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Original Research Article

How accurate is MRI in prediction of musculoskeletal tumors -A prospective evaluation

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Abstract

Background: To determine the accuracy of MRI in determining the characteristics of musculoskeletal tumors, [including both skeletal (primary/secondary) and soft tissue tumors] and correlation of MRI findings with histopathological study.
Methods: 50 consecutive patients referred to the department of radiodiagnosis, of Assam Medical College, Dibrugarh, were included in this study. MRI was performed on 1.5 Tesla superconducting system (MAGNETOM Avanto, Siemens). After localizer sequences, T1W T2W, and STIR images, Fat saturated and post contrast T1W, images were obtained in sagittal, coronal planes, axial planes. Additional sequences like dynamic angiography and spectroscopy were taken when required and when feasible, especially in soft tissue tumors.
Results: Features that indicated benignity of soft tissue tumors (under musculo skeletal tumors) are size (< than 6 cm), homogeneity in T2 signal, absence of oedema, necrosis, haemorrhage, fascial penetration, bone changes. Presence of abnormal blood vessels in dynamic angiography, presence of choline peak in spectroscopy was clue to malignancy. A correct histological diagnosis is reached on the basis of imaging studies alone is 66 % of cases. The sensitivity for a MRI diagnosis of bone and soft tissue tumour was 100 % and accuracy was 98 %. Specificity of detecting benignity and malignancy is 94.7%.
Conclusion: Diagnosis of musculoskeletal tumors is best made by a combination of clinical and plain picture imaging parameters rather than by any single MR characteristic, except lipomas. When a lesion has a non-specific MR imaging appearance, it is useful to formulate a suitably ordered differential diagnosis based on tumour prevalence, age.
Keywords: Bone and soft tissue tumors, MRI.

1. Introduction

The determination of the anatomical extent, characteristics, and histopathological features of bone tumors and soft-tissue tumors involves a diagnostic strategy in which a biopsy is the final step.[1] MRI, however, is usually the best imaging system for the evaluation of a soft-tissue mass or the extent of soft-tissue or bone-marrow involvement by a bone tumor[3]. Radiographs provide critical information regarding lesion location, margin, matrix tissue mineralization, cortical involvement and adjacent periosteal reaction.

Patients:

Between July 2014 and October 2015, 50 consecutive patients underwent MRI followed by biopsy/FNAC (image guided), or surgical excision, for histopathological study or just pathological correlation (eg. electrophoresis in multiple myeloma). The study protocol was approved by our institutional review board. Consent was taken from each patient /attendant.

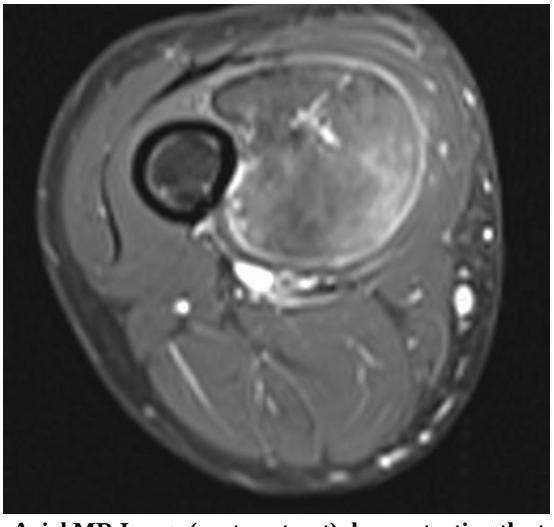


Fig 1: Axial MR Image (post contrast) demonstrating the tumor and the neurovascular bundle which is uninvolved by the tumor.

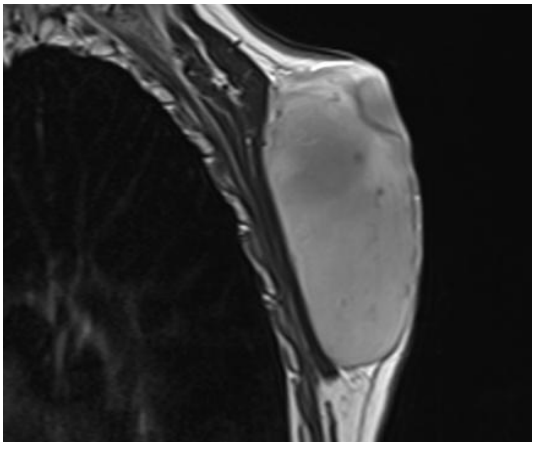


Fig 2A

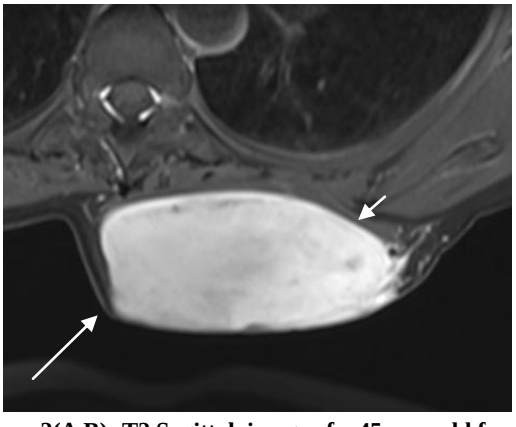


Figure 2(A,B): T2 Sagittal image of a 45 year old female confirmed as low grade fibrosarcoma, shows superficial location(superficial investing fascia –long arrow, fascia in subcutaneous location(short arrow) but size is large, increased vasularity with choline peak on spectroscopy.

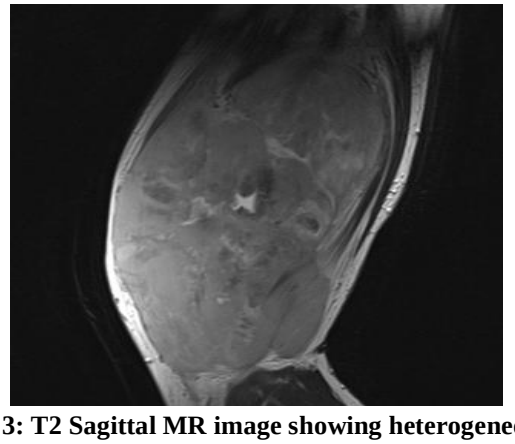


Fig 3: T2 Sagittal MR image showing heterogeneous intensity tumor deep in location, size>6cm with choline peak on spectroscopy

This was a prospective study of suspected /unsuspected cases of bone tumors (primary/secondary or soft tissue tumors) referred from various departments. All patients with suspected bone tumors were first evaluated with plain film examination when possible. The plain film included at least 2 projections [3].

2. Materials and methods

Patients more than 10 years of age were taken up in the study. Vascular lesion and tumor like conditions were excluded in this study. Although MRI could demonstrate different components of tumor, there was no difference in signal intensity patterns of different histological types of tumors. A correct histological diagnosis is reached on the basis of imaging studies alone in 66 %.

2.1 MRI interpretation

Parameters analysed for soft tissue tumors included[3]: (1) depth (superficial or deep), (2) size (,< or >=6 cm diameter) and (3) SI on T2WI (homogeneous or heterogeneous) (4) raised choline peak on spectroscopy.(5) dynamic angiography(when feasible) .

Depth of a lesion was defined as superficial or deep relative to the superficial investing fascia on MR images (Figure 2 B). Lesion size is measured in the longitudinal, anteroposterior and transverse dimensions MRI parameters of size, SI, location in benign and malignant tumours in few cases of our study is shown in (Figure 4). In our study malignant soft tissue tumors showed Size >6cm, T2W1 heterogeneity, deep in location with few exceptions, (eg. Figure 4), rhabdomyosarcoma).Benign tumors were mostly < 6 cm, T2W1 homogeneous (Figure 4, schwannoma ulnar nerve). Choline peak on spectroscopy was a striking feature in all the malignant lesions in our study. However the degree of enhancement was not very significant in differentiating benign and malignant soft tissue tumors.

Table 1: List of specific diagnosis (Musculo skeletal and soft tissue tumors) and number of cases

Benign	No. of cases	Malignant	No. of cases
D T (Fig 1, Fig 5)	2	Multiple myeloma	11
Osteochondroma	1	NHL (primary bone) (fig 6)	1
GCT	4	Chordoma	1
Lipoma	6	Fibrosarcoma(ST) and bone	2
Fibrolipoma	2	Synovial sarcoma tibia	1
Neurofibroma	1	rhabdomyosarcoma (fig 3)	2
Schwannoma	1	Leiomyosarcoma	1
Angiolipoma	1	**Ewings (PNET) ST Ewings(bone)**	**2**
CMF	1	Osteosarcoma(fig 7)	1
		Secondaries	9
Total	**19**	**Total**	**31**

DT- Desmoid Tumor; **GCT**- Giant Cell Tumor; **CMF**- Chondro Myxoid Fibroma; **NHL**- Non Hodgkins Lymphoma; **ST**- Soft Tissue; **PNET**- Primitive Neuro Ectodermal Tumor.

The cases encountered are shown in tabular form (Table 1) Most common clinical presentation in bone tumors was pain,limping,backache.Progressive swelling was common to both (bone and soft tissue tumors). Solid periosteal reaction was seen on X ray in a case of chondro myxoid fibroma (fig 4) suggesting benignity of the tumor, which was the only soft tissue tumor with periosteal reaction.

2.2 MRI findings in bone tumours

Marrow Involvement was seen in 31 out of 32 cases. One case of osteochondroma did not show marrow involvement on MRI which was confirmed on surgery.The

extent of marrow involvement was best shown by T1W images and STIR coronal or sagittal sequence [2].

Soft tissue involvement was seen in 12 out of 31 bone tumor cases. The soft tissue component was mostly present in 11 cases of malignant bone tumors and 1 case of benign bone tumor (Figure 5). Cases of multiple myeloma showed paraspinal soft tissue involvement in 5 cases in our study (figure 9). Extra osseous involvement was best shown by T1W axial post contrast images. Periosteal reaction was present in 3 malignant cases. Joint involvement was noted in 6 cases on MRI.(Table 2)

Signal characteristics of most of the bone tumors were hypointense on T1W images and heterogenously hyperintense on T2W images. In general most tumors had a non specific appearance. Multiple myeloma (11 cases) and Secondaries (9 cases), are not shown in Table 2.

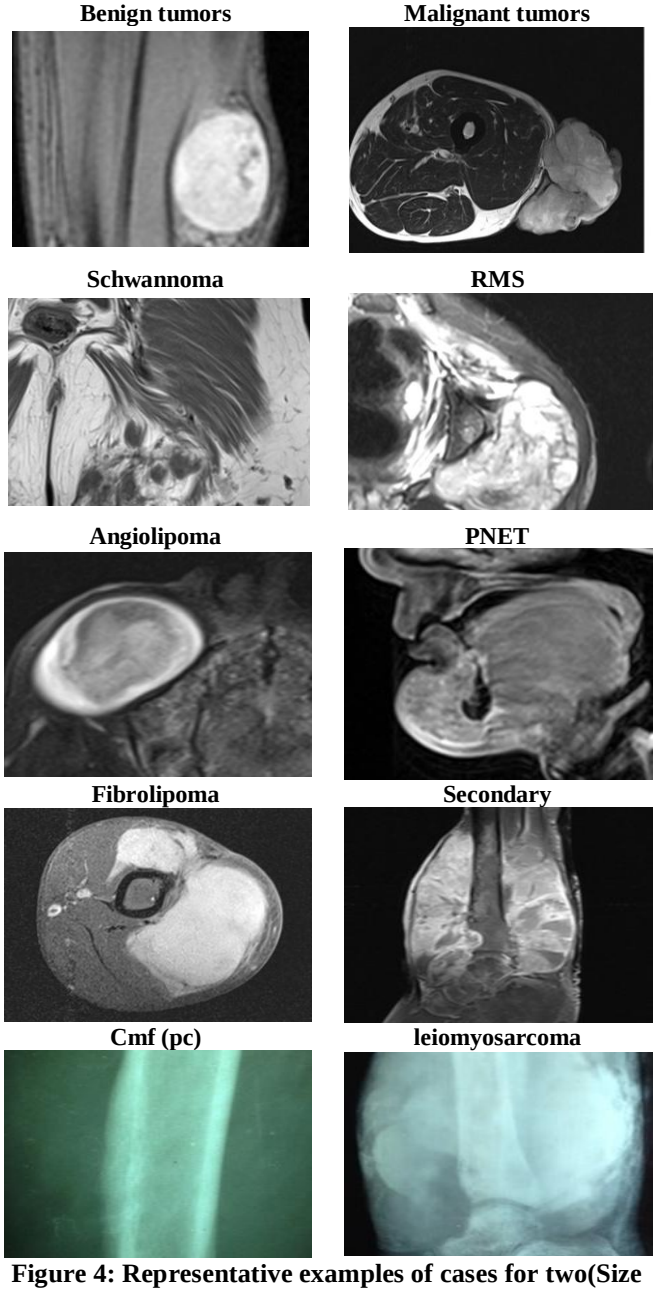


Figure 4: Representative examples of cases for two(Size ,depth) MRI parameters in benign and malignant tumours.

FL- fibromlipoma; **RS**- Rhabdomyosarcoma; **CMF**- Chondromyxoid fibroma; **PNET**- Primitive Neuroectodermal Tumour; **T2WI, PC**- Post Contrast. X-rays of CMF (solid periosteal reaction) & Leiomyosarcoma arrows.

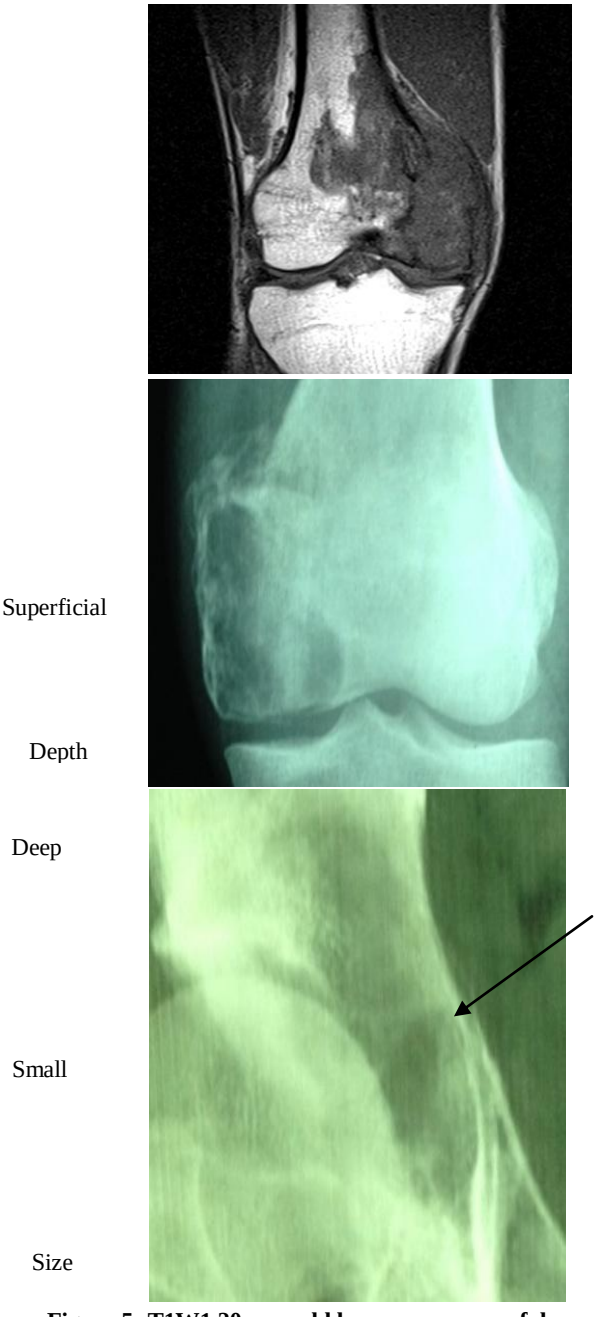
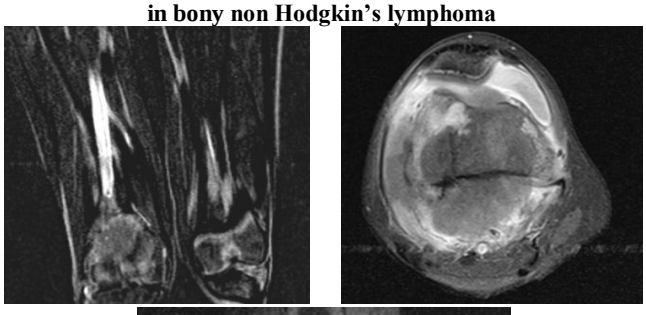


Figure 5: T1W1 20 year old boy proven case of desmoblastic fibroma, a rare tumor with cortical destruction. Soft tissue extension, which is commonly seen. X-ray shows lytic areas also in right femur, pelvic bone (arrow), sacrum(not shown)

Figure 6:T2W1 FS having both bony and soft tissue component in bony non Hodgkin's lymphoma



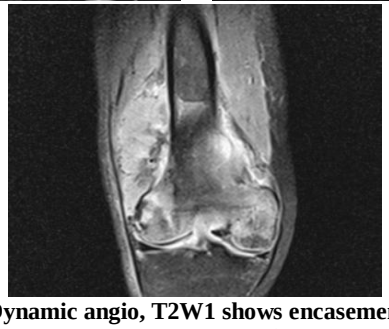


Figure 7: Dynamic angio, T2W1 shows encasement of neuro vascular bundle (arrow), involvement of Joint (arrow head) in a 19 year old female of osteosarcoma

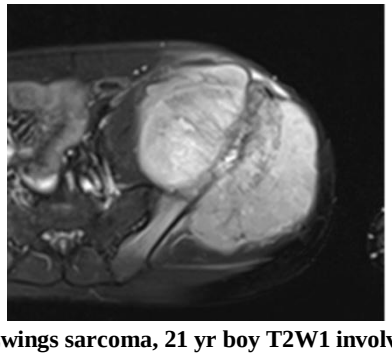


Figure 8: Ewings sarcoma, 21 yr boy T2W1 involving the left iliac bone with sunburst periosteal reaction

3. Results

Age of the patients included in the study ranged from 10 to 70 years. Maximum numbers of patients in the study were in the age group 10-60 years (48 patients). Minimum numbers of patients were in the above 60 years age group (2 patients).

Out of 50 patients included in the study, 31 were males and 19 were females. 62 % patients were males and 38 % were females. Of these tumours seemed to be arising from bone in 32 (64%) and from soft tissue in 18(36%) cases. Malignant tumours were seen in 19 out of 31 male patients (64.51%) and 11 out of 19 female patients (57.89%).

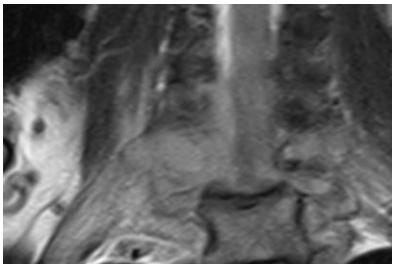


Figure 9: Coronal T2FS shows encasement of brachial plexus in a 54 year old multiple myeloma

Overall prevalence of malignant musculoskeletal tumours is estimated between 5.1 and 15.5% of all sarcomas [4].In Our study the number was (n = 9, 18%). Most of the malignant bone tumors margins were irregular and lobulated,one benign tumor had irregular margins (fig5) which were all confirmed histopathologically. Dynamic angiography showed enlarged vessels, neovascularisation and encasement of neurovascular bundle (fig 7) in the case of osteosarcoma and fibrosarcoma. Thus sensitivity in detecting benignity and malignancy in our study is 100%, specificity 94.7 %, (Table 4). Result in our study is comparable to Baweja S, *et al*[4],who found 100%sensitivity, 92.8% specificity, respectively . R Golfieri *et al*[6] in 1990 studied the role of STIR sequence in MRI examination of bone tumors and found that the STIR sequence suppressed the high signal from fatty bone marrow giving a clear depiction of tumor extent in its intramedullary component. The extent of marrow involvement was best shown by T1W images and STIR coronal or sagittal sequence. Ella Onikul[5], *et al* in 1996 studied the accuracy of MR imaging for estimating imtraosseous extent of osteosarcoma and showed 100% sensitivity. In our study too sensitivity was 100 %.

Table 2: margins, size, PR , cortical breach, intratumoral necrosis, intratumoral haemorrhage, neurovascular involvement, enhancement, joint involvement, Multiplicity,soft tissue ext, in MRI in bone tumors, (secondaries and MM not shown)

Parameter		Number of bony tumors		
		Total	Benign	Malignant
Margins	Well defined	3	2	1
	Lobulated /ID	9	1	8
Size	>6cm	8	5	3
	<6cm	4	4	-
PR		6	-	6
Cortical breach		9	3	6
Intratumoral necrosis		4	1	3
Intratumoral haemorrhage		3	1	2
NV involvement		2	-	2
Enhancement	Heterogeneous	11	5	6
	Homogeneous	1	1	-
Joint involvement		6	3	3
Multiplicity (figure 5)		1	1	-
Soft tissue ext		7	1	6

Pr- periosteal reaction; **NV-** neurovascular ; **Ext-** extension; **MM-** multiple myeloma;

Cases where MRI diagnosis did not coincide with pathological diagnosis are shown in Table 3. Thus a correct diagnosis is reached on the basis of MRI alone is 66% (table 3) in our study. The MRI diagnosis & final diagnosis on benignity and malignancy were compared and the results are tabulated in Table 4.

4. Discussion

The imaging evaluation of bone tumors is critical because it helps distinguish malignant from benign lesions. Differentiation between multiple myeloma and secondary needs history and pathological correlation. MRI is helpful in

delineating extent and helps in early diagnosis. MRI could detect myeloma in 4 cases only in our study.

In our study, in soft tissue tumors size criteria of >6 cm yielded a sensitivity of 66.67% and specificity of 91.67 % respectively, positive predictive value 80% and negative predictive value 84.62%.

Berquist et al in 1990[7] conducted a study on 95 consecutive patients with soft tissue mass lesions and observed that 87% of malignant tumours were larger than 5 cm. 85% of malignant tumours had irregular margins. Moulton et al in 1995[10] showed that size criteria of >5cm had a sensitivity of 85% and irregular margins had a sensitivity of 74%. Compared to the study of Moulton, [10] our study, showed sensitivity 100 %, specificity 92.86%; Positive predictive value 80% and negative predictive value 100% in the criterion of irregular margins.

Table 3: MRI diagnosis and HP diagnosis did not coincide

	MRI Diagnosis	Histopathological diagnosis
	Metastasis/Lymphoma	Giant cell tumor
	Multifocal Metastases	ABC
	Osteosarcoma	Fibrosarcoma
*	Atypical lipoma	fibrolipoma
*	neurofibroma	Fibrolipoma (Fig 4)
*	Soft tissue sarcoma	Low grade fibrosarcoma
*	Soft tissue sarcoma	Rhabdomyosarcoma(fig 4)
*	Soft tissue sarcoma	Leiomyosarcoma(fig 4)
*	Malignant soft tissue tumor	PNET (fig 4)
	Ewings sarcoma	Synovial sarcoma
	Degenerative spine	Multiple myeloma
	Metastases	Multiple myeloma
	Secd/Lymph	MM
	MM/Mets	MM
	MM/secd	MM
	MM/secd	MM

ABC- aneurysmal bone cyst; PNET- primitive neuro ectodermaltumor; Secd- secondary; Lymph- lymphoma; Mets- metastases; MM- multiple myeloma; HP- histopatological

Prospective studies by Ma *et al* [10] Berquist *et al*., [7] and Moulton *et al* [8] respectively, a sensitivity of 100, 94 and 78% and a specificity of 17, 90 and 89% for predicting malignancy were reported. Our study shows a sensitivity of 100% and a specificity of 94.7%.

Rijswijk *et al* observed that the use of combined non enhanced static and dynamic contrast-enhanced MR imaging demonstrated the finest diagnostic performance in the prediction of soft-tissue tumors [9]. This is applicable in our study also. The patient's age, sex and clinical presentation were also used with X rays in case of bone tumors. Specificity was not possible because all cases did not undergo surgery. Few cases, including 11 cases of multiple myeloma and 9 secondary underwent chemotherapy followed by radiotherapy. Choline was reliably detected in all our malignant soft tissue and few bony tumors (having soft tissue component).

MRI could diagnose malignant soft tissue lesions but could not give a specific diagnosis in few (Table 3*). Clinical presentations were varied. Many cases were not suspected to have a tumoral condition clinically, mostly cases of multiple myeloma, which came as backache, clinical suspicion being degenerative spine.

Table 4: diagnoses made or suspected on the basis of MR Imaging (soft tissue and bony) and pathological diagnosis

	MRI Diagnosis	Final diagnosis
Benign	18	19
Malignant	32	31

5. Conclusion

MRI plays a major role in determining the malignant component especially with the aid of spectroscopy, especially in soft tissue tumors. Plain X ray is a pre requisite for MR of bone tumors. Every patient of degenerative spinal disease undergoing MRI examination should have a serum electrophoresis done for occult myeloma.

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