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Role of Ultrasound Elastography and Diffusion Weighted Magnetic Resonance Imaging in Evaluation of Soft Tissue Masses

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ABSTRACT

Background: Ultrasound is the main evaluation modality for superficial soft tissue masses to evaluate their size, position, and relationship between the masses and the surrounding structures.

Objectives: This study's major goals were to reliably predict if a soft tissue mass was benign or malignant, to describe the mass's nature utilizing MR DWI and ultrasound elastography, and to minimize needless biopsies.

Patients and methods: South Valley University's Qena University Hospital served as the site of this cross-sectional investigation. This research comprised 30 patients who were eligible for MRI testing and ultrasound elastography between January 2021 and January 2022 and who had identified superficial soft tissue masses or clinical suspicion of having them.

Results: The majority of findings on MRI were non-enhancing masses (40%). As regard DWI findings among the studied patient, 56.7% of them were non-restricted diffusion and 43.3% were restricted diffusion. 17 benign and 13 malignant lesions recognized by DWI were correctly identified with histopathology. The DWI sensitivity was 94.4%, specificity was 100%, with accuracy of 96.7% for evaluating soft tissue masses. Strain ratio yield sensitivity of 87.1% and specificity of 89.7% with cut off level of 2.5 and AUC 0.813.

Conclusion: In terms of identifying soft tissue masses, DWI has greater sensitivity, specificity, and accuracy than US elastography.

Keywords: Non-enhancing mass, Soft tissue mass, Ultrasound elastography.

INTRODUCTION

Differentiating between benign and malignant tumors is crucial to avoiding delays in the treating of the latter and avoiding the needless surgical removal of the former [(1)].

Pathological diagnosis is often made using a needle biopsy, which is the most reliable technique. However, since it involves intrusive procedures, patients may find it upsetting, and it is not practicable for all soft tissue tumors [(2)]. The main form of assessment for superficial soft tissue masses is ultrasound, which can determine their size, location, and connection with neighboring structures. Ultrasound may offer a preliminary diagnosis by inspections of the edges of the tissue masses, internal echo features, and internal color flow [(3)].

With the use of ultrasonic strain elastography (USE), the stiffness of the tissue structures may be determined [(4)]. It is a useful tool for distinguishing between cancerous and benign tumors [(5)].

A malignant tumor often has more stiffness than a benign tumor. The differential diagnosis used to be mostly relied on the doctors' indirect palpations, which might be restricted in cases of obese people, mass sizes and depths, and doctors' abilities [(6)].

Since its first use at the turn of the 20th century, USE has gained widespread acceptance as a useful technique for differentiating between malignant and benign tumors [(7)]. Furthermore, USE has only sometimes been used to study the distinction between benign and malignant soft tissue tumors [(8)].

By exerting pressure to the inspection regions, the present research intended to evaluate the value of strain elastography (SE) for differentiating between malignant and benign soft tissue masses. USE then acquired reaction information arising from the pressure and calculated the tissue stiffness. Because malignant tumors are often more difficult to distinguish from benign tumors, USE may be utilized to do so [(9)].

In addition, making the proper therapy decisions and planning requires differentiating between benign and malignant soft tissue cancers. Due to its superior ability to differentiate between soft and hard tissues, MRI is superior in the assessment of these malignancies [(10)]. The approach known as diffusion weighted imaging (DWI), which takes into account the structure of the tissue, the stability of the cell membranes, and the tortuosity of the extracellular space, permits assessment of the brownian motion of water in the tissue micro-environment [(11)]. Depending on the motion of the water protons inside the tissue, DWI may provide a variety of contrasts between health and sickness [(12)]. In this study ultrasound elastography in combination with diffusion weighted image results were compared to histopathology.

The objective was to describe a soft tissue mass' kind using ultrasonic elastography and MRI DWI, properly determine if it was benign or malignant, and minimize needless biopsies.

PATIENTS AND METHODS

At South Valley University at Egypt's Qena University Hospital, this cross-sectional research was conducted. 30 patients were included in the sample between January 2021 and January 2022.

Inclusion criteria: Patients who were suitable for an MRI scan and an ultrasound elastography and who

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have verified or clinically diagnosed superficial soft tissue masses.

Exclusion criteria: Patients with MRI-incompatible metallic prostheses. Patients who declined the assessment or who had claustrophobia were also considered. Finally, individuals with compromised renal function were excluded (GFR < 30 mL/minute/1.73 m^2).

METHODS:

The following procedures were applied to all patients: A complete history was taken. **Clinical assessment:** A general and local evaluation was included, ultrasound elastography and MRI examination were used.

All patients were informed about the procedure and ensured their anonymity. Informed consent was obtained from all patients.

Ultrasound elastography:

The examination was performed using a 7.5 MHz linear transmitter connected to the GE Health Care digital ultrasound imaging system (Model: P9 and P6 pro) (Esaote, Italy) while the patient was lying supine or prone (depending on the site of the lesion).

A qualitative or semi-quantitative method based on the applying of compressive waves to tissues is compression elastography (CE). In order to provide an axial strain to the tissue during the exam, the operator applies rhythmic and regular compressions to the region of interest. Softer tissues incur more strain than stiffer tissues at a given applied tension because they deform more readily.

These stresses are caused by changes in longitudinal distance, which are determined by how long US waves take to travel between the transducer and the compression point. A color-coded elastogram is shown on the US screen once the signals are encoded by specialist software. Red typically denotes soft consistency, blue typically denotes hard consistency, and green and yellow typically indicate intermediate stiffness for the color elastogram [(13)]. Additionally, soft tissue structures' absolute elasticity values may be measured using shear-wave elastography (SWE) [(14)]. SWE is more objective than CE since it is less affected by inter-operator variability and may provide more repeatable findings. It permits the evaluation of both qualitative and quantitative measures. However, there are various restrictions that must be taken into account, most notably the restricted size, shape, and depth of the region of interest (ROI) [(15)].

Diffusion Weighted Magnetic Resonance Image

A Philips Achieva 1.5T system was used for the exam. (Netherlands) Solid tumours have a limited ability to diffuse. While using only traditional MR sequences, such as T2WI, would limit the diagnosis because of false positive results that are frequently observed, such as benign prostatic hyperplasia, haemorrhage, hormonal therapeutic and concurrent prostatitis, traditional MR sequences can detect the majority of tumours [(16)].

Employing DW images and ADC maps, which show hyper-intense signal and hypo-intense signal in tumor regions respectively, would limit false positive diagnosis [(16)].

All examinations were performed with patients lying calmly on the examination table and each examination was conducted over a minimum of 20 min.

Investigations: putting emphasis on the renal function tests while also providing laboratory testing.

Ethical considerations:

The study was approved by the Faculty's Ethics Committee. Informed written consent was taken from all patients. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis

Using SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA) and MedCalc 13 (MedCalc Software bvba, Ostend, Belgium) for Windows, all data were gathered, collate d, and statistically evaluated. Frequencies and relative proportions were employed to depict qualitative data. The difference between the qualitative variables was evaluated utilizing Fisher's exact test. Quantitative information was presented as mean ±SD (Standard deviation) and range. $P<0.05$ was considered significant.

RESULTS

The age of the study population ranged from 32-60 years with mean BMI was 26.34 kg/m^2 and (60%) of them were males **(Table 1)**.

Table (1): Demographic distribution of the studied patients

		All patients (n=30)
Age (years) Mean ± SD Range		 51.4 ± 6.82 32 - 60
BMI (kg/m^2), Mean ± SD		26.34 ± 2.51
Sex	Male	18 (60%)
	Female	12 (40%)

The majority of the findings among malignant masses was melanoma (16.7%) and the major findings among benign masses were lipomas (16.7%) **(Table 2)**.

Table (2): Histopathological results in the subjects under study

	All patients (n=30)	
	N	%
Malignant masses	12	40%
Liposarcoma	4	13.3%
Leiomyosarcoma	3	10%
Melanoma	5	16.7%
Benign masses	18	60%
Hemangioma	4	13.3%
Lipoma	5	16.7%
Neurofibroma	1	3.3%
Lymphoma	2	6.7%
Fibromatosis	1	3.3%
Inflammatory masses	3	10%
Abscess	2	6.7%

This table shows that the majority of findings on MRI were non-enhancing masses (40%). Note that more than one MRI findings were detected in the same patient (**Table 3)**.

Table (3): MRI results for the patients under investigation

	All patients (n=30)	
	N	%
Enhancing mass	11	36.7%
Enhancing foci	6	20%
Non-enhancing mass	12	40%
Non-mass enhancement	5	16.7%
Cystic lesion	2	6.7%
Fibrocystic disease	3	10%
Suspicious lymphadenopathy	4	13.3%

In the studied patients, 17 benign lesions recognized by DWI were correctly identified with histopathology (**Table 4).**

Table 4: Efficacy of DWI with histopathology in evaluation of benign and malignant soft tissue masses

DWI	**Histopathology**				**Total**	**P**
	Benign masses (n=18)		**Malignant masses** (n=12)			
	N	%	N	%		
Non-restricted	17	94.4%	0	--	17 (56.7%)	**<0.001**
Restricted	1	5.6%	12	100%	13 (43.3%)	
Total	18	100%	12	100%	30 (100%)	

In the studied patients, 14 benign lesions recognized by US elastography were correctly identified with histopathology out of 18 benign masses (**Table 5)**.

Table 5: Efficacy of US elastography with histopathology in evaluation of benign and malignant soft tissue masses

US	**Histopathology**				**Total**	**P**
	Benign masses (n=18)		**Malignant masses** (n=12)			
	N	%	N	%		
Benign	14	77.8%	0	--	14 (46.7%)	**<0.001**
Malignant	4	22.2%	12	100%	16 (53.3%)	
Total	18	100%	12	100%	30 (100%)	

The DWI sensitivity was 94.4%, specificity was 100%, NPV was 92.3% and PPV was 100% with accuracy of 96.7% for evaluating soft tissue masses. **(Table 6).**

Table (6): Diagnostic value of DWI in evaluation of soft tissue masses

Statistic	Value	95% CI
Sensitivity	94.44%	72.71% - 99.86%
Specificity	100%	73.54% - 100%
Positive Predictive Value (PPV)	100%	---
Negative Predictive Value (NPV)	92.31%	64.11% - 98.78%
Accuracy	96.7%	82.78% - 99.92%

Strain ratio yield sensitivity of 87.1% and specificity of 89.7% with cut off level of 2.5 and AUC 0.813. **(Table 7).**

Table (7): validity of strain ratio in detecting malignant soft tissue masses.

Variables	AUC	S.E.	% Confidence Interval	Cutoff	Sensitivity	Specificity
Strain ratio	.813	.059	.723 - .953	> 2.5	87.1%	89.7%

CASES

Case No. 1

Female patient 33 years with left upper thigh swelling **(Figures 1 and 2)**.

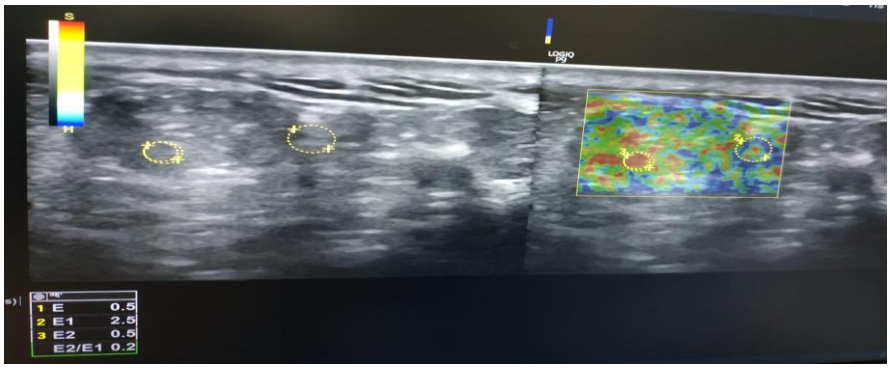
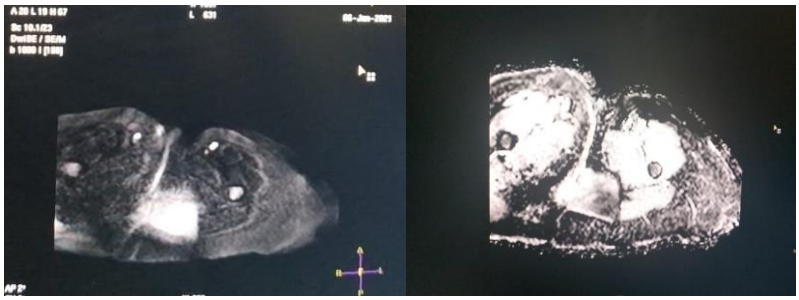


Figure 1: Ultrasound elastography shows: E1/E2 0.2



(A) **(B)**

Figure 2: **(A)** Facilitated in DWIs, **(B)** ADC value: 1.8X10$^{-3}mm^2$/s

Histopathology showed: diffuse lipomatous fat hypertrophy.

Case No. 2
Male patient 60 years presented with back swelling **(Figures 3 and 4)**.

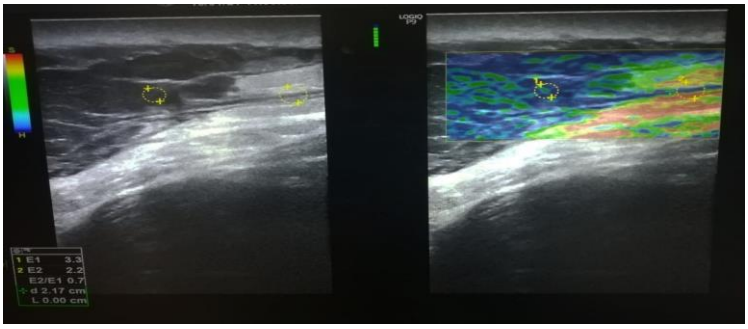
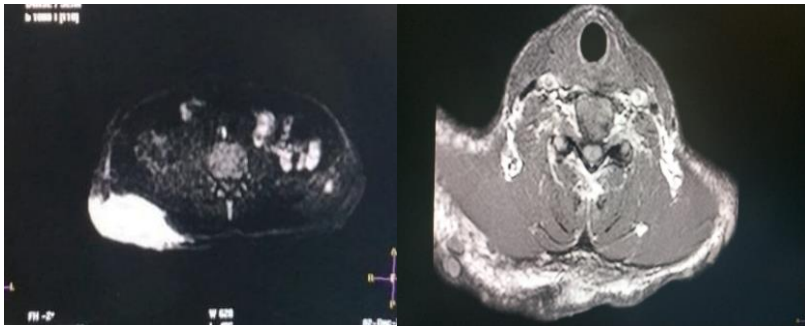


Figure 3: Ultrasound elastography shows: E1/E2 ratio 0.7



(A) **(B)**

Figure 4: (A) Restricted in DWls **(B)** ADC value: 1.5X10$^{-3}mm^2$/s

Histopathology showed: non caseating granulomatous inflammation

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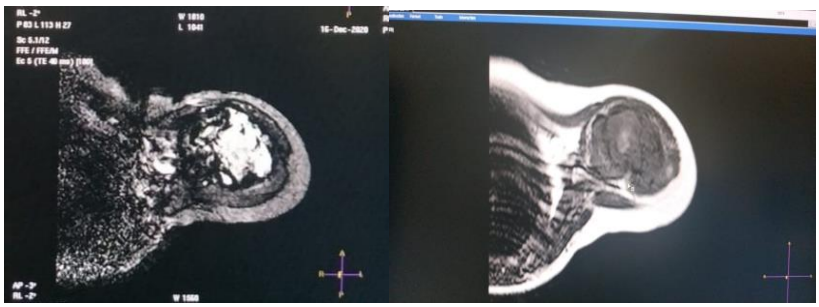
Case No. 3
Male patient 35 years presented with right arm swelling **(Figures 5 and 6)**.



(A) **(B)**

Figure 5: (A) Restricted in DWl. **(B)** ADC value: 0.7X10$^{-3}mm^2$/s

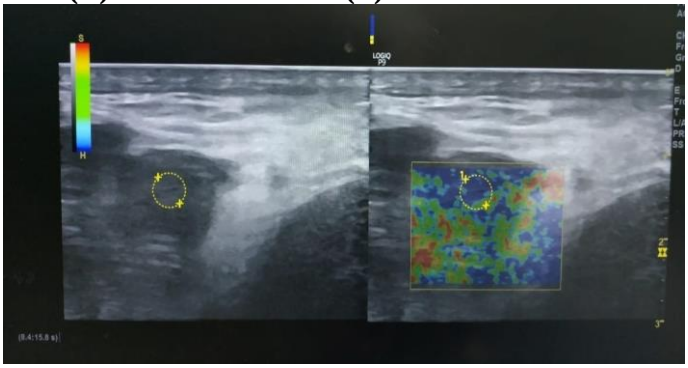


Figure 6: Ultrasound elastography shows E1/E2 4.4

Histopathology: Ewing sarcoma.

Case No. 4

Male patient 48 years presented with lower thigh swelling **(Figures 7 and 8)**.

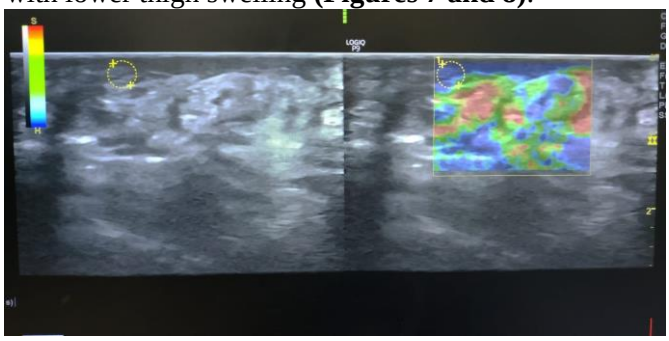
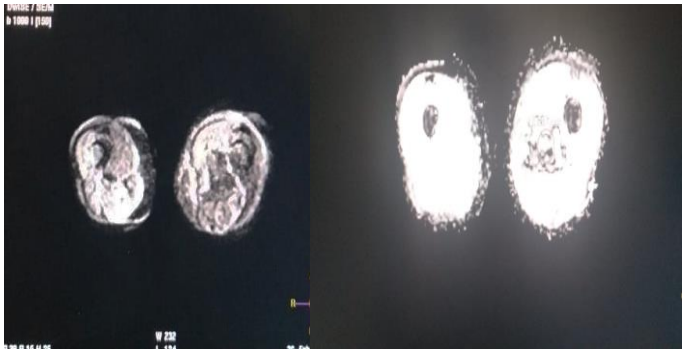


Figure 7: Ultrasound elastography shows: E1/E2 ratio 4.7



(A) **(B)**

Figure 8: (A) Restricted in DWIs, **(B)** ADC value: 0.81X$10^{-3}mm^2$/s

Histopathology: soft tissue sarcoma.

DISCUSSION

Fibrous connective tissue, adipose tissue, skeletal muscle, blood/lymph arteries, and peripheral nervous system are examples of soft tissues that emerge from mesodermal origin and support certain tissues. In general, benign soft tissue tumor incidence is over ten times greater than malignant soft tissue tumor incidence. Site, growth pattern, chance of recurrence, location and existence of metastases, patient's age to understand prognosis, and other factors might be considered in the evaluation of soft tissue tumors. The treatment strategy for the soft tissue masses requires multidisciplinary approach to reduce local recurrence. Since consecutive resections are also difficult to be done and surgical margins are very important in decision making for adjuvant therapies; to detect the lesion, determine lesion composition, predict the tissue that the tumor originated, rule out the malignancy and determine invaded surrounding structures by preoperative imaging findings are essential [17].

For superficial soft tissue tumors, ultrasound is the main evaluation technique used to determine the masses' size, location, and connection to the surrounding structures. External compression is used in elastography to quantify tissue strain and tumor stiff ness. The more recent development of acoustic radiation force impulse (ARFI) imaging should result in less variability since it doesn't need operator external compression. Acoustic radiation is used to transiently compress soft tissues, and the observed dynamic displacement is then utilised to evaluate the mechanical characteristics of the tissue [18].

DW MRI is a type of functional imaging that was initially used for neuro-imaging reasons, but lately it acquired a wide range of extra cranial reasons in numerous body parts involving the head and neck regions for distinction of benign and malignant tumors, aiding in the tumor staging, and for identification of the post-operative relapses and the residual tumor masses. It had also been described as follow-up research for evaluation of the therapeutic reactions in the head and neck regions [19].

This study's primary goals were properly predicting if a soft tissue mass was benign or malignant, identifying the mass's type using ultrasonic elastography and MRI DWI, and minimizing needless biopsies.

South Valley University's Qena University Hospital served as the site of this cross-sectional investigation. This research comprised 30 patients between January 2021 and January 2022 who were

clinically or MRI-eligible and had known or clinically suspected superficial soft tissue masses.

The age of the study population ranged from 32 - 60 years with a mean of 51.4 ± 6.82 years. The mean BMI was 26.34 kg/m^2 and (60%) of them were males. Our results were supported by the study of **Razek *et al*.** [(20)] as they conducted a retrospective analysis on 37 patients with soft tissue lesions (age range: 4-68 years; median age: 41 years; 22 males, 15 females). While in the study of **Shokry *et al*.** [(21)] their research included 30 participants (10 males and 20 females). The patients were between the ages of 29 and 73, with an average age ± SD (53.8 ± 13.1 years).

Among malignancies, soft tissue sarcomas account for less than 1% of cases. Soft tissue lesions have a benign to malignant ratio of more than 100:1, which means that many lesions will be subjected to imaging analysis and biopsy even if they will eventually turn out to be benign [(22)].

The present research revealed that the majority result among malignant masses (40%) was melanoma (16.7%) and the major finding among benign masses (60%) was lipoma (16.7%). Our results were supported by the research of **Akpinar *et al*.** [(23)] as they revealed that thirteen (n: 13; 56.5%) of the masses were benign and the remaining were malignant (n = 10; 43.5 %). While in the study of **Pass *et al*.** [(24)] all the lesions had benign imaging appearance, and for the goals of the study, they were all considered benign because, at follow-up imaging (12 months later), all lesions had either disappeared (n = 5 in the case of hematomas) or remained unaltered. In the studied patients, 17 benign lesions recognized by DWI were correctly identified with histopathology. The DWI sensitivity was 94.4%, specificity was 100%, NPV was 92.3% and PPV was 100% with accuracy of 96.7% for evaluating soft tissue masses. Strain ratio yield sensitivity of 87.1% and specificity of 89.7% with cut off level of 2.5 and AUC 0.813. **Barile et al. [(25)]** have created dynamic contrast-enhanced perfusion MRI-based signal time curves for 23 soft tissue tumors. In this study, two giant cell tumors and two myxofibrosarcomas were noted as the same histopathologically diagnosed tumors that represented different types of signal intensity curves.

Also, **Maeda et al. [(26)]** found no significant difference among ADC values between benign (1.50±0.64×10– 3mm2/second) and malignant (1.45±0.59×10–3 mm2/second) soft tissue tumors (n: 44).

CONCLUSION

DWI is more sensitive, specific, and accurate than US and strain ratio in identifying soft tissue masses. In addition to conventional ultrasonography, ultrasonic elastography has shown to be helpful in differentiating between benign and malignant soft tissue masses via quantitative (strain ratio) and qualitative (elasticity score) examination.

DECLARATIONS

- **Consent for Publication:** I confirm that all authors accept the manuscript for submission
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of Interest:** The authors declare no conflicts of interest regarding the publication of this paper.

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