Role of MRI in the Evaluation of Soft Tissue Masses

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Abstract: **Introduction:** Magnetic Resonance Imaging (MRI) is a major radiologic method for evaluation of soft tissue masses due to superior contrast resolution, Multi-planar imaging and lack of ionizing radiation. Diffusion weighted imaging (DWI) provides the functional information required. The addition of quantitative ADC values plays an important role in more accurate diagnosis. **Aim:** This thesis aimed at evaluation the role of MRI, especially Diffusion weighted sequence and ADC mapping in the initial characterization of soft tissue masses. **Methodology:** This study enrolled 50 patients. Their ages range from 1 to 90 years. All patients present with clinical symptoms of soft tissue mass, according to its site. All were subjected to conventional MRI (T1, T2, and STIR) sequences. DW images were obtained, with calculation of ADC map from them. Gadolinium contrast was administered using automatic injector. Provisional radiological diagnosis was compared to the histo-pathological diagnosis. **Results:** 22 of our lesions were benign and 28 were malignant. Soft tissue masses with well-defined margin are benign (P=0.049). Addition of DW imaging with ADC mapping to the conventional MRI evaluation of soft tissue masses shows sensitivity (100%) and specificity (90.9%). **Conclusion:** MRI is the method of choice for evaluation and characterization of soft tissue masses. The parameter favoring benignity is well-defined margin. Adding DW-MRI with ADC mapping to the routine MRI protocol for soft tissue masses improves diagnostic accuracy and differentiation between benign and malignant masses.

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1. Introduction

Soft-tissue masses derive from a wide spectrum of tissues, and it may be difficult to differentiate non-neoplastic from neoplastic as well as benign from malignant lesions ***(Manaster, 2013).***

Classification and assessment of possible malignancy are of central importance in initial diagnosis of STMs as prognosis and functional outcome rely on early and correct treatment especially of malignant lesions ***(Loizides et al., 2012).***

Despite advances in soft tissue imaging, the radiologist often can only provide the referring physician with a wide set of differential diagnoses due to the inhomogeneity of lesions subsumed as STMs. Thus, biopsy is often necessary to establish a diagnosis ***(Gruber at al., 2016).***

Consequently, prior to biopsy or resection a multifaceted approach is usually employed to narrow down differential diagnoses and stratify patients into high- or low risk arms. Surrogate parameters such as tumor growth, tissue composition, tumor localization, vascularity, and diffusion restriction among others are currently used ***(Nandra et al., 2015).***

Consequently, magnetic resonance imaging (MRI) is the modality of choice for the preoperative evaluation of soft-tissue lesions. Its superior soft tissue contrast and ability to depict anatomic relationship between mass and surrounding structures have led some to believe that it may be a reliable method to determine if soft tissue lesions are benign or not ***(Chen et al., 2008).***

Differentiation between malignant and benign soft tissue tumors is a commonly encountered problem in daily clinical practice. Some benign soft tissue tumors can be correctly diagnosed with standard magnetic resonance imaging (MRI). However, for soft tissue tumors with a nonspecific imaging appearance, standard MRI is often not reliable for distinguishing malignant from benign soft tissue tumors ***(Kransdorf and Murphey, 2014).***

MR images can be particularly useful for characterizing benign lesions that do not require imaging follow-up or biopsy, such as lipomas and ganglia ***(Jim and Mary, 2009).***

There have been inconsistent reports using diffusion-weighted imaging (DWI) at 1.5 T for differentiation of malignant from benign soft tissue tumors ***(lee at al., 2016)***.

DWI provides functional information that can complement the structural and anatomic information obtained from the conventional MR imaging ***(Chhabra et al., 2014).***

DWI with ADC mapping provides a non-contrast MRI alternative for characterization of soft tissue masses ***(Unal et al., 2011).***

Aim of the Study

The aim of this study is to clarify the role of MRI in the initial evaluation and characterization of soft tissue masses, especially the diffusion-weighted imaging with ADC mapping.

2. Patients and Methods

This study was conducted upon 50 patients (22 females & 28 males), with known or clinically suspected soft tissue masses referred to the MRI unit from outpatient clinics. Their ages ranged from 1 year to 90 years. Approval of the Ethics committee and informed written consents were done. The patient data were secured & only used for the scientific purpose.

This study was performed in The National Cancer Institute in the period from April 2017 to August 2018.

Methodology:

Patients were subjected to the following:

- Full history taking.
- Clinical assessment for any contraindication to the procedure.
- Laboratory investigations with stress upon the renal function.
- tests and GFR.
- MRI Examination: MRI was performed on high field system (1.5 Tesla) closed magnet unit (Phillips Achieva XR).

MR protocol used:

All patients were submitted to the following MRI sequences:

- Multi planar MR imaging sequences without contrast including T1, T2 and STIR weighted images.
- Gadolinium-enhanced T1-weighted sequences.
- Diffusion-weighted sequence with multiple b-values.
- ADC maps were calculated from the diffusion-weighted images.

MRI images interpretation:

Assessment of the following criteria was done for each mass lesion:

- Predominant T1WI signal, T2WI signal and STIR signal (intermediate, low and high), as well as post contrast pattern (unenhanced, homogenous and heterogeneous enhancement).
- The lesion margin (well-defined, ill-defined or partially defined).
- The lesion location and shape (oval, rounded or irregular).
- The maximum diameter of the mass was measured in centimeters.
- The lesion was determined on DWI and ADC map by using the conventional MR images as a guide.
- Signal intensity of the lesion on DWIs was determined (low or high).
- Measurements of the ADC values were made using electronic cursor on the ADC map in different regions of interest (ROI) of the lesion.
- Areas of flow void, calcifications or dense fibrosis and normal tissue were avoided during ROI placement.
- ADC of the average value was obtained.
- Finally, after MRI images interpretation was made for each case, each case was categorized regarding their neoplastic nature as either: benign or malignant.

Statistical Analysis:

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 25.

Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparison between quantitative variables was done using the non-parametric Mann-Whitney tests ***(Chan, 2003a)***.

For comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5 ***(Chan, 2003b)***.

ROC curve was constructed with area under curve analysis performed to detect best cutoff value of ADC for detection of malignancy. P-values less than 0.05 were considered as statistically significant.

3. Results

In our study, analysis of different MRI parameters for differentiation between benign and malignant soft tissue masses, revealed that margin of masses is statistically significant in differentiation between benign and malignant (81.8 % of benign masses in our study showed well-defined margin) **(P 0.049)**.

Regarding lesion's shape, in this study eighteen of our study masses with irregular shape were malignant **(P 0.105).**

In T1 sequence, seventeen of our study masses with low signal intensity in T1 sequence were benign, while nineteen masses were malignant **(P 0.425)**.

In T2 sequence, Twenty two of our study masses with high signal intensity in T2 sequence were malignant, while sixteen masses were benign **(P 0.886)**.

In STIR sequence, all malignant masses in our study showed high signal intensity in STIR sequence **(P 0.079)**.

Analysis of the post-contrast enhancement pattern of the lesions included in our study revealed, Twenty masses in our study with heterogeneous post-contrast enhancement were malignant **(P 0.251)**.

Table. 1. Detailed MRI parameters for differentiating between benign and malignant masses.

		Diagnosis				
		benign lesions		Malignant		P value
		Count	%	Count	%	
Shape	Rounded	2	9.1%	5	17.9%	0.105
	Oval	10	45.5%	5	17.9%	
	Irregular	10	45.5%	18	64.3%	
Margin	Ill defined	2	9.1%	7	25.0%	0.049
	well defined	18	81.8%	13	46.4%	
	Partially defined	2	9.1%	8	28.6%	
T1	Low intensity	17	77.3%	19	67.9%	0.425
	intermediate signal	3	13.6%	8	28.6%	
	high intensity	2	9.1%	1	3.6%	
T2	Low intensity	2	9.1%	3	10.7%	0.886
	intermediate signal	4	18.2%	3	10.7%	
	high intensity	16	72.7%	22	78.6%	
STIR	Low intensity	3	13.6%	0	.0%	0.079
	intermediate signal	0	.0%	0	.0%	
	high intensity	19	86.4%	28	100.0%	
Post-contrast Pattern	Homogenous	5	22.7%	7	25.0%	0.251
	Heterogenous	13	59.1%	20	71.4%	
	No	4	18.2%	1	3.6%	

In our study, detailed analysis of ADC value (mm^2/sec) for benign and malignant masses showed that the mean ADC of malignant lesions was (0.69 x10^{-3}) mm^2/sec and the mean ADC of benign lesions was (1.61 x10^{-3}) mm^2/sec.

Table 2. The detailed analysis of ADC (mm2/sec) values for benign and malignant lesions in our study.

	Diagnosis										
	benign lesions					Malignant					P value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
ADC value	1.61	.63	1.55	.21	2.70	.69	.29	.68	.20	1.20	<0.001

For the benign soft tissue masses, the greatest ADC value was seen in case of backer cyst (2.7 x 10−3 mm^2 /sec) and cavernous hemangiomas (2.2 x $10^{-3}$$mm^2$ /sec) while the lowest one was seen in lipoma (0.21 x 10^{-3} mm^2/sec), Almost all benign soft tissue tumors (except for lipoma and giant cell tumor of tendon sheath) have ADC values more than 1.2 x $10^{-3}$$mm^2$/sec.

For malignant soft-tissue masses, the highest ADC value was seen in myxoid liposarcoma (2.7 x $10^{-3}$$mm^2$/sec), while the lowest ADC value was seen in pleomorphic high grade sarcoma (0.25 x $10^{-3}$$mm^2$ /sec). Nearly all malignant soft tissue neoplasms (except for myxoid liposarcoma) have ADC values equal to or less than 1.2 x $10^{-3}$$mm^2$/sec.

Also, the results according to ROC curve for the discrimination between benign and malignant lesions using the ADC value showed that the mean ADC value of benign soft tissue masses was 1.6 mm^2/sec and the mean ADC value of malignant soft tissue masses was 0.69 mm^2 /sec, with the cutoff value between them is 1.2 mm^2/sec (This means that masses with ADC value more than 1.2 mm^2/sec were benign, while masses with ADC value less than or equal to 1.2 mm^2/sec were malignant) showing sensitivity (100%) and specificity (90.9%). There was a significant difference in the mean value for ADC between benign and malignant soft tissue masses **(P < 0.001).**

4. Discussion

Soft tissue masses (STM) are a common entity in everyday routine and comprise pseudo-tumors as well as benign and malignant lesions ***(Gruber et al., 2016).***

MRI is an important tool for soft tissue mass (STM) assessment, particularly to define a lesion's dimensions and extent of disease ***(Grade et al., 2017).***

In MR imaging, characterization of soft tissue masses is based on information obtained by comparison of signal characteristics on various sequences, together with morphologic features ***(Aga et al. 2011).***

Diffusion-weighted imaging (DWI) is being used over the last few years in the domain of musculoskeletal soft tissue lesions to evaluate the tumor cellularity. DWI reflects the degree of free water diffusion within the tissues. Tumors or tissues with lower free water content, proteineous content, or high cellularity tend to restrict diffusion to a greater degree and vice versa. Thus, DWI provides functional information that can complement the structural or anatomic information obtained from the conventional MR imaging ***(Chhabra et al., 2018).***

The addition of quantitative ADC values plays an important role in more accurate diagnosis of malignant soft tissue neoplasms and in the follow up of tumors and their response to therapy ***(Kotb et al., 2014).***

Our study showed that 81.8% of our benign lesions showed well-defined margin, while 53.6% of our malignant lesions showed no-defined margin (25% showed ill-defined margin and 28.6% showed partially defined margin). Our results showed that margin of soft tissue masses is a highly significant parameter for differentiating benign and malignant lesions (P=0.049).

This result agrees with **Grande et al., 2017** who found in his study that lack of well defined margin is a useful MRI feature for characterizing STMs as malignant, with sensitivity 75%, specificity 70.4%, and accuracy 71.8%.

Our results disagree with the study done by **Chen et al., 2009** who found that traditional morphologic and perilesional change parameters had the lowest differentiating capability. The sensitivity of ill-defined margin in his study for predicting malignancy was 77.4%, and the specificity was 44.6%.

In our study, 64.3% of malignant lesions showed irregular shape, while 54.6% of benign lesions showed regular shape (9.1% were rounded and 45.5% were oval) (P=0.105). Also, this study found that all malignant lesions showed high signal intensity in STIR sequence (P=0.079). Also, 77.3% of our benign lesions showed low signal intensity in T2WI (P=0.524), while, 78.6% of our malignant lesions showed high signal intensity in T2WI.

Our results agree with **Grande et al., 2017** who stated in his study that: MR signal characteristics were not found to be significant when assessed. The sensitivity of post-contrast T1 > 50% enhancement of tumor as an imaging feature for characterizing STMs as malignant was 66.7%, the specificity was 40.7%, and the accuracy was 48.7%.

Our results disagree with the study done by **Chen et al., 2009** who stated that component characterizing imaging parameters showed better sensitivity. The sensitivity of T1 high signal matrix in his study for predicting malignancy was 41.9%, and the specificity was 69.6%. The sensitivity of absent T2 low signal matrix in his study for predicting malignancy was 85.5%, and the specificity was 41.1%.

Our study found that 71.4% of malignant lesions showed heterogeneous post-contrast enhancement pattern (P=0.251).

Our results agree with the study done by **calleja et al., 2012** who stated in his study that, the addition of static CE-MR sequences offered no added value compared with conventional and functional non-CE-MR sequences.

Also, **Chen et al., 2009** stated in his study that, the value of intravenous contrast in the evaluation of soft tissue masses is controversial. He found in his study, that contrast helped to characterize tissues, such as myxoid, cyst and necrosis, which in turn had discriminatory power between benign and malignant lesions.

This study showed that the mean ADC values of malignant soft tissue masses were significantly lower than those of benign soft tissue masses. The mean ADC value of benign STMs was 1.6×10^{-3} mm^2/sec while that of malignant STMs was 0.69×10^{-3} mm^2/sec; these values were significantly different (P < 0.001).

This study agrees with **Romeih et al., 2018** who found that the mean ADC values of malignant STTs were significantly lower than those of benign STTs. The mean ADC value of benign STTs was $1.43 \pm 0.56 \times 10^{-3}$ mm^2/sec, while that of malignant STTs was

0.74 ± 0.18 × 10^{-3} mm^2 /sec; these values were significantly different (P < 0.001).

These results are consistent with those of **Neubauer et al., 2012** who found that ADC values of malignant tumors is 0.78 ± 0.45 × 10^{-3} mm^2/sec and that of benign tumors is 1.71 ± 0.75 × 10^{-3} mm^2/sec (P <0.001).

Zou et al., 2016 and **Grande et al.2014** also reported that malignant STTs had significantly lower mean ADC values than benign STTs (P < 0.001).

Razek et al., 2012 also found in his study significant differences in the ADC values between malignant and benign soft tissue masses.

Also the study done by **Khedr et al., 2012** demonstrated the same results: increased apparent diffusion coefficients in benign soft-tissue masses compared to malignant soft-tissue masses where the main ADC value of all benign soft-tissue masses was 1.86 ± 0.67 while the main ADC value for all malignant soft-tissue masses was 0.97 ± 0.35. This may be attributed to the increased diffusion of water molecules in the extracellular spaces in benign lesions as compared to that of malignant soft-tissue masses.

This study also agrees with **Lee et al. 2016** who conducted the study on a 3.0 T MRI and used 5 different b values for DWI (b values of 0, 300, 800, and 1400 mm^2/sec). They concluded that The ADC av, ADC min, and normalized ADCs of malignant soft tissue tumors were significantly lower than those of non- malignant tumors on all b value combinations (P≤0.002).

The cut off value in this study was 1.2 × 10^{-3} mm^2 /sec, a threshold for distinguishing between benign and malignant masses with specificity of 90.9% and sensitivity of 100%.

This agrees with **Hassanien et al., 2018** study which found that the mean ADC value of benign and malignant soft tissue tumors was 1.53 ± 0.91 mm^2/s and 0.84 ± 0.33 mm^2/s, respectively with the cutoff value between them is 1.235 mm^2 /s showing sensitivity, specificity & accuracy 73%, 91.7% & 80.3% respectively. There was a significant difference in the mean value for ADC between benign and malignant soft tissue neoplasm (P < 0.05).

Razek et al. 2012 suggested a value of 1.34 × 10^{-3} mm^2 /sec as a threshold for distinguishing between benign and malignant masses. Using this value, they obtained a sensitivity, specificity, and accuracy of 94%, 88%, and 91%, respectively.

Romieh et al., 2018 in his study which enrolled fifty patients also, found that the ADC cut off value is ≤ 1.1 × 10^{-3} mm^2/sec, with a sensitivity of 83.3%, a specificity of 72.7%, a PPV and NPP of 80% (P <.001) for the characterization of musculoskeletal STTs.

In our study we encountered three cases with malignant myxoid tumors (Myxoid liposarcoma), which show mean ADC value of 2.5x10^{-3} mm^2/sec. We considered it as false negative. **Romieh et al., 2018** in his study found four cases of maliganant myxoid tumor (myxoid liposarcoma) with high ADC values of 2.30 ± 0.28 × 10^{-3} mm^2 /sec, which we considered false negatives. Also, **Hassanien et al., 2018** in his study encountered two cases of malignant myxoid tumor (high-grade myxofibrosarcoma), the mean ADC value was 2.05 ± 0.30 × 10^{-3} mm^2/sec so he considered it as false negative.

This is comparable to the study made by **Nagata et al., 2008** as in his study the data showed that the ADC (mean ± SD) in myxoid-containing tumors was 1.92 ± 0.41 × 10^{-3} mm^2 /sec, whereas that in nonmyxoid neoplasms was 0.97 ± 0.33 × 10^{-3} mm^2/sec.

The most likely cause of increased diffusivity in myxoid-containing tumors is the abundance of free water in the myxoid matrix, which lead to highest ADC values, directly reflecting the low collagen and high mucin content of these lesions as well as the large amount of extracellular water seen histologically ***(Peterson et al., 2014).***

In our study we found two cases with lipoma, which showed mean ADC value of 0.21x 10^{-3} mm^2 /sec. We considered it as false positive. **Hassanien et al., 2018** in his study found five patients with benign masses, demonstrating low SI in DWI and very low ADC value similar to those of malignant soft-tissue masses, yet proved to be lipomas with mean ADC value 0.31 ± 0.91 ×10^{-3} mm^2/sec and they were considered as false positive.

Romieh et al., 2018 in his study encountered four patients with benign lesions who had low signal intensity on DW-MRI and low ADC values (0.90 ± 0.10 × 10^{-3} mm^2/sec; similar to those of malignant STTs) and who were diagnosed with lipomas; these were considered false positives, and the observed restricted diffusion can likely be explained by the presence of a large amount of fatty tissue.

In our study we found two cases with baker cyst, which show mean ADC value of 2.5 x 10^{-3} mm^2/sec and one case of cavernous haemangioma, with high ADC value of 2.2 x 10^{-3} mm^2/sec.

This agrees with **Hassanien et al., 2018** who found a case of cavernous haemangioma in his study with high ADC value, measuring 2.5 x 10^{-3} mm^2/sec.

Romieh et al., 2018 also found a case of cavernous haemnagioma in his study with high ADC value, measuring 2.1 x 10^{-3} mm^2/sec. These results are consistent with those reported by **Costa et al., 2011**, who found high ADC values in haemangiomas

(2.3 x 10^{-3} mm^2/sec) and schwannomas (1.46 x 10^{-3} mm^2/sec).

Our study encountered two cases of giant cell tumor of tendon sheath (GCT), with low ADC values, measuring 0.67 x 10^{-3} mm^2/sec and 0.65 x 10^{-3} mm^2/sec. This result was considered false-positive result.

This result agrees with **Pekcevik et al., 2015** which showed ADC value in their study for giant cell tumor of tendon sheath to be 0.74 x 10^{-3} mm^2/sec. **Pekcevik et al., 2015** suggested that this was attributed to the fact that these tumors contain little necrotic, cystic or myxoid areas and do not have a large extracellular space with a resulting decrease in their ADC values.

Our result disagrees with the study conducted by **Romieh et al., 2018** who found high ADC value in giant cell tumor, measuring 2.34 x 10^{-3} mm^2/sec.

Nagata et al., 2008 had three cases of GCT with low ADC values agreeing with this study, their ADC values were as follows, 0.70 x 10^{-3} mm^2/sec, 0.78 x 10^{-3} mm^2/sec and 0.51 x 10^{-3} mm^2/sec, which was also reported in the study done by **Lee et al., 2016**.

Our study showed single case of hematoma, with low ADC value. It measures 0.48 x 10^{-3} mm^2/sec. This result disagrees with **Oka et al., 2008** who found in his study significant difference between hematomas and malignant soft tissue tumors.

Our study showed that ADC values in other malignant (non-myxoid) tumors are low. Such as spindle cell sarcoma, metastatic melanoma, Kaposi sarcoma and peripheral malignant nerve sheath tumor.

These results agree with **Romieh et al., 2018** who found in his study that ADC values are relatively low in several non-myxoid malignant tumors, such as undifferentiated high-grade pleomorphic sarcoma, Ewing 's sarcoma, malignant peripheral nerve sheath tumors, and lymphoma.

Hassanien et al., 2018 found in his study that Nearly all malignant soft tissue neoplasms (except for high-grade myxofibrosarcoma) have ADC values less than 1.1 x 10^{-3} mm^2/sec.

These results disagree with the study done by **Jeon et al., 2016** that showed that malignant peripheral nerve sheath tumors (MPNST) and malignant melanoma had high ADC values unlike their malignant nature.

Nagata et al. 2008 stated in their study that, all ADC values for malignant non-myxoid tumors ranged from 0.40 x 10^{-3} mm^2/sec to 1.35 x 10^{-3} mm^2/sec. These findings suggest that if an ADC value exceeds 1.35 x 10^{-3} mm^2/sec in non-myxoid tumors the possibility of malignancy is low. Furthermore, these findings suggest that a low ADC value does not exclude the possibility that a tumor is benign.

Our study showed that ADC values in other benign tumors are high. Such as fibromatosis, elastofibroma dorsi, lieomyoma and plexiform neurofibroma.

These results agree with **Hassanian et al., 2018** who found that almost all benign soft tissue tumors (except for lipoma) have ADC values more than 1.275 x 10^{-3} mm^2/sec.

Costa et al., 2011reported that fibromatosis and neurofibroma had low ADC values 1.1 x 10^{-3} mm^2/sec and 1.35 x 10^{-3} mm^2/sec, respectively.

Romieh et al., 2018 found that there is some overlap in his study was observed in the ADC values of malignant and benign soft tissue tumors.

Summary and Conclusion

Soft-tissue masses derive from a wide spectrum of tissues, and comprise pseudo-tumors, benign, and malignant masses. It may be difficult to differentiate non-neoplastic from neoplastic as well as benign from malignant lesions.

Soft-tissue lesions are frequently encountered by radiologists in everyday clinical practice. Characterization of these soft-tissue lesions remains problematic, despite advances in imaging.

Magnetic Resonance Imaging is an important radiologic method for evaluation of soft tissue masses. It has the advantages of high soft tissue contrast, lack of ionizing radiation, ability to directly image in sagittal, axial and coronal planes, and ability to determine lesion's dimensions and extent.

Diffusion weighted imaging provides functional information that can complement the structural or anatomical information obtained from the conventional MR imaging.

The addition of quantitative ADC values plays an important role in more accurate diagnosis of benign and malignant soft tissue neoplasms and in the follow up of tumors and their response to therapy.

The aim of this thesis was to clarify the role of MRI in the initial evaluation and characterization of soft tissue masses, especially the diffusion-weighted imaging with ADC mapping and their ability in determining whether benign or malignant.

This study included 50 patients. Their ages ranged from 1 to 90 years. 22 females and 28 males were found in our study. Conventional MRI examination was done to all our patients. Diffusion weighted imaging with ADC mapping was added to the examination.

Provisional diagnosis was made according to MRI sequences. The diagnosis was confirmed by histo-pathological biopsy according to standard histo-pathological procedures. Our study showed 22 benign and 28 malignant masses.

The results in our study revealed that the mean ADC values of malignant soft tissue masses were significantly lower than those of benign soft tissue masses. The mean ADC value of benign STMs was 1.6×10^{-3}mm^2/sec while that of malignant STMs was 0.69×10^{-3}mm^2/sec; these values were significantly different ($P < 0.001$).

The cut off value in our study was 1.2×10^{-3}mm^2/sec, a threshold for distinguishing between benign and malignant masses with specificity of 90.9% and sensitivity of 100%.

In our study we found two cases of myxoid liposarcoma with high ADC values. Also we found two cases of lipoma and two cases of giant cell tumor of tendon sheath with low ADC values.

We concluded that MRI is the method of choice for the evaluation and characterization of soft tissue masses. Margin of soft tissue masses can be used for differentiating between benign and malignant. The parameter favoring benignity is well-defined margin. Diffusion weighted imaging is a rapidly, valuable, non-invasive, non-contrast tool for differentiating between benign and malignant soft tissue masses. There is significant difference in the ADC values between benign and malignant soft tissue masses. So, adding DWI and ADC analysis to the routine soft tissue masses MRI protocol improves soft tissue masses diagnostic accuracy.

References

1. Aga P, et al.: Imaging Spectrum in Soft Tissue Sarcomas. Indian Journal of Surgical Oncology, 2011; 2:271-279.
2. Calleja M, dimigen M, Saiffudin A: MRI of superficial soft tissue masses: analysis of features useful in distinguishing between benign and malignant lesions. Skeletal Radiol, 2012; 41:1517-1524.
3. Chan Y (a): Biostatistics102: Quantitative Data-Parametric & Non-parametric Tests. Singapore Med J., 2003; 44:391-396.
4. Chan Y (b): Biostatistics103: Qualitative Data-Tests of independence. Singapore Med J., 2008; 44:398-503.
5. Chen C, Wu H, yen C. at al.: Differentiating Benign and Malignant Soft Tissue Masses by Magnetic Resonance Imaging: Role of Tissue Component Analysis. J Chin Med Assoc, 2009; 72:194-201.
6. Chhabra A, Callan A, Hwang H, et al.: Conventional MR and diffusion-weighted imaging of musculoskeletal soft tissue malignancy: correlation with histologic grading. Eur Radiol., 2018; 18: 5845-5849.
7. Costa F, et al.: Diffusion-weighted magnetic resonance imaging for the evaluation of musculoskeletal tumors. Magn Reson Imaging Clin N Am 2011;19:159-180.
8. Grade F, Ahlawat S, Fayad L, et al.: Characterization of Intermediate Soft Tissue Masses Referred for Biopsy: what is the Added Value of Contrast Imaging at 3.0 Tesla?, J. MAGN. RESON. IMAGING 2017; 45:390-400.
9. Gruber L, Gruber H, Glodny B, et al.: Dose size reliably predict malignancy in soft tissue tumours?. Eur Radiol., 2016; 26:4640-4648.
10. Hassanien O, Younes R, Dawoud R: Diffusion weighted MRI of soft tissue masses: Can measurement of ADC value help in the differentiation between benign and malignant lesions?. Egypt J Radiol Nucl Med., 2018; 49:681-688.
11. Jim S. and Mary G: Soft Tissue Tumors and Tumorlike Lesion: A Systemic Imaging approach. Radiology, 2009; 243:247-316.
12. Khedr A, Hassaan M, Sakr A: Diagnostic impact of echoplanar diffusion-weighted magnetic resonance imaging (DWI) in musculoskeletal neoplastic masses using apparent diffusion coefficient (ADC) mapping as a quantitative assessment tool. Egypt J Radiol Nucl Med., 2012; 43: 219-226.
13. Kotb S, Sultan A, Elhawary G, et al.: Value of Diffusion weighted MRI in differentiating benign from malignant bony tumors and tumor like lesions. Egypt J Radiol Nucl Med., 2014; 45:467-476.
14. Kransdorf M, and Murphey M: Imaging of soft tissue masses. In: Kransdorf MJ, Murphey MD (eds) Imaging of soft tissue tumors, 3rd eds. Lippincott Williams & Williams, Philadelphia, 2014; p39-94.
15. Lee S, Jee W, Kim S, et al.: Differentiation of malignant from benign soft tissue tumours: use of additive qualitative and quantitative diffusion-weighted MR imaging to standard MR imaging at 3.0 T. Eur Radiol., 2016; 26:743-754.
16. Loizides A, Peer S, Gruber H, et al.: Perfusion pattern of musculoskeletal masses using contrastenhanced ultrasound: a helpful tool for characterisation? Eur Radiol, 2012; 22:1803-1811.
17. Manaster B: Soft-Tissue Masses: Optimal Imaging Protocol and Reporting. AJR, 2013; 201:505-514.
18. Nagata S, Akiba J, Abi T, et al.: Diffusion-weighted imaging of soft tissue tumors: usefulness of the apparent diffusion coefficient for differential diagnosis. Radiation Medicine, 2008; 26:287-295.

19. Nandra R, Forsberg J, Grimer R: If your lump is bigger than a golf ball and growing, think Sarcoma. Eur J Surg Oncol, 2015; (EJSO) 41:1400–1405.
20. Neubauer H, et al.: Diffusion-weighted MRI for detection and differentiation of musculoskeletal tumors and tumor-like lesions in pediatric patients. World J Pediatr November 2012; 8:342-349.
21. Oka K, Sato H, Mizyta H, et al.: Ability of Diffusion-Weighted Imaging for the Differential Diagnosis Between Chronic Expanding Hematomas and Malignant Soft Tissue Tumors. JOURNAL OF MAGNETIC RESONANCE IMAGING, 2008; 28:1195-1200.
22. Pekcevik Y, Kahya M, and Kaya A: Characterization of Soft Tissue Tumors by Diffusion-Weighted Imaging, 201512:1-6.
23. Razek A, Nada N, Ghaniem M, Elkhamary S: Assessment of soft tissue tumours of the extremities with difusion echo planar Mr imaging. Radiol Med., 2012; 117:96-101.
24. Romeih M., Raafat T., Sallam K., et al.: The diagnostic value of diffusion-weighted magnetic resonance imaging in characterization of musculoskeletal soft tissue tumors. Egypt J Radiol Nucl Med., 2012; 49: 400-407.
25. Unal O, Koparan H, Avcu S, et al.: The Diagnostic Value of diffusion-weighted magnetic resonance imaging in soft tissue abscesses. Eur J Radiol., 2011; 77:490-494.
26. Zou Y, Wang Q, Zong M, et al.: Apparent diffusion coefficient measurements with diffusion-weighted imaging for differential diagnosis of soft-tissue tumor. J Can Res Ther, 2016; 12:864 -870.

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