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Research Article

ROLE OF MRI IN ASSESSMENT AND DIFFERENTIATION OF BENIGN AND MALIGNANT SOFT TISSUE TUMORS USING INTERNAL SIGNAL CHARACTERISTICS AND NEUROMUSCULAR INVOLVEMENT

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ABSTRACT

Sarcomas account for less than 1 % of all the types of cancers and radiological imaging plays a key role in the overall work up of the study, with each imaging modality having its advantage The main aim of this research study, however, is to differentiate between the malignant and the benign lesions by assessing signal characteristics, enhancement following contrast administration, and osseous and neurovascular involvement. Results indicated that MRI showed a higher sensitivity and specificity, PPV and NPV of MRI with the following values respectively -74%, 94%, 88% and 85%The study demonstrates that MRI is an extremely useful diagnostic tool for the detection of tumours.

INTRODUCTION

Soft tissues connect different organs and structures in the body, which are derived from the mesenchyme and includes fats, muscles, tendons and ligaments (fibrous tissues), joints (synovial tissue), lymph vessels, blood vessels and also the peripheral nervous system[1]. The soft tissue tumours are the non-epithelial extraskeletal growth of the tissues connecting different structures of the body that are typically mesodermal in origin. The recognition of the tumour is complicated by the unrecognizable architectural patterns during the study of the tumour cells[2].

These tumours are mostly classified by mesodermal differentiation. The soft tissue sarcomas (STS) occur in different locations, such as the extremities, head, neck, retroperitoneum and the chest wall. The STSs often are visible in various histologic subtypes. These can be located deep inside the tissues or at the subcutaneous tissues. Most of the sarcomas metastasize through the blood, although a few subtypes may spread through the lymphatic system. The most common type of STS is undifferentiated pleomorphic sarcoma (UPS). Although sarcomas may occur at any age, patients over 55 years of age are at more risk with UPS or liposarcoma being the commonest. Rhabdomyosarcoma or synovial sarcoma is commonly observed in patients below 20 years of age, while epitheloid sarcoma is common among younger adults[3].

Sarcomas account for less than 1% of all the types of cancers and occur in 2 to 4 persons per 100,000 population[4]. The STSs are more evident than primary malignant bone tumours. Benign soft tissue tumours are about 100 times more common than malignant soft tissue tumours and about 300 persons per 100,000 individuals are affected by it. The malignant STSs are quite uncommon, representing only about 1% of all the types of malignant tumours[5,6].

The incidence of tissue sarcoma in the UK reported that in 2010 there 531 new cases of bone sarcoma and 3,298 cases of STS. Between the year 1996 to 2010, the incidence of STS increased from 39 per 100,000 to 45 per 100,000. Based on age, STS was highest among males aged 85 years and above and counted 230 per million. The ratio for males were higher than the females (1.9:1) for this age group. Among the individuals of 45 to 59 years age group, the count for females was marginally higher than the males, which was probably due to the presence of gynaecological sarcomas. The rates of bone sarcomas were higher in males than in females below 20 years age group[7].

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Based on the site, the extremities present the most common area of the development of soft tissue (23%) and bone sarcomas (52%). The STSs of the limbs account for about half (50%) of all sarcomas, gastrointestinal consisting of 25% and head and neck 9% of all sarcomas[8]. About 10% of the sarcomas develop in the retroperitoneal tissues [9].

Diagnosis of STSs is a challenge for the health professionals. The STSs are often detected at a later stage with chances of recurrence, which is associated with low prognosis. Various imaging techniques, including invasive, non-invasive, radiology and computer assisted imaging are used for the diagnosis of STSs[9]. Initially a chest X ray helps to diagnose the presence of sarcoma and its spread to the nearby structures. CT scans uses cross sectional images through X rays, to determine the presence of STS in the chest, abdomen, retroperitoneum or its spread in the lungs, liver or the other nearby organs. CT-guided needle biopsy helps in guiding the biopsy needle to the tumour. Positron emission tomography uses instillation of radioactive sugar into the blood as cancer cells utilises sugar at an higher rate than any other cells of the body. An MRI provides a better picture of the sarcoma than the CT scan. It uses radio waves and magnetic fields to determine the presence and spread of the sarcoma. MRI is currently used for the examination of bone and soft tissue for the detection of tumours and other abnormalities, intraarticular extension, intratumoral necrosis and haemorrhage[10].

MRI is a computer based imaging modality that provides significant superior soft tissue contrast, absence of beam hardening artifacts, allows multiplanar image acquisition, obviates iodinated contrast agents and ionizing radiation. MRI avoids the detection of streak artefacts, which is commonly evident in CT. When MRI is combined with numerous other scans it makes an extremely sensitive and resourceful imaging technique. MRI helps in staging of the sarcomas, the extent of the condition and tumour necrosis. Appropriate diagnosis helps in a definitive treatment of the the patients with STSs. These characteristics make MRI as an effective diagnostic technique for tissue characterization than ultrasonography, CT scan and radiography[11].

The knowledge about the advantages of MRI over ultrasonography and CT scan led the author to conduct this study in order to observe the tumour staging of STSs, identify the osseous, neurovascular bundles and joint space involvement by soft tissue tumors, prevention of unwanted biopsy and surgeries owing to accuracy in diagnosis of the condition, and appropriate differentiation between benign and malignant lesion by different intralesional tissue signal characteristic with histopathological correlation. The main aim of this research paper was to study the MRI characteristics to assess the operability of different soft tissue tumours by identifying osseous, neurovascular bundles and joint space involvement by soft tissue tumours.

MATERIALS AND METHODS

The present prospective study was conducted from September 2016 to September 2018. Patients who presented with the diagnosis of having soft tissue tumours at Bapuji Hospital and Chigateri General Hospital were enrolled in the study.

Sample Size

A total of 50 patients participated in the present study.

Inclusion Criteria

All the patients with soft tissue tumours were included in this study. It included lesions of the primary neoplastic aetiology of soft tissues of the whole body. Patients of both gender and age group between 18-65 years, who gave consent for participation in the study, were included.

Exclusion Criteria

Patients with soft tissue tumours with inconclusive or inappropriate histological diagnosis, patients already treated, patients with recurrent or residual lesion after surgery, having soft tissue lesions not included in WHO classification, like ganglion, abscess, neurogenic tumours and patients unwilling to give consent for the study were excluded.

Procedure

The present study was initiated after getting the approval from the Institutional Ethics Committee. Written consent was obtained from each participant before screening the patients. Patients abiding by the inclusion and exclusion criteria were included in the study.

MRI scan was conducted for all the patients included in this study on 1.5 Tesla MR Imaging machine Achieva by Phillips Medical Systems. Localizer was taken in axial and coronal planes after proper positioning of the patient. The MRI protocol consisted of T2W, T1W, STIR Axial, T2W STIR Coronal and T1, T2 sagittal sequence. MR Angiogram, Contrast MRI and special sequence were used wherever required. All patients included in this study had undergone histopathological work up for correlation and confirmation of the diagnosis.

Statistical Analysis

The data were entered in Microsoft excel sheet and analysed using SPSS version 22 software. The categorical data were represented in the form of frequency and percentage. The chi-square test was used to test the significance for qualitative data. Continuous data were represented as mean and standard deviation. P value <0.05 was considered as significant.

RESULTS

The present study shows that the common age group among the participants was 31 to 40 years among which the youngest participant was 1 year old female and the oldest was a 80 year old male. Based on malignancy, 68% of the cases were malignant and 32% cases were benign. Benign lesions were common in females, whereas higher number of males had malignant tumours. About 32% of the patients with malignant sarcoma had synovial sarcoma and 31.5% of the patients with benign tumour had lipoma.

Table 1 Types of lesions

Type of tumor	No. of patients	Percentage
Benign	16	32.0%
Malignant	34	68.0%

Table 2 Final diagnosis and frequency of distribution

SL. No.	Final diagnosis	Total N (%)	No. (%) in benign	No. (%) in malignant
1	Synovial sarcoma	11 (22.0%)	0 (0.0%)	11 (32.4%)
2	Liposarcoma	4 (8.0%)	0 (0.0%)	5 (14.7%)
3	Malignant fibrous hystiocytoma	3 (6.0%)	0 (0.0%)	3 (8.8%)
4	Epitheloid sarcoma	2 (4.0%)	0 (0.0%)	1 (2.9%)
5	Desmoids tumor	3 (6.0%)	3 (18.8%)	0 (0.0%)
6	Planter fibromatosis	1 (2.0%)	1 (6.3%)	0 (0.0%)
7	Fibroma	0 (0.0%)	0 (0.0%)	0 (0.0%)
8	Pleomorphic sarcoma	4 (8.0%)	0 (0.0%)	3 (8.8%)
9	Myxoid sarcoma	2 (4.0%)	0 (0.0%)	2 (5.9%)
10	Lipoma	6 (12.0%)	5 (31.5%)	0 (0.0%)
11	Lymphangioma	0 (0.0%)	1 (6.3%)	0 (0.0%)
12	Haemangioma	2 (4.0%)	1 (6.3%)	0 (0.0%)
13	Leomyosarcoma	3 (6.0%)	0 (0.0%)	3 (8.8%)
14	Myxoma	1 (2.0%)	1 (6.3%)	0 (0.0%)
15	Leomyoma	1 (2.0%)	1 (6.3%)	0 (0.0%)
16	Dermatofibrosarcoma	2 (4.0%)	0 (0.0%)	1 (2.9%)
17	Fibrosarcoma	1 (2.0%)	0 (0.0%)	2 (5.9%)
18	Angiofibroma	1 (2.0%)	1 (6.3%)	0 (0.0%)
19	Glomustumor	1 (2.0%)	1 (6.3%)	0 (0.0%)
20	Benign fibrous hystiocytoma	0 (0.0%)	1 (6.3%)	0 (0.0%)
21	Rhabdomyosarcoma	1 (2.0%)	0 (0.0%)	2 (5.9%)
22	Clear cell sarcoma	1 (2.0%)	0 (0.0%)	1 (2.9%)

No.- Number, N= total number, %= Percentage, n= number

Table 3 Final Diagnosis and Frequency of Distribution

SL. No.	Final diagnosis	Total N (%)	No. (%) in benign	No. (%) in malignant
1	Synovial sarcoma	11 (22.0%)	0 (0.0%)	11 (32.4%)
2	Liposarcoma	4 (8.0%)	0 (0.0%)	4 (11.8%)
3	Malignant fibrous hystiocytoma	3 (6.0%)	0 (0.0%)	3 (8.8%)
4	Epitheloid sarcoma	2 (4.0%)	0 (0.0%)	2 (5.9%)
5	Desmoids tumor	3 (6.0%)	3 (18.8%)	0 (0.0%)
6	Planter fibromatosis	1 (2.0%)	1 (6.3%)	0 (0.0%)
7	Fibroma	0 (0.0%)	0 (0.0%)	0 (0.0%)
8	Pleomorphic sarcoma	4 (8.0%)	0 (0.0%)	4 (11.8%)
9	Myxoid sarcoma	2 (4.0%)	0 (0.0%)	2 (5.9%)
10	Lipoma	5 (10.0%)	5 (31.5%)	0 (0.0%)
11	Lymphangioma	1 (2.0%)	1 (6.3%)	0 (0.0%)
12	Haemangioma	2 (4.0%)	1 (6.3%)	0 (0.0%)
13	Leomyosarcoma	3 (6.0%)	0 (0.0%)	3 (8.8%)
14	Myxoma	1 (2.0%)	1 (6.3%)	0 (0.0%)
15	Leomyoma	1 (2.0%)	1 (6.3%)	0 (0.0%)
16	Dermatofibrosarcoma	2 (4.0%)	0 (0.0%)	2 (5.9%)
17	Fibrosarcoma	1 (2.0%)	0 (0.0%)	1 (2.9%)
18	Angiofibroma	1 (2.0%)	1 (6.3%)	0 (0.0%)
19	Glomustumor	1 (2.0%)	1 (6.3%)	0 (0.0%)
20	Benign fibrous hystiocytoma	1 (2.0%)	1 (6.3%)	0 (0.0%)
21	Rhabdomyosarcoma	1 (2.0%)	0 (0.0%)	1 (2.9%)
22	Clear cell sarcoma	1 (2.0%)	0 (0.0%)	1 (2.9%)

Table 4 Distribution of Symptoms

Symptoms	Benign N (%)	Malignant N (%)	Total N(%)
Pain	4 (25.00%)	32 (94.12%)	36 (72.0%)
Swelling	13 (81.25%)	16 (47.06%)	29 (58.0%)
Other	3 (18.75%)	11 (32.35%)	14 (28.0%)

Table 5 Accuracy of Pain to Distinguish Malignant and Benign Lesions

Pain	Malignant	Benign	Total		
Yes	32	4	36	89%	PPV
No	2	12	14	86%	NPV
	34	16	50		
	94% Sensitivity	75% Specificity			
P=0.00012(Significant)					

Both benign (68.7%) and malignant tumours (73.5%) were commonly present in the lower limbs than the upper limbs.

Table 6 Site distribution

Site	Benign N (%)	Malignant N (%)	Total N (%)
Upper Limb	5 (31.3%)	9 (26.5%)	14 (28.0%)
Lower Limb	11 (68.7%)	25 (73.5%)	36 (72.0%)

No.- Number, N= total number, %= Percentage, n= number

Table 7 Signal characteristics

Image sequence	Signal intensity	Benign N (%)	Malignant N (%)	Total N (%)
T1	Hypointense	8 (50.0%)	24 (70.6%)	32 (64.0%)
	Hyperintense	5 (31.25%)	9 (26.5%)	14 (28.0%)
	Isointense	3 (18.75%)	3 (8.8%)	6 (12.0%)
T2	Hypointense	1 (6.25%)	2 (5.9%)	3 (6.0%)
	Homogeneous Hyperintense	8 (50.0%)	6 (17.7%)	14 (28.0%)
	Heterogeneous Hyperintense	7 (43.8%)	27 (79.4%)	34 (68.0%)
STIR	Isointense	3 (18.75%)	1 (2.9%)	4 (8.0%)
	Completely suppressed	5 (31.25%)	1 (2.9%)	6 (12.0%)
	Partially suppressed	3 (18.75%)	0 (0.0%)	3 (6.0%)
	Not suppressed	8 (50.0%)	33 (97.1%)	41 (82.0%)
Post contrast	Homogeneous	11 (68.8%)	3 (8.8%)	14 (28.0%)
	Heterogeneous	6 (37.5%)	30 (88.2%)	36 (72.0%)
	Mild	8 (50.0%)	20 (58.8%)	28 (56.0%)
	Moderate	7 (43.8%)	13 (38.2%)	20 (40.0%)
	Strong	1 (6.25%)	2 (5.9%)	3 (6.0%)
	Peripheral	1 (6.25%)	3 (8.8%)	4 (8.0%)

No.- Number, N= total number, %= Percentage, n= number

About 71% of the malignant tumours were hypointense in the T1w images and 97% were hyperintense in T2w images. Heterogeneous hyperintensity and heterogeneous post contrast enhancement had higher sensitivity, specificity, PPV and NPV, which predicted malignancy. Heterogeneous hyperintensity was significantly associated with malignant lesions (p value<0.05). The ill-defined margins showed higher sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), predicting malignancy. The chi square test revealed that the margins were significantly associated with malignant lesions (p =0.002).

Table 8 Accuracy of T2W heterogeneous hyperintensity to distinguish malignant and benign lesions

T2 Heterogeneous Hyperintense	Malignant	Benign	Total		
Yes	27	7	34	79%	PPV
No	7	9	16	56%	NPV
Total	34	16	50		
	79% Sensitivity	63% Specificity			
	P=0.011(Significant)				

No.- Number, N= total number, %= Percentage, n= number, PPV- Positive predictive values
NPV: Negative predictive values

Table 9 Accuracy of post contrast heterogeneous enhancement to distinguish malignant and benign lesions

	Malignant	Benign	Total		
Yes	31	5	36	86%	PPV
No	3	11	14	79%	NPV
	34	16	50		
	91% Sensitivity	69% Specificity			
	P=0.000011(Significant)				

No.- Number, N= total number, %= Percentage, n= number, PPV- Positive predictive values
NPV: Negative predictive valueS

Table 11 Extent of the lesion

Extension and involvement of lesion	Benign N (%)	Malignant N (%)	Total N (%)
Osseous	1 (6.3%)	8 (23.5%)	9 (18.0%)
Neurovascular bundle	2 (12.5%)	12 (35.3%)	14 (28.0%)
Joint	1 (6.3%)	4 (11.76%)	5 (10.0%)

No.- Number, N= total number, %= Percentage, n= number

Table 12 Accuracy of osseous involvement to distinguish malignant and benign lesions

Osseous involvement	Malignant	Benign	Total		
Yes	7	1	8	88%	PPV
No	27	15	42	36%	NPV
Total	34	16	50		
	21% Sensitivity	94% Specificity			
	P=0.1970(Not significant)				

No.- Number, N= total number, %= Percentage, n= number, PPV- Positive predictive values
NPV: Negative predictive values

Among the patients with benign tumour, 12.5% showed neurovascular extension, and 6.3% showed bone and joint extension each. Among the patients with malignant tumour, 35.3% showed extension to the neurovascular bundle, while the tumour in 23.5% and 11.76% were extended to the bone and joint. Osseous involvement has lower sensitivity NPV but higher specificity and PPV predicting malignancy and was not significantly associated with malignant lesions (p=0.1970) (Table 13). Osseous and neurovascular involvement was more common in malignant tumours, which was observed to be 14% and 24% respectively. The total osseous and neurovascular involvement in both benign and malignant tumours in the study was 16% was 28% respectively. It was also observed that neurovascular involvement had higher specificity and PPV predicting malignancy and the chi-square test suggested there was no significant association among neurovascular involvement and malignancy (p=0.0940).

Table 13 Accuracy of involvement neurovascular bundle to distinguish malignant and benign lesions

	Malignant	Benign	Total		
Yes	12	2	14	86%	PPV
No	22	14	36	39%	NPV
Total	34	16	50		
	35% Sensitivity	88% Specificity			
	P=0.0940(Not significant)				

No.- Number, N= total number, %= Percentage, n= number, PPV- Positive predictive values
NPV: Negative predictive values

DISCUSSION

Appropriate diagnosis of a condition promotes good prognosis and proper pre and post operative management. Soft tissue sarcomas exhibit complicated results during diagnostic procedures, which requires the need for radiology and pathology to confirm the characteristics of the sarcoma. MRI is a widely established tool that has been used for detection and local staging of soft tissue tumors. However, its ability to differentiate between the benign and malignant lesions varies widely. In the present study we have successfully employed MRI for the differentiation of benign and malignant soft tissue tumors using certain parameters.

The present study shows a common age group between 31 to 40 years with benign and malignant cases of STS and no significant age difference was observed between the benign and malignant cases. Sen *et al*. stated that the most common age group in their study for benign and malignant cases was below 20 years and above 20 years respectively[12]. Kransdorf reported that the most common age group was between 16-25 years in both benign and malignant cases in his study[13]. The differences in the results were probably due to the geographical distribution of the population, the site of the study and differences in sample size.

The heterogeneous hyperintensity on T2w image in malignant lesions showed sensitivity (79%), specificity (63%), PPV (79%) and NPV (56%) respectively. Statistical analysis using chi square test revealed that the T2 Heterogeneous hyperintensity is significantly associated with malignant lesions (p value<0.05). Similar finding was reported by *Chen, et al*. They have shown that MRI can differentiate between the malignant and benign lesions with 41.9% sensitivity, 69% of specificity, 60% of PPV and 52% of NPV[14].Datir, *et al*. reported the sensitivity of 100% and specificity of 50%[15]. According to the reports presented by Hermann *et al*., it was observed that 40% of the malignant tumors were hyperintense on T1-weighted images and 100% were hyperintense on T2-weighted images with a sensitivity of 72% and specificity of 87%. It was also reported that 17% of the benign tumors were hypointense and 58% were hyperintense on T1-weighted images and 85% benign tumors were hyperintense on T2-weighted images[16].

The osseus involvement was reported in 6.3% of the patients with benign tumour and 23.5% patients among malignant cases. This finding had lower sensitivity (21%) and lower NPV (36%), but it showed higher specificity (94%) and PPV (88%) in predicting malignancy. The Osseous involvement is not significantly associated with malignant lesions (p value>0.05). While Chen *et al*. reported similar findings, such as lower sensitivity (35.5%) and lower NPV (51.2%), but higher specificity (75%) and higher PPV (61%)[14], Alex *et al* reported contrasting results, showing high sensitivity (83.3%), specificity (84%), PPV (83%) and NPV (84%) in their study[17].

Heterogenous post contrast enhancement was able to predict the malignancy with 91% sensitivity, 69% specificity, 86% PPV and 79% NPV (p value<0.05). Similar results were reported by *Alex, et al.,* which showed sensitivity of 100%, specificity of 70%, PPV of 86% and NPV of 79% for predicting malignancy[18]. Similarly, Sen, *et al*. revealed sensitivity of 91%, specificity of 38%, PPV of 51% and NPV of 86% in predicting malignancy[12].

Among patients reported to have neuromuscular bundle involvement, 12.5% were benign cases and 35.3% were malignant cases. MRI scanning higher specificity (88%) and PPV (86%), but lower sensitivity (35%) and NPV (39%) with no significant association between the neurovascular involvement and predicting malignancy (p=0.0940). Similar findings were observed in the study conducted by Chen *et al*. (high sensitivity of 73% and 60.5% of PPV, low sensitivity of 37.1% and 51.3% of NPV) [14]. Baweja *et al*. reported in his

study that four patients out of 25 cases showed neuromuscular involvement among them all were malignant. The study sensitivity showed 100%, specificity 92.8 %, positive predictive value 75% and negative predictive value 100%[10]. Similar to Baweja *et al*., Alex, *et al*. also reported higher sensitivity (83%), specificity (88%), PPV (86%) and NPV (85%)[17.] Both the studies showed contrasting results to the present study. The positive predictive value was higher as lesser number of patients showed neurovascular involvement.

The results of joint involvement showed that a total of 10% of the total patients the extent of lesion to the joints with 6.3% of benign cases and 11.76% malignant patients. In the study conducted by Baweja *et al*., 23% of the cases demonstrated the involvement of the joints and showed a sensitivity of 100%, specificity 86%, positive predictive value 50% and negative predictive value 100%[10].

According to the present study, MRI to predict the malignancy showed higher sensitivity, specificity, PPV and NPV of MRI were 74%, 94%, 88% and 85% respectively. It was also observed that MRI could make only 43 appropriate diagnosis out of 50 cases. Five malignant cases were diagnosed as benign and two benign cases were diagnosed as malignant. The results could be compared to the study conducted by Sen *et al*., which shows that the overall sensitivity, specificity, PPV, NPV, and accuracy for diagnosing malignancy were found to be 83%, 81%, 76%, 87%, and 82%, respectively. Similar to the present study, the specific diagnosis could be made only in 42% of the cases[12].

CONCLUSION

The study demonstrates that MRI is an extremely useful diagnostic tool for the detection of soft tissue tumours. A higher sensitivity and specificity was reported for differentiation of malignant and benign tissue tumors by MRI. Moreover, it was also reported that osseous and neurovascular involvement were most commonly involved with the malignancy.

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