external rotation with the elbow flexed to 90° and the arm held to the side	It is graded from 0-5 Grade 0: No contraction or muscle movement Grade 2: Movement at the joint with gravity eliminated Grade 3: Movement against gravity, but not against added resistance Grade 4: Movement against external resistance with less strength than usual Grade 5: Normal

Table 2: Demography of patients

Parameters	Number (*N*)
Total patients enrolled	116, 16 cases excluded based on inclusion and exclusion criteria
Effective sample size	100
Full-thickness supraspinatus tear	18
Age (years)	32-77
Mean age (years)	61
Sex (%)	
Males	10 (55)
Females	8 (45)
Side (%)	
Right	13 (72)
Left	5 (18)
Dominant arm (%)	
Right	18 (100)
Left	00
Mean BMI (range)	26.8 (18-31)
Occupation	
Homemaker	8
Office work/desk	6
Job	
Heavy work	4

BMI: Body mass index

Table 3: Types of rotator cuff tears and their frequency

Tendon	Types of tear	*n*
Supraspinatus	Partial	49
	Complete	18
	Total	67 patients
Infraspinatus	Partial	3[a]
	Complete	00
Subscapularis	Partial	1[b]
	Complete	00

[a]1 case was associated with partial supraspinatus tear, 2nd case was associated with complete supraspinatus tear and 3rd case was associated with complete supraspinatus tear and partial subscapularis tear, [b]1 case was associated with complete supraspinatus tear and partial infraspinatus tear

Drop arm test has positive likelihood ratio of 11, suggesting that it is very useful test in ruling in the disease. Diagnostic values of individual tests and combination of tests are presented in Tables 7 and 8.

Discussion

This study evaluates diagnostic values of individual patient's characteristics, symptoms, and clinical tests in supraspinatus tendon tears. The prevalence of supraspinatus tendon tears in our study is 67%; in other studies, it is 40%.[6,12]

According to Murrell and Walton[12] and van Kampen *et al.*,[13] rotator cuff tear prediction increases with increasing age. Our study also showed increased incidence of cuff tear in 51–60 years of age group. In our study, age above 50.5 years has very significant correlation ($P = 0.009$) with

Table 4: Various magnetic resonance imaging diagnosis

MRI diagnosis	Frequency
Normal	9
Partial tear of supraspinatus tendon	49
Complete tear of supraspinatus tendon	18
Others diagnosis	24
Total	100

MRI: Magnetic resonance imaging

Table 5: Other diagnosis on magnetic resonance imaging

Diagnosis	Number of patients
Acromioclavicular joint arthritis	7[a]
SLAP tear	6[b]
Subacromial bursitis	3
Biceps tendinitis	2[c]
Supraspinatus and infraspinatus tear	2
Supraspinatus, infraspinatus, and subscapularis tear	1
Calcific tendinitis	1
Type 2 acromion	1[d]
Bankart's lesion	1[e]
Total	24

[a]4 cases were associated with partial supraspinatus tear, 1 case was associated with complete supraspinatus tear, 1 case was associated with biceps tendinitis, [b]1 case was associated with partial supraspinatus tear, [c]1 case was associated with complete supraspinatus tear, [d]1 case was associated with complete supraspinatus tear, [e]1 case was associated with partial supraspinatus tear. SLAP: Superior labral tear from anterior to posterior

supraspinatus tendon tears. Night pain has sensitivity of 89% in the study by van Kampen *et al.*, while our study showed similar result (89%). Further, radiation of pain and patients taking analgesics showed high sensitivities of 73% and 78%, respectively. Weakness has 34% sensitivity and 55% specificity in the study by van Kampen *et al.*, while our study had sensitivity of 40% and specificity of 88% for weakness.

Sensitivity of clinical tests ranged from 6% to 96%. Painful arc test showed highest sensitivity of 96%, which was also reported in study by Park *et al.*[14] Hawkins test had highest sensitivity of 95.2%.

Specificity of clinical tests ranged from 21% to 100%. Palpation test and external rotation test at 0° showed highest specificity and PPV of 100%. Drop arm test had specificity of 97%. Park *et al.* showed that infraspinatus muscle test had highest specificity of 75% and highest PPV of 90.6% for rotator cuff disease of any type. Drop arm test had highest specificity of 100%. In the study by Wolf and Agrawal,[15] the transdeltoid palpation test was found to have a sensitivity of 95.7%, a specificity of 96.8%, a PPV of 95.7%, a NPV of 96.8%, and an overall accuracy of 96.3%.

The present study (2018), Ardic *et al.*,[16] Kim *et al.*,[17] Caliş *et al.*,[18] and Itoi *et al.*[19] have MRI as reference

Table 6: Diagnostic values of various symptoms

Symptoms	Sensitivity	Specificity	PPV	NPV	+LR	–LR
Weakness	40	88	87	42	3.3	0.7
Radiation	73	52	75	49	1.5	0.5
Night pain	89	49	78	70	1.7	0.2
Are you able to lift weight without bending elbow?	51	27	59	21	0.7	1.8
History of trauma?	28	76	70	34	1.1	0.9
History of smoking?	24	88	80	36	2	0.9
Are you taking analgesics?	78	55	78	55	1.7	0.4
Is ADL limited?	45	61	70	35	1.1	0.9
Comorbidities	57	58	73	40	1.4	0.7

All values are in percentages. ADL: Activities of daily living, PPV: Positive predictive value, NPV: Negative predictive value, +LR: Positive likelihood ratio, –LR: Negative likelihood ratio

Table 7: Diagnostic values of various clinical test

Clinical tests	Sensitivity	Specificity	PPV	NPV	+LR	–LR
Neer test	90	18	69	46	1.1	0.5
Hawkins-Kennedy test	75	30	69	37	1	0.8
Drop arm test	34	97	96	42	11	0.7
Full can test	93	64	84	81	2.6	0.1
Painful arc test	96	21	72	88	1.2	0.2
Empty can test	78	73	85	62	3	0.3
Palpation test	30	100	100	41	∞	0.7
External rotation at 0°	06	100	100	34	∞	0.9
Supraspinatus strength test	84	39	74	54	1.4	0.4
Infraspinatus strength test	31	91	88	40	3	0.8

All values are in percentages. PPV: Positive predictive value, NPV: Negative predictive value, +LR: Positive likelihood ratio, –LR: Negative likelihood ratio

Table 8: Diagnostic accuracy of combination of tests

Combination of clinical tests	Sensitivity	Specificity	PPV	NPV	+LR	–LR
Neer test + Painful arc test	100	53	81	100	2.1	–1.9
Neer test + full can test	100	97	99	100	33	0
Full can test + painful arc test	100	82	92	34	5.6	–1.2
Neer test + painful arc test + full can test	100	100	100	100	∞	0

All values are in percentages, PPV: Positive predictive value, NPV: Negative predictive value, +LR: Positive likelihood ratio, –LR: Negative likelihood ratio

standard. Barth *et al*.,[20] Itoi *et al*.,[21] Park *et al*., and MacDonald *et al*.[22] have arthroscopy as reference standard. Holtby and Razmjou,[23] Murrell and Walton, and Leroux *et al*.[24] have operation as reference standard. Study designs with operation and arthroscopy as reference standard are invasive and can induce verification bias because only patients who require surgery were tested with reference standard.

According to Murrell and Walton, when all three tests are positive (supraspinatus weakness, weakness in external rotation, and impingement) or if two tests were positive and patient's age is >60 years, there is 98% chance of having the rotator cuff tear. Combined absence of these features excludes the diagnosis. According to Park *et al*., Hawkins test, painful arc test, and weakness in external rotation form the best combination in diagnosing overall impingement syndrome. According to Ardic *et al*. and McDonald *et al*., combination of Hawkins test and/or Neer test was diagnostically inaccurate. According to our study (2018), Neer test, painful arc test, and full can test form the best combination in diagnosing supraspinatus tears of any type. Individual clinical tests do not have higher sensitivity, specificity, PPV, NPV, positive likelihood ratio, and negative likelihood ratio all together, hence requiring combination of clinical tests and/or prediction model. The present study confirms that combination of clinical tests improves the diagnostic value for supraspinatus tears.

Limitation of our study

(1) Small sample size of 100 patients, but we have ensured all patients have undergone rigid protocol. (2) Examiner was not blinded about history information of the patient, which might influence the test results. Bias was tried to be avoided by performing rigid fixed order of clinical tests. (3) We did not assess every clinical test for supraspinatus tear that was published. (4) Intra- and inter-observer reliability in conducting clinical tests and in interpreting of MRI results was not studied. (5) Fatigue component leading to positive result was not studied.

Conclusions

Our study shows that individual clinical tests were less accurate in diagnosing supraspinatus tendon tears as compared to combination tests. Diagnostic value improves significantly when clinical tests are combined together. Neer test, painful arc test, and full can test form the best combination in diagnosing supraspinatus tears of any type. This study is useful in low-income countries with limited access to MRI and to limit the number of MRI ordered.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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