

USG Evaluation of Traumatic and Inflammatory Conditions of Musculoskeletal System

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Abstract: *Musculoskeletal sonography is a rapidly evolving technique that is gaining popularity for the evaluation and treatment of traumatic and inflammatory conditions of musculoskeletal system. Ability to perform dynamic real time imaging is major advantage as compared to other MSK imaging modalities (MRI). Ultrasonography has established itself as the primary diagnostic modality for the abnormalities of rotator cuff and developmental dysplasia of hip. Traumatic and inflammatory conditions of tendons, ligaments, bursae, articular cartilage, can be readily detected by sonography. Also hematoma, abscesses, foreign bodies are easily identified [1]. Ultrasound also offers guided puncture of effusions and collections.*

Keywords: MSUS, Injury, RA, DDH, Rotator tear

1. Introduction

Ultrasonography not only plays a major role in assessing abnormalities of musculoskeletal system, but in specific situations, it also has clear advantage over other imaging modalities. Inherent advantages of USG include wide availability, low cost, quick scan time, multiplanar capability, bed side examination and lack of ionizing radiation. Distinct advantages are ability to perform dynamic real time imaging with contralateral comparison. The quality and consistency of USG rely on expertise of the examiners. Operator dependency is a notable drawback.

2. Review of Literature

A number of authors have reported sensitivity and specificity above 90% in sonographic evaluation of **preoperative** patients with **rotator cuff tear**. There are no significant differences in either sensitivity or specificity between MRI and ultrasound in the diagnosis of partial- or full-thickness rotator cuff tears [2].

Sonography has demonstrated that it can produce result atleast equal to MR imaging if performed by an experienced individual [3]. If other abnormalities are suspected such as labral tear, MR imaging is currently the method of choice. With advances in technique like, sono-CT and harmonics imaging, the sonography will likely become established further. The diagnosis of dislocated and dysplastic hip of infant is more accurate with sonography [4]. Universal clinical screen with USG of hip can aid in early diagnosis of DDH in newborns. Large population-based studies from developing countries need to look in its cost-effectiveness. [5]. Sonography is also useful in assessing abnormalities adjacent to the patellar tendon, such as soft-tissue foreign bodies, bursitis, and peritendon hematomas and tumours. [6]. Sonography is a useful and inexpensive method of detecting presence of rupture of the anterior cruciate ligament in the clinical setting of a traumatic hemarthrosis. In study by Ptasznik et al. the technique was therefore 91%

sensitive and 100% specific. The positive predictive value was 100%. The negative predictive value was 63% [7]. US may be useful as a screening examination for patients suspected of having PCL injury and for deciding whether to perform more expensive MR imaging or surgical intervention[8]. Also ultrasound is highly sensitive for detection of MCL injury [9].

Bianchi et al reported the potential usefulness of ultrasonographic detection of lipohearthrosis rests in its ability to promptly demonstrate a fat-fluid level, strongly suggestive of a fracture or severe capsulo ligamentous injury [10]. Use of ultrasonography is safe and reliable with 94% sensitivity and 100% specificity with 95% accuracy in diagnosis partial ruptures of the Achilles tendon [11]. USG can differentiate reliably between conditions that require surgical intervention and those that will respond to conservative therapy [12].

Ultrasonography being highly sensitive for early inflammatory and destructive changes in RA joints [13]. In RA USG with the use of Doppler modalities is a useful imaging tool to depict inflammatory abnormalities (i.e. synovitis, tenosynovitis and bursitis) and structural changes (i.e. bone erosions, cartilage damage and tendon lesions). In addition, MSUS has been demonstrated to be able to monitor the response to different therapies in RA to guide local diagnostic and therapeutic procedures such as biopsy, fluid aspirations and injections [14]. Ultrasound evidence of fluid in the flexor sheath is a useful sign in the early diagnosis of acute suppurative flexor tenosynovitis. US appears to be a reproducible tool for evaluating and monitoring tenosynovitis in RA [15]. A Ultrasound guided aspiration should be considered if infection is a clinical possibility. Over use phenomena usually have a clinical history suggesting the early diagnosis. De Quervain's disease constitute most frequently occurring tenosynovitis and is readily confirmed on ultrasound demonstrating thickening and oedema of synovial sheath of the tendons of the abductor pollicis longus and extensor pollicis brevis muscles. In septic arthritis, sonography provides accurate

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localisation of the soft tissue swelling and extent and consistency of the joint effusion. Fat necrosis appear as focal, illdefined hyperechogenesity. Cellulitis appear as diffuse hyperechogenesity. Periosteal abscess formation is particularly common in children and sonography allows both its initial diagnosis and diagnostic aspiration. Ultrasound is particularly good in assessing loosening of internal fixation of fractures. Intraarticular effusion in noted in non infected total hip arthroplasties. The extraarticular extension of effusion is highly suggestive of infection [16].

3. Material & Method

Real time linear array transducers are preferred for the examination of the musculoskeletal system. In our study of 75 cases we used 3.5,6,7 MHz linear array transducers and the ultrasound equipment used was Core Vision 400, Toshiba. Although it is possible to use curved linear & sector probes, the flat linear configuration provides less distorted images. The highest possible frequency that permits penetration of the soft tissue must be used. For hand and foot, small foot print is preferred for easy maneuverability. For best resolution of the infant hip, 7.5 MHz probe is used upto the age of 3 months. For infant age 3-7 months, 5 MHz probe & 3.5 MHz probe for infant age 7-12 months is preferred. After 12 months, large ossification centre of head inhibit visualisation of acetabulum.

The aims and objectives of this study are -

- To describe ultrasonic features of joint pathologies in traumatic and inflammatory conditions.
- To review the clinical indications of musculoskeletal sonography.
- To identify its role in bone involvement in inflammatory conditions of soft tissue.
- To stress its role as a primary imaging modality for diagnosis of rotator cuff tears and developmental dysplasia of hip.

4. Observation and Results

Total 75 cases were scanned for evaluation of musculoskeletal system. All cases of trauma and inflammatory arthritis were included in this study.

Joint Involved	No. of Patients
Shoulder	35
Elbow	3
Wrist	8
Infant hip	8
Adult hip	2
Knee	15
Ankle	4
Total	75

Total no. of patients 35. Age and sex wise distribution is as.

Age Group	Male	Female	Total
11-20 yrs	1	-	1
21-30 yrs	8	2	10
31-40 yrs	7	9	16
41-50 yrs	1	4	5
51 years and above	-	3	3
Total	17	18	35

Shoulder Joint. The total no. of cases presented for suspected rotator cuff disorder were 28. Their clinical presentation:

Clinical Presentation	No. of Cases
Inability to abduct	17
Shoulder pain	24
Swelling	4
Acute dislocation	1

Types of tear observed-

Type of Tear	No. of Patients
Full thickness tear	7
Partial thickness tear	15
Normal	3
Total	28

The patients with partial thickness tear were distributed as

Side of Tear	No. of Cases
Bursal side tear	5
Articular side tear	9
Intrasubstance tear	4

Based on the diagnostic criteria, following findings were noted in patients with full thickness tear.

Findings	No. of Patients
Total nonvisualisation of cuff	2
Focal nonvisualisation of cuff	3
Discontinuity	1
Abnormally increased echogenosity	1
Associated Findings	
Biceps Tendinitis	4
Subdeltoid bursal effusion	1
Concave subdeltoid bursal contour	3
Effusion	1
Humeral head elevation	-

Infant Hip

7 patients were studied.

Age Group In Months	Male	Female	Total
0 - 3	1	2	3
3 - 6	-	3	3
More than 6	-	1	1
Total	1	6	7

One patient had bilateral involvement. Both hips were taken as different cases, hence 8 cases. **The findings were as follow :**

Type	No. of Patients
Normal	2
Subluxated	1
Dislocatable	2
Dislocated reducible	2
Dislocated irreducible	1
Total	8

The other associated findings were

Findings	Cases.
Interposition of fibroadipose tissue	3
Acetabular dysplasia	-
Delayed appearance of ossific nucleus	1
Hip joint effusion	1

Post Traumatic Joint Disorder

The following patients were studied for post traumatic evaluation. The patients presented with post traumatic shoulder pain with muscles involved other than rotator cuff where included in this study.

Joint	Findings	No. Of Patients
Shoulder	Biceps muscle rupture	1
	Biceps long head hematoma	1
	Subscapularis hematoma	1
Hip	Callus formation	1
Knee	Meniscal Tear	5
	Lateral Colateral lig. tear	1
Ankle	Tendo achilles rupture	3
Total		13

Inflammatory Disorders- 26 patients were included in this study, referred for evaluation of joints in inflammatory disorders. Known cases of rheumatoid arthritis, suspected infection involving shoulder joint where grouped in this category.

Joint	Findings	No. of Cases
Shoulder	Acromioclavicular inflammation	1
	Joint effusion	3
	Supraspinatus abscess	1
	Wetoid abscess	1
Elbow	Effusion	1
	Pyoarthrosis	1
	Periosteal reaction in Coffey's disease	1
Wrist	Tuberculous erosion	1
	Rheumatoid pannus + Erosion	1
	Ganglion	1
	DeQuervain's dis	1
	Tenosynovitis	2
Hand	Tuberculous soft tissue	1
	Periosteal reaction in coffey's	1
Hip	Psoas abscess	1
Knee	Supra patellar effusion	2
	Medial meniscus cyst	1
	Synovial thickening (rheumatoid)	2
	Articular cartilage changes (OA)	1
	Popliteal swelling	5
	<ul style="list-style-type: none"> • Baker cyst • Abscess • Pseudo aneurysm 	1
Femur	Periosteal reaction (OM)	1

A total of 28 shoulder joint cases were studied 25 cases were reported to have sonographic evidence of rotator cuff tear. 22 cases were confirmed surgically or arthroscopically. 3 cases were reported as rotator cuff tear on sonography were found to have intact tendons (1 on surgery and 2 on arthroscopy). 3 patients had normal rotator cuff. Thus an overall positive findings was confirmed in 89.2% cases. 7 patients showed complete tear of rotator cuff of which two cases showed complete nonvisualisation, three cases showed focal nonvisualisation of cuff. Discontinuity of rotator cuff and abnormally increased echogenesity each noted in one case. The associated findings such as biceps tendinitis noted in 5 cases, subdeltoid bursa effusion in one case, concave

subdeltoid contour in two cases and shoulder effusion noted in one case. Out of 18 cases of partial tear of rotator cuff one had evidence of bicipital tendinitis and bursal effusion. 6 cases of articular side tear showed evidence of shoulder joint effusion.

Total 8 hip joints were included in this study, one had evidence of subluxation and two had dislocatable hips, which on abduction, relocated. Out of 3 cases shows frank dislocation, 2 were reducible and one irreducible. 2 cases were normal joints. In one case with subluxated hip on left and dislocatable hip on right side was reexamined after 6 weeks which showed normal sonographic features. Of all 3 cases of dislocated hip there was evidence of fibroadipose tissue in acetabulum. One female patient also showed evidence of delayed appearance of ossific centre for femoral head.

Total 13 patients of trauma were included in this study involving hip, knee, ankle. The trauma involving shoulder joint, other than rotator cuff muscles were included under this heading of trauma. The 5 cases had classical features of muscle / tendon tear which were confirmed on surgery. Of 5 cases of meniscal tear, 3 underwent menisectomy and findings were confirmed. One case of meniscal tear was reported normal on arthrography where as last case was reported as normal meniscus on arthroscopy. The patient with subscapularis hematoma also had hair line fracture of clavicle, as detected on sonography and was treated conservatively. The male child at 40 days of age was referred for painful hip. On sonography examination marked periosteal thickening with increased echogenesity in surrounding muscles noted in upper end of both femur. Similar findings noted on radiograph where left femur lower end was also involved. Fracture lines were noted on CT scan, confirming callous formation.

Total 26 patients with inflammatory disorders were examined in this study for evaluation of joints and periarticular soft tissue for inflammatory disorders and infections. Shoulder joint involvement in rheumatoid arthritis was also included in this group. Though number of cases studied in each category were less but had diagnostic ultrasound features. The reports of ganglion and de Quenain's tenosynovitis were confirmed on surgery. The popliteal abscess and supraspinatus abscess were confirmed on needle aspiration, later drained. Deltoid abscess drained without needle aspiration in view of symptoms of pyrexia and localised redness. The iliopsoas abscess treated conservatively as tuberculous abscess in view of other clinical and laboratory findings.

5. Discussion

Degenerative disease of the rotator cuff is quite common, but fortunately, is not severe enough to result in tendon disruption. The 1cm long portion of the supraspinatus tendon, proximal to the insertion is described by Codman as 'critical portion' as it is hypovascular compare to rest of the tendon. This may lead to necrosis and tear. The area of necrosis may calcify resulting in calcific tendinitis. Even with minor trauma this may lead to rotator cuff tear. The normal rotator cuff tendon is sonographically homogenous

in appearance with low level echogenicity. As the tear extends and becomes larger, a defect in which no tendon is visible. When the edge of the tendon is visible, it may appear as a simple termination of the normal tendon, with or without fraying. The defect pattern was seen in 4 of our cases, all 4 were proved surgically. We believe this finding to be very specific of a complete rotator cuff tear.

As the tear enlarges one may not image any normal appearing rotator cuff at all. There is evidence of subdeltoid bursal effusion seen in patients with a large tear. Associated findings of fluid in the biceps tendon were seen in 4 cases. Also evidence of bursal or joint effusion noted in few cases.

Common diagnostic pitfalls

There few interpretative errors with ultrasound which may be classified as below :

- Those from failure to recognize normal anatomy. This can be easily overcome by experience and comparison to the normal contralateral rotator cuff.
- Those caused by soft tissue abnormalities these are seen in patients with calcific tendinitis simulating rotator cuff tear.
- Those caused by bony abnormalities, for example, fractures and subluxations. These can be avoided by review of the plain radiographs before performing ultrasound.
- Those caused by technical limitation of the study. This is due to inability to image the rotator cuff beneath the acromion. Also in obese patients where excess soft tissue require the use of lower frequency transducer which in turn limit the accuracy.

Failure to orient transducer parallel to fibres, causes artifactual areas of disease echogenicity, as more pronounced with sector scanners.

To evaluate the accuracy of hip sonography, sonographic findings have been compared with clinical and radiographic findings [17, 18]. Sonography has been found to be highly specific and sensitive with false positive and a false negative rates in the 1-2% range. The sonography has detected dislocation and other abnormalities that were not detected clinically or radiographically. The few false positive and false negative sonographic results have been seen in cases of subluxation. The subluxation encompasses a wide range of capsular laxity and displacement of head, and the assessment of the degree of dislocation is the some extent subjective. The false positive studies indicate the higher sensitivity of the modality while the false negative studies have been attributed to lack of patient relaxation [19]. There is higher frequency of transient capsular laxity. Which usually resolves without treatment in first two months of life. Repeat sonographic evaluation at 4-6 weeks of age can confirm normalcy, preventing unnecessary treatment [19]. As an alternative to mass screening of all new borns, a risk factor based screening has been advocated by Clarke. Usually the study is not obtained till 4-6 weeks of age, by which time, minor and questionable abnormalities have resolved.

Ultrasound plays several roles in diagnosis of inflammatory disorders of joints. It can detect the presence of effusion and synovial hypertrophy. Although synovial hypertrophy (pannus) is seen most commonly in inflammatory

arthropathies, it is also seen in tuberculous and fungal infarctions [20]. In these cases fibrous adhesions or synechiae are seen. Pannus is hypoechoic relative to the surrounding tissues. In rheumatoid arthritis, synovial villi are covered with precipitated fibrous material that can be dislodged, eventually settling into the synovial recess. The severity and detection of complications i.e. tendon rupture, synovial cyst, loose bodies in the setting of arthritis can be evaluated satisfactorily by ultrasound. Monitoring the response to treatment in inflammatory arthritis can be done by sonography [21]. The first sign of a positive response to therapy has been shown as decrease in the quantity of intra articular fluid, most often seen within 48 hours of the initiation of treatment Serial ultrasound for measurement of synovial thickness and articular cartilage thickness may prove useful in the evaluation of therapeutic response [22].

Because of its importance, Baker's cyst deserve a special mention. Rupture of a Baker's cyst incites severe inflammatory response form the surrounding tissue. Sonography can reliably establish the correct diagnosis of ruptured Baker's cyst which can mimic deep vein thrombosis of the lower extremity. Hemorrhage and infection of the Baker's cyst is also detected by presence of internal echoes and septation.

Sonography reliably demonstrates posterior and peripheral meniscal tears, which are not well demonstrated with arthroscopy sonography is limited however, in its ability to detect small tears along the inner margins of the menisci [23]. MRI remains the gold standard for the meniscal tears. The role of sonographic examination of the menisci includes the detection of meniscal tears in the setting of Baker's cyst; detection of meniscal capsular separation, a notoriously difficult diagnosis with MRI; and evaluation of the knee when other studies are negative but symptoms are still referable to the menisci [23]. Baker's cyst are associated with the tears of medial and lateral menisci in 70% and 40% of patients respectively. An enlarging meniscal cyst can mimic a soft tissue tumor. It can also cause torsion of the lateral tibial plateau. Such erosions may simulate those of an inflammatory arthropathy. In these cases, sonography can provide valuable information.

Bursal inflammation can result from RA, gout, TB, hemorrhage and infection [23]. Traumatic bursitis can be differentiated from bursitis due to systemic causes as the latter results in synovial proliferation. The presence of internal echoes is suggestive of infection. However, the only echogenic material without anechoic fluid collection can be occasionally seen in the setting of bursitis which should not be mistaken for diffuse synovial hypertrophy.

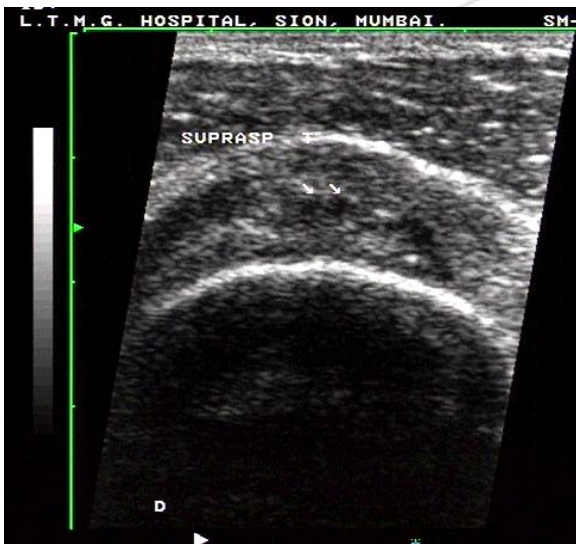
Sonography has a role in differentiating between the bursal and tendon pathologies. There is considerable overlap but the theories for these conditions are markedly different and hence differentiation is essential. Tendon tears can also be reliably assessed by sonography. Early diagnosis of quadriceps tendon rupture is essential because surgery is not possible 4-5 weeks after injury. The modality allows detection of infected hip and knee prosthesis. In the absence of complete tendon rupture, making a diagnosis clinically, can be difficult, particularly in establishing the exact

location of the abnormality and identifying partial torn tendons.

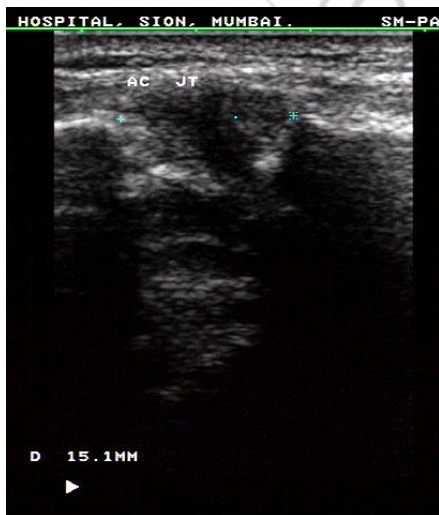
6. Images



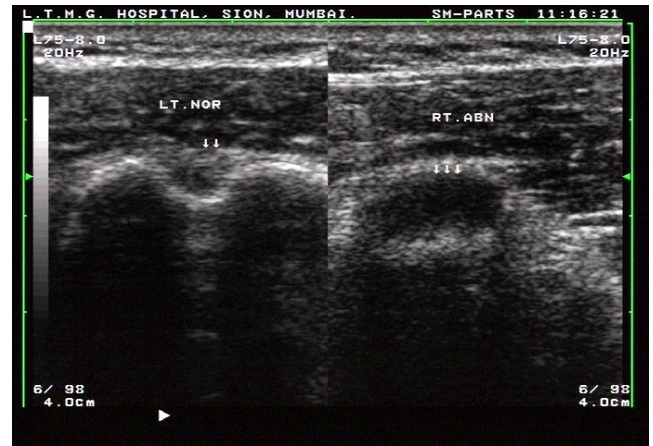
Longitudinal scan of the left supraspinatus tendon showing complete tear with an anechoic fluid collection



Longitudinal scan of the left shoulder demonstrating a partial tear of the supraspinatus tendon



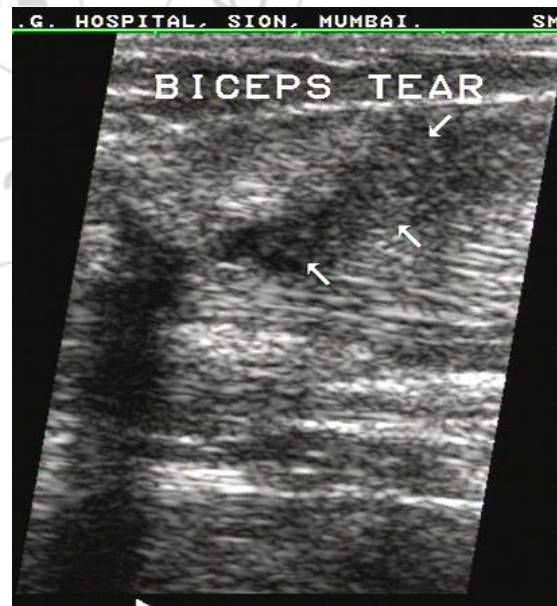
Transverse scan showing inflammation of the left acromioclavicular joint with bony erosion, pannus and effusion



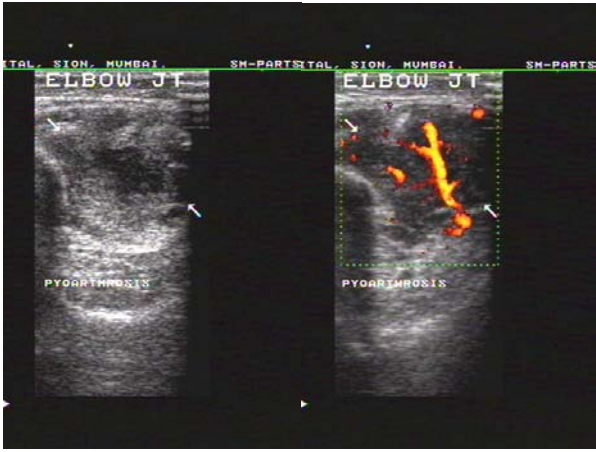
Transverse scan of the bicipital groove demonstrating enlarged, hypoechoic biceps tendon s/o biceps tendinitis



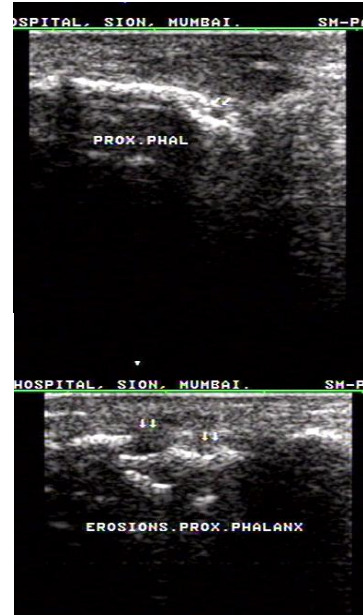
Longitudinal scan of the left bicipital groove demonstrating posttraumatic hematoma due to complete tear of the long head of the biceps tendon



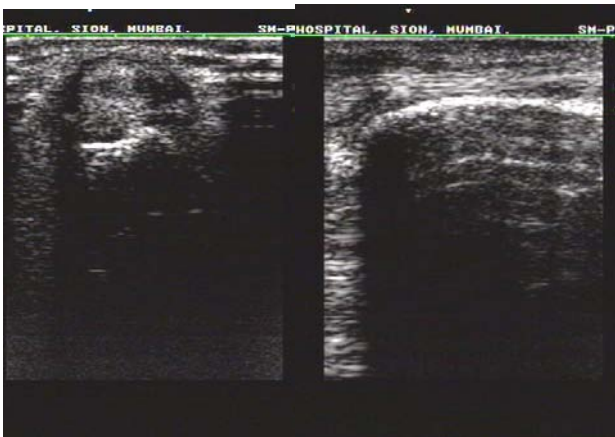
Longitudinal scan of right biceps muscle showing posttraumatic tear with hematoma within



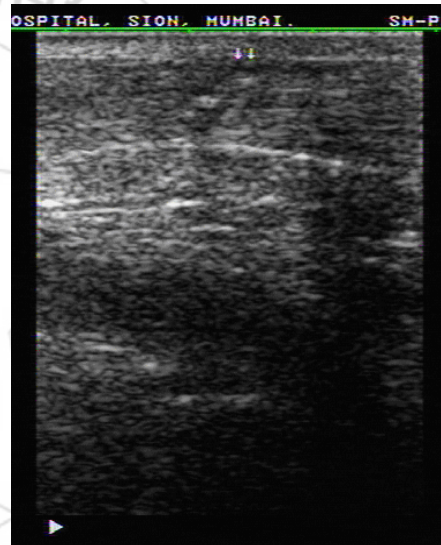
Longitudinal scan of the right elbow showing effusion with internal echoes and increased vascularity due to acute Pyoarthrosis



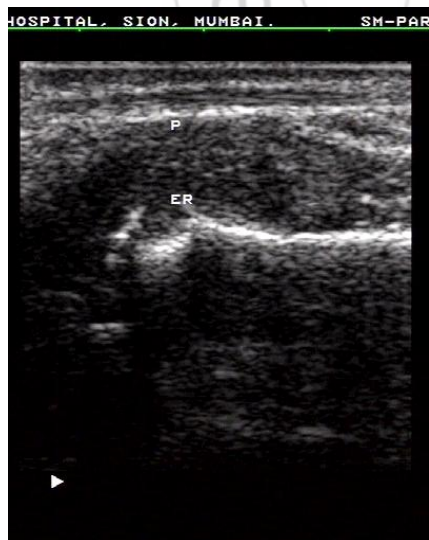
Bony erosion and overlying soft tissue in a case of tuberculosis of middle phalanx of the little finger



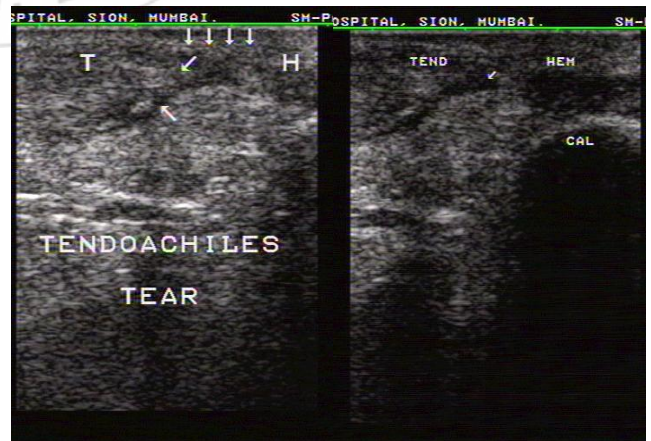
T Transverse scan of the rt wrist showing extensor tenosynovitis



Longitudinal scan of the tendoachilles showing a partial tear.



Longitudinal scan of the left wrist showing pannus formation and erosion of the ulnar styloid in a case of rheumatoid arthritis

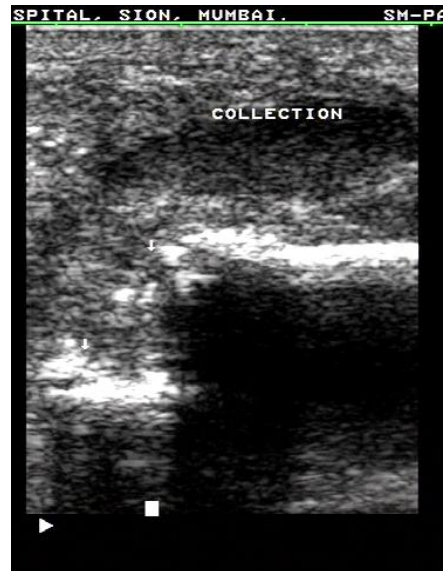


Complete tear of the right Achilles tendon

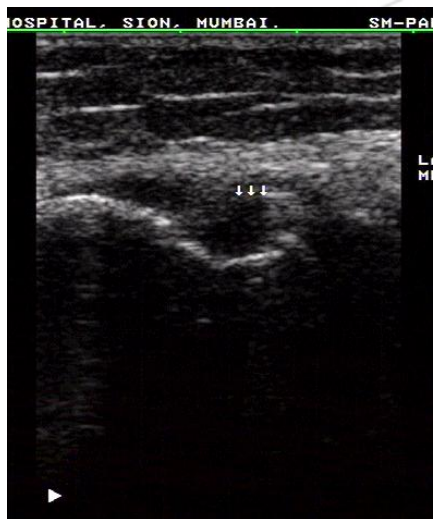
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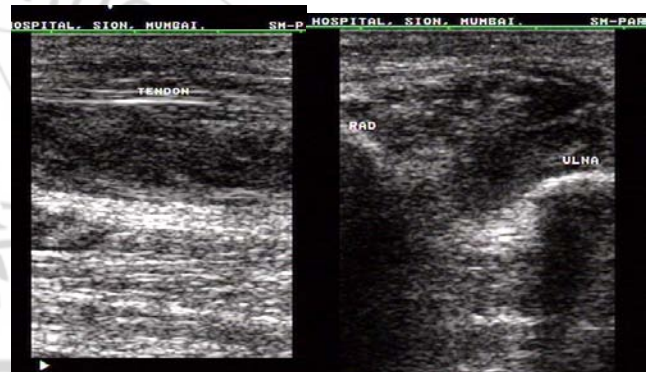
Longitudinal scan of the right knee joint showing a partial tear of the medial meniscus



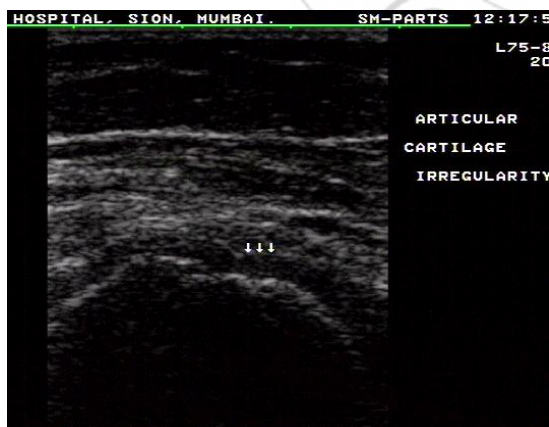
Longitudinal scan of the right leg demonstrating bony erosion with periosteal reaction and overlying abscess suggestive of osteomyelitis of the right tibia



Longitudinal scan of the lateral meniscus showing a meniscal cyst



Longitudinal and transverse scans showing hypoechoic muscle in a case of myositis



Longitudinal scan of the flexed knee showing the articular cartilage irregularity in a case of early osteoarthritis



Congenital chronic dislocation of the left hip with dysplastic femoral head



Dislocated hip joint. Longitudinal coronal view

7. Summary

The impetus for investigating new imaging method is that the older method have not been proven satisfactory. Traditionally arthrography and arthroscopy were the diagnostic gold standards for evaluation of internal derangement and other lesions of the joints. Ultrasonography in particular has been used to diagnose wide variety of soft tissue lesions.

The sonography offers many advantages :

- Non invasive (unlike arthrography and arthroscopy).
- No ionising radiation (unlike radiography and CT scan).
- Rapidly performed (unlike MR imaging).
- Real time dynamic assessment.
- Contralateral normal side for easy detection of small lesions.
- Multiplanar examination to confirm the findings in various planes.
- Widely available, low cost and bed side examination.
- Diagnostic aspiration of collections and biopsies.

No wonder, sonography is readily accepted by patients. Its use in evaluation of chronic repetitive injuries and evaluation of phase of healing process and planning of surgery has made it popular amongst physicians.

As demonstrated in our study of rotator cuff pathology, the positive findings were seen in 89% cases, a fairly good result. In addition, we could also pick out associated abnormalities of biceps tendon and effusion. These could serve as a rough guide for closer examination of rotator cuff for undiagnosed tears in patient showing fluid in the biceps tendon and joint.

The principles of one area of musculoskeletal sonography easily generalise to other areas. Although we had limited number of patients in each category of disease, most of them showed characteristic findings and very convincingly demonstrated the fact that ultrasound may be used effectively to diagnose and treat wider range of musculoskeletal inflammatory & infections disorders and injuries.

Our study of infant hip drove home the efficacy of this well proven and time tested diagnostic method. The results of 100% accuracy in the diagnosis of the different presentations and severities of developmental hip dysplasia are testimonial to this fact. As with any sonographic study, the accuracy of examination is related the skill and experience of examiner.

The difficulties we experienced in correct interpretation of ultrasound findings, we attribute to the learning curve associated with this technique, with the advent of sono-CT, tissue harmonics imaging, extended field of view and high resolution linear array transducers, the ultrasonography will be uniquely powerful tool in musculoskeletal ultrasonography.

8. Future Scope

Advances in technology like higher frequency transducers, colour flow imaging, harmonics imaging, 3-Dimension imaging and extended field of view function have facilitated the progressive development of MS-USG. More number of training programs can help to overcome limitations like long learning curve and time intensive examination. Sonography is a noninvasive modality which is also readily accepted by patients and with increase in awareness amongst physicians and improvement in technique, further expansion of its role in diagnosis of pathologies of joints and soft tissue lesions is anticipated.

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