



EVALUATION OF SENSITIVITY & SPECIFICITY OF ULTRASONOGRAPHY AS A FIRST LINE IMAGING MODALITY FOR THE EVALUATION OF NON-TRAUMATIC LESIONS OF MUSCULOSKELETAL SYSTEM

Radiodiagnosis

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ABSTRACT

Soft tissue masses have varied presentations. Developments in digital ultrasound technology, availability of high frequency transducers, lack of ionizing radiations, easy availability, real time capability, cost effectiveness and ability to examine in any direction makes ultrasonography the ideal imaging modality for examination of soft tissue lesions. Ultrasonography is an excellent imaging modality for determining nature, consistency and vascular characteristics of the lesion, its relationship to surrounding structures and extent of the lesion. Ultrasonography also plays an indispensable role in imaging guided FNAC/Biopsy for histopathological confirmatory diagnosis.

USG is increasingly becoming first line, real-time investigation for evaluation of Lesions of Musculoskeletal Lesions and their early diagnosis before subjecting the patients to invasive and time-consuming investigations like biopsy, FNAC etc. However, USG has its limitations and is not always accurate or conclusively diagnostic. This study is conducted to evaluate the reliability and dependability of USG in evaluation of Lesions of Musculoskeletal System.

KEYWORDS

Musculoskeletal System, Ultrasonography, Soft Tissue Lesions

• AIMS AND OBJECTIVES

The aim of this study was to review the experience using ultrasound to assess superficial non-traumatic soft-tissue lesions of musculoskeletal system to:

1. To determine sensitivity and specificity of ultrasound in identifying the type of lesion
2. To recognize the lesions that cause diagnostic difficulty
3. To highlight the spectrum of superficial non-traumatic soft-tissue lesions encountered in clinical practice.

• METHODOLOGY

This is a randomized prospective study compromising 50 patients over a period of one year. Patients, with complain related to soft tissue swellings of MSK, referred from surgery and orthopedic department were included in the study without bias on a serial basis. Ultrasonographic evaluation was performed using high frequency transducers with the lesions being examined in both longitudinal and transverse axes in B-mode and color filling spectral Doppler mode. *The sonographic indices of the soft tissue swellings noted were location/plane, nature, size, margin, echo pattern and calcification. Vascularity of the lesions was assessed with color and spectral Doppler parameters. In patients with inconclusive USG evaluation, biopsy/FNAC/surgical excision was done and a correlation of USG diagnosis and HPE was obtained.*

• RESULTS

The diagnostic accuracy of ultrasound for evaluation of non-traumatic lesions of musculoskeletal system was evaluated by comparing the provisional USG diagnosis with the confirmatory diagnosis as obtained histopathological evaluation. There are certain lesions that could be diagnosed with USG evaluation with high degree of sensitivity and specificity. These include lipomas, abscess, ganglion cysts, vascular lesions, epidermoid etc. (sensitivity and specificity of 82.3% and 100% for lipomas, 100% and 100% for abscesses, 100% and 95.7% for ganglion cysts, 87.5% and 100% for vascular lesions respectively). Certain lesions with lack of characteristic USG features could not be evaluated accurately. Overall, ultrasonography has excellent accuracy to be used as an initial imaging modality for the evaluation of soft tissue lesions of musculoskeletal system. Reduced observer awareness of specific tumor entities tended to contribute to underdiagnosis more than poor specificity of ultrasound findings

• CONCLUSION

Ultrasonography with its extended capabilities in the form of Color flow evaluation and Doppler interrogation is ideal not only for initial evaluation of soft tissue lesions but also for follow up and affecting treatment strategy. While the precise histological diagnosis of a lesion based on USG features may be limited due to absence of characteristics features in a number of lesions; a combination of grayscale and color doppler findings can help to narrow down the list of differential

diagnosis. At the same time, USG has excellent specificity for a number of lesions, demonstrating the high ability of USG to exclude a particular diagnosis when it is actually not present. This advantage of USG takes a hit when lesions with similar presentation and USG features are encountered. Thus, familiarity with the basic anatomy of musculoskeletal system, its USG appearance, the spectrum of soft tissue lesions and changes associated with a pathology is required to enhance the usefulness of USG for this particular indication.

• INTRODUCTION

Soft tissue masses have varied presentations. Developments in digital ultrasound technology, availability of high frequency transducers, lack of ionizing radiations, easy availability, real time capability, cost effectiveness and ability to examine in any direction makes ultrasonography the ideal imaging modality for examination of soft tissue lesions. Ultrasonography is an excellent imaging modality for determining nature, consistency and vascular characteristics of the lesion, its relationship to surrounding structures and extent of the lesion. Ultrasonography also plays an indispensable role in imaging guided FNAC/Biopsy for histopathological confirmatory diagnosis.

USG is increasingly becoming first line, real-time investigation for evaluation of Lesions of Musculoskeletal Lesions and their early diagnosis before subjecting the patients to invasive and time-consuming investigations like biopsy, FNAC etc. However, USG has its limitations and is not always accurate or conclusively diagnostic. This study is conducted to evaluate the reliability and dependability of USG in evaluation of Lesions of Musculoskeletal System.

• Methodology

Source Of Data: Patients, with complain related to soft tissue swellings of MSK, referred from surgery and orthopedic department of our institution were included in the study without bias on a serial basis. This is a randomized prospective study compromising 50 patients over a period of one year. The study was approved by the Ethics Committee of institution. The procedure was explained to the patient and a written informed consent was taken from each patient prior to conducting the scan. Adequate pre-procedural counseling of the patient alleviated anxiety and ensured patient cooperation.

Inclusion Criteria

- a. Age Group: Any
- b. Both male & female patients
- c. Individuals with Soft Tissue Lesions of Musculoskeletal referred for USG evaluation.
- d. Incidentally detected Musculoskeletal Manifestations of some undiagnosed underlying primary disease.

Exclusion Criteria

- a. Patient is already known case of some systemic disease with

- Musculoskeletal Manifestations (but not the incidentally detected ones).
- Lesions that have been known to arise after any operation, surgical procedure or trauma.
 - Patients giving negative consent for investigations and management.

Imaging Protocols

Ultrasonography was performed on Philips Affinity 50 Machine and Samsung AVXGE30/IN Machine using a high frequency linear transducer (4-10 MHz). The patients were examined in appropriate position and imaging was carried out in both longitudinal and transverse axes in B-mode and color filling Doppler mode.

The sonographic indices of the soft tissue swellings noted were location/plane, nature, size, margin, echo pattern and calcification. Vascularity of the lesions was assessed with colour and spectral Doppler parameters. Soft tissue swellings like foreign bodies, liquefied abscess and hematomas were readily confirmed to evaluate the accuracy of USG in these lesions. In patients who underwent biopsy/FNAC/surgical excision, a correlation of USG diagnosis and HPE was also done.

Histopathological Correlation

Histopathological confirmation of the diagnosis was made in collaboration with Pathology, Surgery and Orthopedics Department either by preoperative biopsy or FNAC of the lesion or by postoperative mandatory histopathological examination of the tissue excised.

Histopathological evaluation was done after proper processing of the tissue material with subsequent block and slide preparation. Appropriate staining was done wherever necessary. Each of the slides were observed by pathologist using and a histopathological confirmation of the nature of soft tissue lesion was made.

RESULTS AND OBSERVATIONS

The power of a test to separate patients from healthy people determines its accuracy and diagnostic value. Therefore, a test with 100% accuracy should be the first choice. However, this does not happen in reality as the accuracy of a test varies for different lesions and in different situations. The characteristics of a test that reflects the efficiency of an imaging modality are accuracy, sensitivity, specificity, positive and negative predictive values and positive and negative likelihood ratios. However, for this study, evaluation is done on the basis of sensitivity and specificity.

Statistical Calculation:

- Patient:** Positive for disease
- Healthy:** Negative for disease
- True positive (TP):** Cases correctly identified as patient
- False positive (FP):** Cases incorrectly identified as patient
- True negative (TN):** Cases correctly identified as healthy
- False negative (FN):** Cases incorrectly identified as healthy

a. Sensitivity: The sensitivity of a test is its ability to determine the patient cases correctly. To estimate it, the proportion of true positive in all evaluated cases is calculated. Mathematically, this can be stated as:

$$\text{Sensitivity} = \text{TP} / (\text{TP} + \text{FN})$$

b. Specificity: The specificity of a test is its ability to determine the healthy cases correctly. To estimate it, the proportion of true negative in healthy cases is calculated. Mathematically, this can be stated as:

$$\text{Specificity} = \text{TN} / (\text{TN} + \text{FP})$$

Total of 50 patients were included in the study, including both males and females of various age groups. All of these patients presented with soft tissue swellings which may or may not were associated with other symptoms like pain, tenderness, movement restriction.

Common locations were torso (16 patients, 32%) followed by lower limb (14 patients, 28%), upper limb (11 patients, 22%) and head & neck (9 patients, 18%).

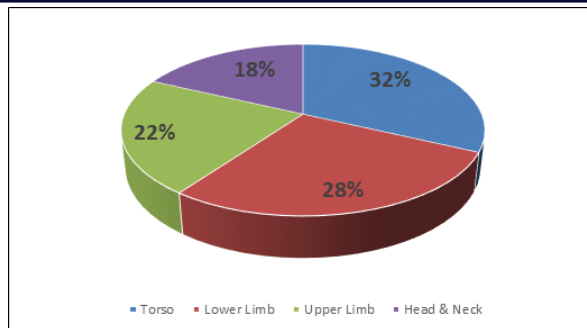


Chart 1: Percentage Distribution of Lesions

Statistics of Present Study:

Table 1: Total lesions studied

Tissue of Origin	Specific Diagnoses (Histopathology)		Total	
Fat	Lipoma		12	17
	Liposarcoma		3	
	Others		2	
Vessels	AV Malformation		3	8
	Lymphatic Malformation		1	
	Hemangioma		2	
	Aneurysm		1	
	Superficial Thrombophlebitis		1	
Nerves	Neurofibroma		2	4
	Schwannoma		1	
	Malignant NS Tumor		1	
Tendons & its structures	Ganglion		5	7
	Tenosynovitis		2	
Muscles & Connective tissue	Rhabdomyosarcoma		1	3
	Desmoid Tumor		1	
	Fibromatosis		1	
Others	Skin	Epidermoid	3	11
		Pilomatricoma	1	
	Joints	Synovial Cysts	2	
		Baker's Cyst	1	
	Collections/Abscesses		4	

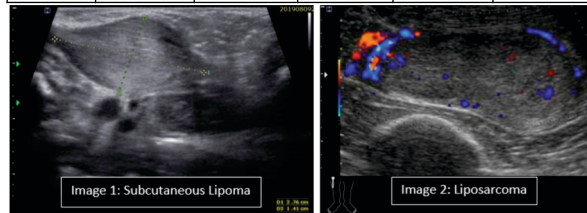
Detailed Evaluation:

Lipomatous Lesions:

17 cases of lipomatous lesions were evaluated in our study; of which 14 cases consisting of 12 lipomas and 2 liposarcomas were confirmed the same on histopathological evaluation. In the other 3 cases, the provisional USG diagnosis was later refuted on histopathological evaluation. This consisted of 2 cases with USG diagnosis of lipomas that were proved on histopathology to be liposarcomas and 1 case of a profoundly obese patient in which the lesion diagnosed as lipoma was later found to be normal fat deposition.

Table 2: Statistical evaluation of Lipomatous lesions

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
17	14	3	94%	82.3%	100%

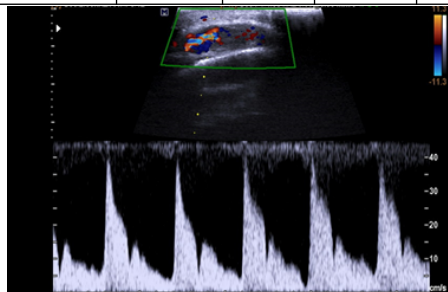


Vascular Lesions:

Of the 8 cases of vascular lesions evaluated in our study, USG exhibited an excellent sensitivity by correctly revealing 7 of these lesions. The addition of color and spectral doppler USG to the routine gray scale imaging significantly boosts the sensitivity of USG for the evaluation of these lesions. Spectral Doppler interrogation makes the evaluation of the origin of the lesion possible with arterial malformation eliciting high resistance waveforms and venous malformation eliciting low velocity waveforms. Lymphatic malformations do not show any color filling on CFM mode.

Table 3: Statistical evaluation of Vascular lesions

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
8	7	1	98%	87.5%	100%

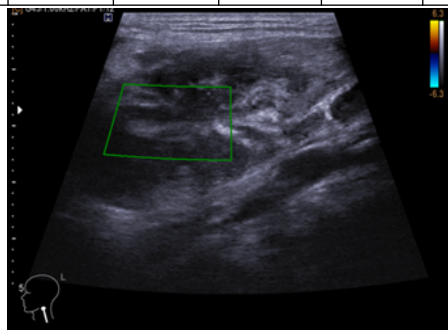
**Image 3: AV Malformation**

- Collections (Abscesses):**

4 such cases were studied and all 4 of these were diagnosed correctly by USG evaluation. 3 of these were abscesses and 1 was a hematoma in organizing stage. The abscesses were mostly tuberculous in origin. The real time imaging capability of USG with the demonstration of moving echoes and debris within the hypo-to-anechoic lesion with absence of color filling on CF mode makes possible the diagnosis of these lesions with high degree of confidence.

Table 4: Statistical evaluation of Collections

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
4	4	0	100%	100%	100%

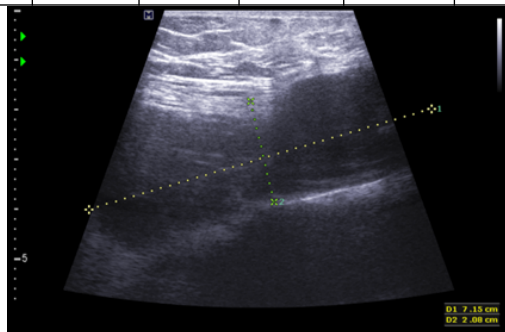
**Image 4: Collection (Tubercular Abscess)**

- Nerve Sheath Lesions:**

These particular lesions are the ones that largely remained elusive in our study; as was also found in a number of studies carried out by other researchers. 4 such patients were studied in our research who were later evaluated by histopathology. However, only 2 of these were correctly identified, that too with limited degree of confidence. Besides, the differentiation of benign and malignant nerve sheath lesions, the differentiation of neurofibroma and schwannoma solely from USG findings is often limited.

Table 5: Statistical evaluation of Nerve sheath lesions

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
4	2	2	96%	50%	100%

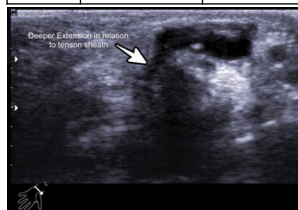
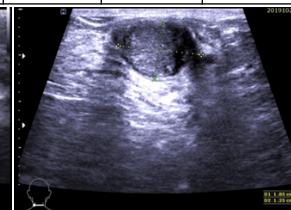
**Image 5: Malignant Nerve Sheath Tumor**

- Ganglion Cyst:**

5 cases were studied, in which the USG findings with demonstration of neck extending to tendon sheath or a joint capsule compounded with the clinical examination in the form of typical location of the lesions, allowed accurate diagnosis of the lesion. Result was consistent with histopathology in all 5 of these cases. The significant other conditions that poses diagnostic confusion with ganglion is synovial cyst, that also arises from joint space, similar to ganglion. 2 such cases of synovial cysts were falsely diagnosed as ganglion cyst on USG; thereby limiting the specificity of USG.

Table 6: Statistical evaluation of Ganglion cyst

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
5	5	2	100%	100%	95.7%

**Image 6: Ganglion Cyst****Image 7: Epidermoid**

- Epidermoid:**

3 cases of epidermoid were evaluated and all were diagnosed accurately owing to the characteristic USG features of hypoechoic lesions with linear strands within associated with posterior acoustic enhancement; demonstrating the reliability of the USG for evaluation of these lesions.

Table 7: Statistical evaluation of Epidermoid cyst

Total Cases	Correctly Diagnosed	Mis diagnosed	Accuracy	Sensitivity	Specificity
3	3	0	100%	100%	100%

- DISCUSSION**

In an article by Bruno D. and Fornage, M.D. entitled as "Soft Tissue Masses: The Underutilization of Sonography", it was concluded that "US can yield valuable information in the evaluation of soft tissue masses by confirming the presence or absence of a morphologic abnormality with a very high negative predictive value, by determining the cystic or solid nature of a mass, by guiding percutaneous needle biopsy or drainage, by localizing nonpalpable masses pre- or intraoperatively, by monitoring lesions that are treated conservatively and by detecting early recurrences of soft tissue sarcomas. US can often provide diagnostic information similar to that provided by MR imaging for only a fraction of the cost of MR imaging, making US as a first-line imaging examination modality for soft tissue lesions of musculoskeletal systems". Such high accuracy of USG with its unique advantages in the form of real time evaluation of flow dynamics and imaging in different planes was also confirmed in our study.

Lipoma was the most common benign tumor encountered as soft tissue masses. These tumors often were found to be located in the subcutaneous plane, though their locations in intramuscular and intermuscular planes aren't infrequent. On USG, most of the lipomas were found to be homogeneously hyperechoic relative to the surrounding structures with peculiar pattern of echogenic parallel lines also depicted with the tumor. However, some of the lipomas were hypoechoic or even isoechoic to the surrounding structures. We inferred that lipomas have an echogenic pattern ranging from hyperechoic to hypoechoic with parallel echogenic lines being a characteristic feature.

USG exhibited an excellent sensitivity of 100% and specificity of 100% for the evaluation of collections and abscesses, which appear as hypo to anechoic lesion with internal echoes and debris with no evidence of internal vascularity. Similar high degree of accuracy of USG for evaluation of collections was found by Dr Pooja Shamsukha and Dr Prasanna Mishrikotkar in their study in which all the 20 cases were confidently diagnosed on USG with sensitivity of 100%.

Ganglion is a cystic mass lesion and may present as unilocular or multilocular cystic lesion with myxoid matrix. The characteristic

feature of anechoic cystic lesion with “neck of the lesion” extending towards adjacent joint or tendon sheath allowed the diagnosis with high degree of confidence, with a sensitivity of 100% and specificity of 95.7% according to the present study.

Neurofibromas and schwannomas are the two most common neural tumors presenting as soft tissue swellings. Both the tumors are heterogeneous and predominantly hypoechoic. The presence of intrinsic blood flow on color Doppler sonography and peripheral nerve continuity suggests the diagnosis of peripheral nerve sheath tumor. However, USG features of neurofibroma and schwannoma are frequently overlapping. Even in our study, nerve sheath tumors frequently posed diagnostic confusion with accurate diagnosis being obtained in only 50% of the total cases studies. An important finding is that a nerve eccentrically entering a mass was seen only in schwannomas, and that may allow differentiation between neurofibromas and schwannomas.

Epidermal inclusion cysts most often appears sonographically as a hypoechoic mass containing variable echogenic foci without color Doppler signals. Sonographic findings are related to the lamellar pattern of keratin debris and the granulation tissue the lesion. These definitive features of Epidermoid allows the diagnosis of Epidermoid with high degree of accuracy, as was also concluded in our study, which found a USG sensitivity as well as specificity of 100% for diagnosis of Epidermoid cysts. Most cases presenting diagnostic difficulty were the cases of ruptured cysts, which exhibits lobulated configuration with color Doppler signals.

In present study, the frequency of benign lesions was 90% and malignant lesions was 10%; with benign lesions surpassing the malignant lesions. While color flow was an important indicator; it was not a definitive marker for malignant lesion. No definitive flow pattern was identified that was specific to malignant lesions. Color Doppler US could not distinguish malignant masses from benign masses, but spectral analysis was found to be useful for distinguishing acute inflammatory diseases (that show reduced impedance) from neoplasms (that show increased impedance).

• CONCLUSION

Soft tissue lesions of musculoskeletal system are commonly encountered in day-to-day practice. Ultrasonography has excellent accuracy to be used as an initial imaging modality for the evaluation of soft tissue lesions of musculoskeletal system. It is simple, convenient and radiation free with the capability for real time imaging in different plane. Moreover, evaluation of vascular flow characteristics by Doppler USG is excellent. Precise histological characteristic of the lesion can frequently be predicted from ultrasonography findings. These particularly includes lesions like lipoma, abscesses, vascular lesions, ganglion etc., thereby obviating the need for complex and expensive imaging modalities like MRI.

Besides the characterization of the lesion, USG also helps evaluate the origin of the lesion and its relation to surrounding structures and hence determine the extent of the lesion; thereby, affecting the treatment strategy for the lesion. Moreover, being an easily available and inexpensive modality without the use of radiations, it can be used for the follow up of the lesions being managed conservatively or follow up evaluation after treatment.

Thus, Ultrasonography with its extended capabilities in the form of Color flow evaluation and Doppler interrogation is ideal not only for initial evaluation of soft tissue lesions but also for follow up and affecting treatment strategy. However, familiarity with the basic anatomy of musculoskeletal system, its USG appearance, the spectrum of soft tissue lesions and changes associated with a pathology is required to enhance the usefulness of USG for this particular indication.

• CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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