ULTRASOUND OF THE SHOULDER JOINT FOR IMPINGEMENT SYNDROME, CORRELATION WITH ARTHROSCOPIC SURGERY FOR OPERABILITY OF PARTIAL SUPRASPINATUS TENDON TEAR
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ABSTRACT: To show the accuracy of ultrasound studies in diagnosing impingement syndrome of the shoulder joint by correlating with arthroscopic surgery for operability of partial supraspinatus tendon tear. AIM: To correlate the sensitivity and specificity of ultrasound in the diagnosis for intrinsic causes of impingement syndrome of the shoulder joint, correlation with arthroscopic surgery and operability for supraspinatus tear. MATERIALS AND METHODS: This was a prospective study done on 40 patients clinically diagnosed with impingement syndrome who underwent ultrasound assessment. Arthroscopic correlation was done in 38 patients. OBSERVATIONS AND RESULTS: In our study of rotator cuff integrity assessment, ultrasound showed type-1 in 3(7.5%), type-2 in 10(25%), type-3 in 21(52.5%), type-4 in 3(7.5%) and type-5 in 3(7.5%) When compared to the arthroscopic surgery findings, Sensitivity and specificity of PTT was 85.5% and 75% respectively. On dynamic evaluation of shoulder joint for impingement, our present study showed grade-2 abnormality in 30 patients (75%) and 8(20%) patients had grade-1 abnormality, this was found to be statistically significant. DISCUSSION: ultrasonography can detect impingement syndrome and partial tear of the SST with high specificity and sensitivity, which makes it the most cost effective, noninvasive, rapidly performed, and widely available and most acceptable investigation to the patients. KEYWORDS: Impingement Syndrome, Full Thickness Tear, Subacromial Subcoracoid Bursal Fluid.

INTRODUCTION: The factors causing shoulder impingement can be broadly classified as:
1. Intrinsic or intratendinous factors, which are related to the intrinsic theory on the origin of impingement, and
2. Extrinsic or extratendinous factors, which are related to the mechanical theory. They can be further characterised as primary or secondary:
   a) Primary aetiology which could be either intrinsic or extrinsic factors—these cause impingement by decreasing the subacromial space or as a result of a degenerative process of the rotator cuff tendons.(¹)
   b) Secondary aetiology is the result of another process, such as instability, neurological injury, tight posterior capsule of the glenohumeral joint and muscle dysfunction the net effect of secondary causes is usually an anterosuperior translation of the humeral head, which causes impingement of the cuff against the coracoacromial arch.(²)
Musculoskeletal ultrasound has evolved over the years and has become a reliable and effective tool for the diagnosis of shoulder joint pathologies. Ultrasound can help assess, detect and diagnose using real time dynamic assessment, the diagnosis of shoulder impingement syndrome. This advantage of dynamic assessment is unmatched by other modalities such as MRI.

AIM & OBJECTIVES: Our aim is:

1. To study the anatomy, technique and the imaging pitfalls.
2. To determine the age and sex distribution of patients with impingement syndrome.
3. To correlate the sensitivity and specificity of ultrasound in the diagnosis for intrinsic causes of impingement syndrome of the shoulder joint, correlation with arthroscopic surgery and operability for supraspinatus tear.

MATERIALS AND METHODS: This was a prospective study conducted at A J. Institute of Medical Sciences, Mangalore, from December 2009 to December 2012. Prior approval was obtained from the hospital ethics committee and a written informed consent was taken from all patients. It is a hospital based study. Patients clinically diagnosed for chronic shoulder impingement, patients with shoulder pain lasting more than one month were examined clinically for symptoms and signs of impingement syndrome. Those who were diagnosed to have impingement were clinically evaluated by ultrasonography. Those patients who did not improve with conservative treatment for six weeks were arthroscopically treated unless there were surgical contraindications.

Inclusion Criteria: Shoulder pain lasting more than four weeks were evaluated for shoulder impingement.

Positive findings on clinical examination: positive Neer impingement sign, positive Hawkins and Kennedy sign, Positive Neer impingement test were performed to a few by an injection of 10 cc of 1% lidocaine into the subacromial space.(3,4,5)

Exclusion Criteria: Patients who were less than 30 years of age, with bilateral manifestation of symptoms or concomitant symptoms suggestive of other shoulder disorders, such as:

1. Cervical radiculopathy
2. Brachialgia caused by peripheral neuropathy or the thoracic outlet syndrome
3. Adhesive capsulitis (frozen shoulder)
4. Arthritis
5. Multidirectional instability
6. Secondary impingement
7. Steroid injections (in order to eliminate cases of possible cuff atrophy secondary to administration of steroids. We excluded patients who were given steroid injection into the subacromial space within two months before study or who were given more than two injections).
8. Complete SS tear with retraction of tendon.
Ultrasound Machine used: Volusion 730 Expert. High frequency probe: Linear Array SP 6-12 MHz.

Measurements to be taken and findings to look for in shoulder joint were:

a. Rotator Cuff Integrity.

b. Rotator cuff thickness.

c. Subacromial subcoracoid bursal thickness.

d. Dynamic Evaluation.

e. Dominant Limb Involvement.

   Rotator cuff to be viewed in coronal, sagittal and axial planes.

USG TECHNIQUE:

1. Evaluation of the rotator cuff integrity in the standard I and II view according to the modified 5-grade Wiener and Seitz Classification. The status of the rotator cuff was recorded on the basis of the following sonographic criteria:

   a. Type I: normal cuff contour and echogenicity, slightly hyperechoic to the deltoid muscle; no cuff discontinuity.

   b. Type II: Abnormal, non-homogenous cuff echogenicity; hypo- or hyperechoic foci within the cuff tendons, with no discontinuities of the internal or external surfaces of the cuff, diffuse cuff hypoechoogenicity with cuff thickening, especially when accompanied by thickening of subacromial bursa. Type II maybe associated with diffuse cuff inflammation or degenerative changes with disturbances in the tendon structure.

   c. Type III: Area of cuff discontinuity at the inner or outer side of the cuff tendons local loss of “anterior arc” of the cuff shape or major hyperechoic area within the cuff. This type corresponds to partial thickness tear.

   d. Type IV: Hypoechoic linear zone extending through the entire thickness of the cuff. Segmental loss of convex cuff contour and the deltoid muscle may be found pushed into the cuff defect to the degree where it is in contact with the humeral head. Visualisation of the hyaline cartilage underlying the cuff tendons “naked cartilage sign”

   e. Type V: non-visualization of the rotator cuff tendons. Subdeltoid fascia and the deltoid muscle opposed to the contour of humeral head.

2. Measurement of the rotator cuff thickness in the standard I view. The measurement was usually taken 15 mm lateral to the long biceps tendon, but in cases of partial cuff tear, it was measured at the narrowest part of the tendon; in cases with irregular tendon thickness, the measurement was taken 10, 20 and 30 mm lateral to the long biceps tendon and the average result was recorded. The mean value calculated on the basis of the three measurements allowed for estimation of overall (average) cuff thickness (within the supraspinatus and infraspinatus tendons) with one numerical value.

3. SASDB thickness Measurement should be measured between the deltoid and the SS tendon. Normally, it measures less than 2mm.
DYNAMIC STUDY - A dynamic sonography evaluation was done in all our patients in the position based on the MR study by Brossmann et al. (7) They showed on cadavers that subacromial impingement was best seen at 60° forward flexion, 60° abduction and internal rotation. This manoeuvre is also similar to the impingement test described by Neer. (8) For dynamic sonographic evaluation, our patients were instructed to elevate the arm halfway between flexion and abduction with the hand in pronation and the elbow on extension. The ultrasound probe was positioned in the coronal plane along the long axis of the supraspinatus tendon, between the acromion and the greater tuberosity of the humerus, thereby, the active movements being repeated for few times.

Dynamic Sonographic Classification of Subacromial Impingement.

Grade Clinical Finding Sonography Finding:

0  No pain elicited during shoulder motion. No evidence of anatomic impingement.
1  Pain elicited during shoulder motion. No evidence of anatomic impingement.
2  Pain elicited during shoulder motion. Evidence of soft-tissue impingement.
3  Pain elicited during shoulder motion. Evidence of upward migration of the humeral head.

OBSERVATIONS & RESULTS: A radiological study with 40 patients was undertaken to study the correlation of findings of ultrasound and arthroscopic surgery. This prospective study was carried out in 40 patients who were referred with shoulder pain and difficulty in abducting the arm from the Department of Orthopaedics. Most of these patients had shoulder pain lasting more than 3 months. General and local examinations of the patients were carried out. Patients were subjected first for ultrasound. All the patients underwent ultrasonography in sitting position. Opposite shoulder was used for comparison. All these patients after being diagnosed for impingement on ultrasound underwent arthroscopic surgery.

Patients who were more than 40 years of age, were included in this study. Our study group patients belonged to the age group of 40 to 45 and 51 to 55. Mean age of involvement is 50yrs (+/- 5.8 SD). Ozaki (9) et al have also shown in their study that the incidence of rotator cuff failure and tear increased with increasing age.

In our study, most of the patients had right shoulder involvement n=28 (70%) compared to left side n=12 (30%). In our study of rotator cuff integrity assessment, ultrasound showed type-1 in 3(7.5%), type-2 in 10 (25%), type-3 in 21(52.5%), type-4 in 3(7.5%) and type-5 in 3(7.5%). Out of the 24 arthroscopically proven cases of PTT, 16 patients had type-3 rotator cuff integrity. In our study, patient with impingement syndrome showed reduction in rotator cuff thickness when compared to the normal side, a reduction of thickness more than 1.2 mm was noted in 28 patients (67.5%) and the same was found statistically significant for detecting partial thickness tear on USG (0.0001).

SASDB effusion was noted in 32 patients on ultrasound, out of which 24 patients had partial thickness tear and 2 patients had full thickness tear, this was found to be statistically significant (0.0001). Mary.S.Holister et al (10) did a study on sonographically detected SASDB effusion and intra-articular fluid with rotator cuff tear. They found that 67 out of 163 patients had joint effusion and bursal fluid and 21 patients had rotator cuff tear. So they concluded that intra-
articular fluid when combined with SASDB had a high specificity and sensitivity in detecting rotator cuff tears.

On dynamic evaluation of shoulder joint for impingement, our present study showed grade-2 abnormality in 30 patients (75%) and 8(20%) patients had grade-1 abnormality, this was found to be statistically significant (0.0001). Pekka U. Farin et al\(^{(11)}\) described a method of shoulder sonography in which lateral and anterior elevation of the arm is used to be effective in impingement syndrome. In 102 of 381 patients studied, surgical diagnosis was available for correlation. Study showed 81% sensitivity and 95% specificity in early stages 1 and 2 of the impingement syndrome.

Out of the 40 patients, for assessment of rotator cuff integrity, our study showed normal study in 3, PTT in 31, FTT in 3 and Type-5 rotator integrity in 3 patients. When compared to the arthroscopic surgery findings, sensitivity and specificity of PTT was 85.5% and 75% respectively. US depiction of partial-thickness tear of the rotator cuff was studied by Van Holsbeeck MT et al.\(^{(12)}\) Their study reported partial-thickness tears in 17 shoulders, of which three were found to be with false-positive findings. They had got one patient with a false-negative finding. In their study, the sensitivity of ultrasound in depiction of partial-thickness tears was 93% and specificity was 94%. They got a positive predictive value of 82% and the negative predictive value of 98%. In our study, dominant limb involvement was found in 37 patients. Out of that 28 were arthroscopically proved and the same was found to be statistically significant.

**DISCUSSION:** The main pathogenic factor in the development of the Shoulder Impingement Syndrome is a rotator cuff disease, particularly a tear, which might be attributed to degenerative changes within the cuff tendons or to extrinsic factors such as shoulder trauma or a mechanical impingement of humeral head and acromion.\(^{(13,14)}\) The average age of persons with rotator cuff tear is approximately the sixth decade of life. The rotator cuff pathology leads to a disturbed balance of forces between the cuff muscles (especially the supraspinatus) and the deltoid muscle. The deltoid gains advantage and its pull leads to elevation of the humeral head with respect to the glenoid, which decreases the size of subacromial space and further aggravates the impingement of the rotator cuff and the acromion.\(^{(13,15,16)}\)

Several theories have been postulated to explain the exact mechanism of rotator cuff tears.

**Avascularity of Tendon:** There is an avascular area in the supraspinatus tendon about 1cm proximal to its insertion known as the critical zone, corresponding to the area of degeneration and rupture. Lindholm and Moseley\(^{(17)}\), felt this was where there was an anastomosis between blood vessels from the bone and those from the muscle belly. Rathbun and Macnab\(^{(18)}\) proposed that with the arm adducted and neutral, there is constant pressure of humeral head on the supraspinatus, ‘wringing’ the blood out of the tendon in the critical area. They maintain that this precedes and is not the result of degenerative changes.

**Mechanical wear:** Neer\(^{(19)}\) felt this is a mechanical process secondary to progressive wear and tear due to chronic microtrauma. He found that the anterolateral aspect of acromion was only involved with or without osteophytes from the acromioclavicular joint.
Morrison and Bigliani\textsuperscript{20,21} have described three types of Acromion:

- **Type I** – Curved – Most common.
- **Type II** – Flat.
- **Type III** – Hooked.

The shape of the acromion is a primary anatomic characteristic that is independent of age. The configuration of the acromion can be assessed with MRI\textsuperscript{22}. There is an association of acromion morphology decreasing the supraspinatus outlet and greater incidence of rotator cuff tears. Lateral or anterior downward sloping of the acromion or low lying acromion can also play a role in impingement and thereby narrowing of the supraspinatus outlet\textsuperscript{23}. Anterior downward sloping of the acromion can be seen on sagittal MRI, whereas lateral downward sloping of the acromion can be seen on coronal MRI. Most rotator cuff pathologies are related to cuff failure. Epidemiological and pathological studies have shown that the incidence of rotator cuff fibre failure, resulting in rotator cuff tears increase with age. Cuff fibre failure probably commences as degenerative process (tendinopathy) and progresses through partial thickness tears to full thickness tears of the rotator cuff, generally involving first, the supraspinatus tendon and then, multiple tendons.

Cuff fibres may fail few at a time, giving rise to the clinical presentation often misinterpreted as bursitis or tendinitis. In 1972, Neer\textsuperscript{19} coined the term impingement. The supraspinatus tendon is the most commonly tendon involved. Forward flexion is the most common movement of the upper body. As the humerus is raised, the supraspinatus tendon abuts against the coracohumeral ligament and anterior edge of acromion. This compression leads to mechanical irritation and ischemia. These insults, if prolonged, later lead to degenerative changes (Tendinopathy). This and consequent fibre failure impair an important rotator cuff function of stabilization of humeral head at the glenoid and humeral depression. As a result, there is an increased tendency for impingement as humerus is elevated unopposed by deltoid contraction, leading to further attrition of the rotator cuff. Impingement occurs against the coracoacromial arch.

**Impingement:** As described above, failure of humeral depression is the major precipitating cause of impingement. Without this, the humeral head will be uplifted by deltoid contraction causing impingement of suprapinatus and subacromial bursa against one or more components of the coracoacromial arch.

The coracoacromial arch is composed of 5 basic structures - Distal clavicle, AC joint, anterior one third of acromion, coracoacromial ligament and anterior one third of the coracoid process.

Potential causes of shoulder impingement by acromion are anterior/ lateral acromion sloping, acromioclavicular joint callus, coracoacromial ligament thickening, post traumatic bone remodelling and acromion spurs.\textsuperscript{24} The subacromial bursa may distend with fluid and chronically lead to synovial hypertrophy causing pain and limitation of motion of rotator cuff during movement because of thickened inflamed tissues. Poor humeral depression may be due to poor muscle coordination or weakness. The latter may due to trauma, inflammation or tears involving
the rotator cuff, the most important component of which being the supraspinatus tendon. A vicious cycle occurs whereby impingement causes trauma, inflammation and tendinopathy, predisposing to further tearing of supraspinatus tendon, which in turn worsens the severity of impingement. Tendons with degenerative inflammatory changes are more susceptible to tears.

Nathalie J. Bureau et al\textsuperscript{25} has proved usefulness of ultrasound in the diagnosis of rotator cuff tears, rotator cuff tendinosis, calcific tendinosis and subacromial bursitis and has become an accepted method of investigation of shoulder pathology. Dynamic sonography can provide direct visualization of the relationships between the anterior one third of the acromion, subacromial bursa, supraspinatus tendon and greater tuberosity of the humeral head during active shoulder motion. In the cases where there is no subacromial impingement, the motion of forward flexion of the arm halfway between flexion and abduction with pronation of the hand is not painful and on sonography, the greater tuberosity of the humeral head can be seen gliding easily beneath the anterior one third of the acromion.

They have found patients with grade 1 shoulder impingement who felt some pain during the dynamic evaluation show no evidence of anatomic impingement on sonography. They hypothesized that in patients with grade 1 subacromial impingement, pain can result from impingement occurring medially on a hypertrophic degenerative acromioclavicular joint or from contact with the coraco-acromial ligament. In dynamic evaluation of shoulder joint for impingement, our present study shows grade-2 abnormality in 30 patients (75\%) and 8 (20\%) patients had Grade-1 abnormality, this was found to be statistically significant (0.0001) This shows that dynamic study is significant in detecting early stages of impingement syndromes. Out of the 40 patients, our study showed normal study in 3, PTT in 31, FTT in 3 and Type-5 rotator integrity in 3 patients. When compared to the arthroscopic surgery findings, sensitivity and specificity of PTT was 85.5\% and 75\% respectively.

To conclude, ultrasonography can detect impingement syndrome and partial tear of the SST with high specificity and sensitivity, which makes it the most cost effective, noninvasive, rapidly performed, widely available and most acceptable investigation to the patients. Comparison of normal contralateral shoulder and real time dynamic assessment is possible for diagnosis of shoulder impingement syndrome and is significantly comparable in its diagnostic efficiency with the invasive procedure of arthroscopy.

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**Figure-1 (a):** Long axis view of supraspinatus tendon showing a hypoechoic area - suggestive of an intrasubstance tear.

![Fig. 1 (a)](image)

**Figure-1 (b):** Long axis view of supraspinatus tendon showing a midsubstance full thickness tear.

![Fig. 1 (b)](image)

**Figure-1 (c):** Long axis view of supraspinatus tendon showing calcification of the tendon with a hypoechoic area suggestive of partial tear extending to the bursal surface.

![Fig. 1 (c)](image)
**Figure-1 (d):** Long axis view showing a partial tear of supraspinatus tendon extending to the articular surface.

![Fig. 1 (d)](image_url)

**Figure-1 (e):** Full thickness anterior tear of supraspinatus tendon.

![Fig. 1 (e)](image_url)

**Figure-1 (f):** Complete Tear.

![Fig. 1 (f)](image_url)
Figure-3. Sensitivity and Specificity for detection of PTT in USG on comparison with arthroscopic finding.

|       | Sensitivity | Specificity |
|-------|-------------|-------------|
| PTT   | 85.5        | 75          |

Table-1: Patients seen with various ultrasound findings
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