Role of MRI in Primary Malignant Bone Tumours

Pustthay Sunil Kumar[1], P. Sree Hari[2]

ABSTRACT

Introduction: MRI is the emerging diagnostic aid in the identification of tumours. This study was done to evaluate the role of MRI in cases of primary malignant bone tumours and to determine the MRI characteristics of different primary malignant bone tumours, to correlate and compare the imaging findings with surgical and gross pathological findings wherever possible and to stage the tumours on MRI, correlating them with operative and histopathological findings.

Material and Methods: This was a prospective study which evaluated fifty patients of suspected primary malignant skeletal neoplasms for two year period starting from July 2012 to October 2014, the age ranged from 10 years to 75 years (mean 40 years). There were 28 males and 22 females. Data collected as history, clinical examination, clinical diagnosis, Multiplanar MR Imaging of primary malignant bone tumours with surgical and histopathological correlation.

Results: Of the 50 cases, fifteen were Osteosarcomas, ten were Ewing's sarcomas, nine were Chondrosarcomas, eight were Giant cell tumours, Chordomas were 6, and multiple myelomas cases were 2. In eight Giant cell tumours, one case was malignant. Of the total 50 cases cortical break was detected on MRI in 43 cases. It was absent in 7 cases. Thus 86% cases demonstrated cortical break and 14 % did not show cortical break on MRI. It is best demonstrated on T1W imaging. Forty one cases were operated and nine cases were not operated due to the presence of distant metastasis. Out of the forty one cases operated, cortical involvement was seen in 37 cases and was absent in 4 cases. The sensitivity in our study is 100%, specificity 96.2%, positive predictive value 100 % and negative predictive value is 96.2%

Conclusion: MRI is very sensitive in detecting cortical involvement but less sensitive in detecting the periosteal reaction, tumour osteoid and calcification when compared to plain radiography.

Keywords: Bone tumours, Magnetic resonance imaging, Plain radiography

INTRODUCTION

Bone tumours develop when cells in the bone divide abnormally and uncontrollably, they can form a mass or lump of tissue. This lump is called a tumour. As the tumour grows, abnormal tissue can displace healthy tissue. Some tumours are benign, meaning they aren't cancerous. While benign bone tumours wont spread to other parts of the body and are unlikely to be fatal, they can still be dangerous and may require treatment. Benign tumours can grow and could compress your healthy bone tissue. The cause of bone tumours isn't known. The tumours often occur when parts of the body are growing rapidly. A few possible causes are genetics, radiation treatment and injuries to the bones. Types of malignant tumours are osteosarcoma, Ewing sarcoma family of tumours, chondrosarcoma, secondary bone cancer, multiple myeloma. Your treatment will depend on what type of bone cancer you have and whether it has spread. If cancer cells are confined to the tumour and its immediate area, this is called the localised stage. In the metastatic stage, cancerous cells have already spread to other parts of the body. This makes curing the cancer more difficult. Surgery, radiation and chemotherapy are the main strategies for treating cancer. The most vascularised parts of tumour and MRI guidance makes it possible to avoid biopsing necrotic areas and these are revealed by Contrast enhanced MRI. Superior contrast is provided by MRI and it allows multi planar image acquisition, and is commonly devoid of streak artifacts encountered with CT. MRI is helpful in local staging and surgical planning because it assesses the degree of intramedullary extension (and dimensions) and invasion of the adjacent physeal plates, joints, muscle compartments and neurovascular bundles. The purpose of this study is to evaluate the role of MRI in cases of primary malignant bone tumours.

MATERIAL AND METHODS

This was a prospective study which evaluated fifty patients of suspected primary malignant skeletal neoplasms for two year period starting from July 2012 to October 2014, the age ranged from 10 years to 75 years (mean 40 years). There were 28 males and 22 females. Patients history, clinical examination and clinical diagnosis was obtained.

Plain radiographs of both anteroposterior and lateral projections were taken. After tumour diagnosed on plain radiography, MRI was performed. Magnetic Resonance Imaging (MRI) was performed in forty consecutive patients who are with diagnosed malignant bone tumors. Transitional zone, intramedullary extent, soft tissue extent, mineralization of matrix, periosteal response, cortical involvement, joint involvement and epiphyseal involvement are considered for study on radiography and MRI. Involvement of neurovascular bundle and signal characterization was studied on MRI. Contrast was administered in 10 patients. The degree and pattern of enhancement and involvement of adjacent structures was noted. All patients were subjected to surgery, detailed operative finding with their histopathology report was taken and MRI with morphology was correlated. Staging was done (radiographs and MRI) according to Enneking's system of staging bone sarcomas and Giant cell tumours were staged according to Enneking's staging for giant cell tumours.

RESULTS

The study "Multiplanar MR Imaging of primary malignant bone tumours with surgical and histopathological correlation"

[1]Post Gradute, [2]Associate Professor, Department of Radiology, Osmania General Hospital and Osmania Medical College, Hyderabad, Telangana, India

Corresponding author: Dr. P. Sree Hari, H. No 9-14, Ravindra Nagar Colony, Habsiguda, Hyderabad- 500007, India

How to cite this article: Pustthay Sunil Kumar, P. Sree Hari. Role of MRI in primary malignant bone tumours. International Journal of Contemporary Medical Research 2016;3(7):2144-2148.

Diagnosis	No.	Male	Female	Age range	Median age
Osteosarcoma	15	8	7	10-24	17
Ewing's sarcoma	10	5	5	11-30	21
Chondrosarcoma	9	5	4	29-75	52
Chordoma	6	4	2	32-66	49
GCT	8	5	3	23-48	36
Multiple myeloma	2	2	0	52-66	59

Table-1: Demographic distribution study group

Osteosarcoma	
Lower end of Femur	5
Upper end of Tibia	3
Upper end of Femur	2
Upper end of Humerus	3
Thigh	2
Ewing's sarcoma	
Shaft of femur	3
Ilium	2
Femur upper end	2
Humerus upper end	2
Rib	1
Chondrosarcoma	
Pelvis	2
Femur	1
Humerus upper end	1
Radius lower end	1
Humerus upper end	1
Femur upper end	1
Tibia upper end	1
Tibia lower end	1
Chordoma	
Sacrum	6

Table-2: Site of the lesion

Cortical involvement	MRI findings	Surgical pathological findings
Present	27/31 (87%)	28/31 (90%)
Absent	4/31 (13%)	3/31(10%)
Soft tissue involvement		
Present	24/31 (77%)	26/31 (83%)
Absent	7/31 (22%)	5/31 (16%)
Joint involvement		
Present	13/31 (41%)	11/31 (35%)
Absent	19/31 (61%)	20/31 (64%)
Neurovascular involvement		
Present	4/31 (13%)	5/31 (16%)
Absent	27/31(87%)	26/31 (84%)

Table-3: MRI and surgical pathological findings in study

comprised of 50 patients in a two year period starting from July 2012 to October 2014 the age ranged from 10 years to 75years (mean 45 yrs). There were 29 males and 21 females.

Of the 50 cases, fifteen were Osteosarcomas, ten were Ewing's sarcomas, nine were Chondrosarcomas, eight were Giant cell tumours, chordomas were 6 cases, and two cases multiple myelomas. In eight Giant cell tumours there is 1 case was malignant bone tumour.

Of the total 50 cases cortical break was detected on MRI in 43 cases. It was absent in 7 cases. Thus 86% cases demonstrated cortical break and 14 % did not show cortical break on MRI. It is best demonstrated on T1W imaging. Forty one cases were operated and nine cases were not operated due to the presence of distant metastasis. Out of the forty one cases operated, cortical involvement was seen in 37 cases and was absent in 4 cases.

Out of total fifty cases, 4cases showed joint involvement on MRI. The joint was uninvolved in 27 cases. Thus 13% cases demonstrated involvement of joint and 16% cases did not show joint involvement on MRI. Surgery could only be performed in 31 of these patients due to presence of metastasis in nine cases**.** The sensitivity was 100%, specificity90.4%, positive predictive value 83.3% and negative predictive value 100%.

Out of a total of forty cases, MRI showed neurovascular bundle involvement in four cases. It was uninvolved in 27 cases. Thus 10% cases demonstrated involvement of neurovascular bundle and 87% cases did not show involvement of neurovascular bundle on MRI.

The sensitivity in our study is 100%, specificity96.2%, positive predictive value 100 % and negative predictive value is 96.2%

DISCUSSION

Many studies have shown the role of MRI in primary malignant bone tumours.

Willium D. Zimmer, Thomas H. Berquist et al[1] evaluated fifty two cases of bone tumours. For demonstrating the extent of tumour in marrow, MR was superior to CT in 33% of cases, about equal to CT in 64% and inferior to CT in 2% cases. For delineating the extent of tumour in soft tissue, MR was superior to CT in 38% of cases and about equal to CT in 62%. Willium P. Shuman, Randall M Patten et al[2] compared short tau inversion recovery (STIR) imaging and a double spin echo (SE) sequence at 1.5T in 45 sequential patients with suspected extremity tumours. STIR sequences enabled detection of all 45 lesions; 44 were detected with SE sequence. Tumour appeared most conspicuous on STIR images in 35 patients (78%) and was most conspicuous on SE images in 10 patients (22%); peritumoural brightening which indicates either peritumoral edema or microscopic tumour infiltration was detected in 20 patients but was detected only with STIR sequence in nine patients. It conceded that, although STIR and SE sequences are comparable for lesion detection in the extremeties, most lesions appear more conspicuous on STIR. Rainer Erlemann, Maximillan F Reviser et al[3] performed static and dynamic Gd-DTPA enhanced MR imaging in 69 patients with bone and soft tissue tumours. T1 weighted spin echo imaging after i.v. administration of Gd-DTPA improved the differentiation of necrotic from viable areas; the contrast to noise ratio(C/N) between tumour and muscle was an average 44% lower compared with that in T2 weight SE imaging. The C/N between tumour and bone between tumour and bone marrow or fatty tissue was 43% and 37% lower respectively, compared with that in non enhanced T1 weighted SE imaging. Dynamic

changes of signal intensity after Gd-DTPA enhancement were assessed with fast low angle shot imaging of malignant tumours, 84% exhibited slopes higher than 30% per minute. The dynamic technique enabled assessment of the malignant potential of a tumour with some overlap (accuracy 79.9%). Necrotic areas and peritumoral edema showed significantly lower and more gradual increase in SI than adjacent neoplastic tissue.

Karen I Norton, George Hermann et al[4] used plain radiography and magnetic resonance imaging to assess the extent of transphyseal involvement in 15 patients with long bone osteosarcoma and unfused epiphyses. Conventional radiography accurately predicted transphyseal spread in only nine of 15 cases (60%). Spread into the epiphysis was present in 12 out of 15 cases (80%) and was accurately predicted on MR in all 12 cases. This finding contradicts the common misconception that the physis acts as a barrier to tumour spread. David M. Panicek, Constantine Gatsonis et al[5] assessed the relative accuracies of CT and MRI in the local staging of primary malignant bone and soft tissue tumours of 316 patients. 183 had primary bone tumours and 133 had primary soft tissue tumours, there was no statistically significant differences between CT and MRI in determing tumour involvement of muscle, bone, joints or neurovascular structures. The combined interpretation of CT and MR images did not satistically significantly improve accuracy.

Loralic D Ma, Frank L Frassica et al[6] studied the diagnostic potential of the rim to centre differential enhancement in the MR imaging differentiation of benign from malignant musculoskeletal masses. Dynamic Gd enhanced fast multiplanar spoiled gradient – recalled acquisition in the steady state imaging was performed to evaluate 17 bone and soft tissue masses (10 malignant and 7 benign) in 14 patients. Nine of ten malignant masses showed rapid rim enhancement with delayed central fill in. This enhancement pattern was absent in benign masses. The average maximum rate of enhancement was 3.41% per second ± 2.20 for malignant masses and 2.74 % per second ±2.46 for benign masses. They concluded that intratumoral enhancement patterns of malignant and benign masses differ because of differences in vascular architecture. Murali Sundaram and Michael H Mc Guire et al[7] studied 34 patients with solitary tumour. They concluded that when radiographic depiction of tumour permits assessment of its morphology, matrix and probable histologic nature. MR ought to be the next examination solely for staging purposes.

Oonagh M. Redmond, Stack JP et al[8] studied 14 cases of osteosarcoma on MR imaging and MR spectroscopy. There was excellent correlation of intramedullary tumour extent as determined with MR imaging and pathologic examination (r=99%). This was facilitated by the presence of chemical shift artefact at the tumour-marrow interface on T1 weighted images. T2 weighted images were optimal in demonstrating soft tissue mass and breach of the epiphysis or cortex. Vascular involvement was also readily identified. The value of the tumour soft tissue component deceased in patients who were deemed to have responded well to therapy. P-31 MR spectroscopy of five patients with osteosarcoma showed elevated levels of phosphorous monoesters (PMES), inorganic phosphate (pi) and phosphorus diesters (PDES). PME and PDE peak areas decreased in three patients after chemotherapy, while Pi peak areas increased. James S. Jelinek, Mark D Murphey et al[9] evaluated MRI and CT for predicting the histoogical grade of parosteal osteosarcomas in 60 cases. they concluded that a poorly defined soft tissue component distinct from the ossific matrix was the most distinctive feature of high grade parosteal osteosarcoma and might be an optimal site for biopsy.

William D Zimmer, Thomas H Berquist et al[10] compared clinical usefulness of MRI and CT in evaluating 10 cases of osteosarcomas. MRI was superior to CT in 60% and about equal to CT in 40% in demonstrating tumour extent in marrow. For defining soft tissue mass, MRI was superior to CT in 40% and about equal in 60%. Cortical destruction, periosteal new bone and soft tissue masses all could be identified on MRI. Invaded cortex appeared grey rather than black. Invaded cortex lost its sharp interface with medullary bone and with surrounding soft tissues. They found that the spin echo sequence with a long repeat time is the most useful in evaluating bone tumours. The advantages of MRI include- vascular involvement, longitudinal extent of the lesion, skip lesions, joint and epiphyseal involvement can be defined well. They showed that signal intensity in bone tumours was not useful in predicting malignancy or benignity, but within a tumour, poorly defined, irregular inhomogeneities other than calcium were highly suggestive of malignancy. Golden Pan, A. Kevin Raymond et al[11] demonstrated four MR patterns after chemotherapy in osteosarcoma - dark, mottled or speckled, homogeneous and cystic. The dark pattern, hypointense on T1 and T2 corresponded to tumour matrix (either calcified osteoid or cartilage) and dense granulation tissue at histologic examination. The mottled or speckled pattern showed predominant area of intermediate signal intensity on T1 and high signal intensity on T2 with mottled or dark speckled pattern on T2. These corresponded to necrosis, clusters of hemosiderin and edematous granulation tissue. Homogenous pattern was due to viable tumour cells interspersed into tumour matrix and loose granulation tissue. Cystic pattern was due to fluid or blood filled cysts lined by viable tumour cells. The other findings included decrease in peritumoral edema, dark rim around extramedullary component of the tumours and development of metaphyseal haemorrhages and bone marrow infarcts and intramedullary vascular channels.

Orest B. Boyko, David A. Cory et al[12] evaluated twenty patients with biopsy – proven Osteogenic (11cases) and Ewing's (9 cases) sarcomas by MR imaging on a 0.15T resistive unit. In all 20 cases MR identified tumour spread into bone marrow, and it was superior to CT in five cases. Extension of tumour into the soft tissues adjacent to bone was better by MR than CT in six cases. compared with CT, MR identified cortical disease but had inferior spatial resolution and defined calcium poorly. MR can be used to monitor tumour response to chemotherapy and the relationship of tumour to adjacent vasculature can be determined without the use of contrast agents. Two pulse sequences are necessary for maximum display of disease, tumour involvement of the bone marrow is better assessed on T1WI. They also report that the inhomogeneous MR signal of Osteogenic sarcoma did not correlate with the histologic distribution of chondroid or osteoid tumour matrix. Cortical disease can be better appreciated in axial images. The limitation of MR is the inability to definitely identify tumour matrix calcification and periosteal reaction in all cases. Christophe Fronge, Daniel

Vanel et al[13] studied the role of MR imaging in the evaluation of Ewing's sarcoma in 27 patients. Plain radiography proved to be the best imaging method to assess probable histological diagnosis. For the evaluation of the chemotherapeutic response, CT and MRI gave the same information about the variation in size of the tumour and extension within the bone marrow in two cases each. MRI accurately identified epiphyseal spread in two cases. It was not possible with MRI to differentiate active tumour from reactive change even after Gd-DTPA infusion.

Eve K. Cohen, Henbert Y. Kressel et al[14] studied 16 chondroid matrix lesions on MR. The tumour with homogenous high signal intensity in a defined lobular configuration by thin low intense septae on T2 weighted images corresponded to areas of hyaline cartilage matrix with its uniform composition, low cellularity and high water content. Tumours with high cellular stroma with scattered islands of chondroid matrix were isointense or hypointense on all MR sequences. Maartje J. A. Geirnaerdt, Johan L. Bloem et al[15] correlated gadolinium enhanced MR images with histopathological findings in patients with cartilaginous tumours. Peripheral enhancement characterized by enhancement only in the periphery of the tumour was noted in osteochondromas (3 cases), septal enhancement, characterized by the presence of thin curvilinear areas in the tumour margin and in the center of the tumour was characteristic of low grade chondrosarcoma (found in 24 of 27 cases). inhomogeneous enhancement was noted in high grade chondrosarcomas. Marcia F. Blacksin, Jill R. Siegal et al[16] studied the MR characteristics of synovial sarcoma. Small lesions of less than 5 cm demonstrate a non aggressive appearance with well circumscribed margins and homogenous signal intensity. Farrok Dehdashti, Barry A. Siegal et al[17] assessed the ability of positron emission tomography with 2-[fluorine-18] flouro- 2-deoxy-D-glucose (FDG) to allow differentiation of benign from malignant intraosseous lesions. With the use of a 2.0 cut off value for srandardized uptake value, 14 of 15 malignant lesions were categorized correctly and 4 of benign lesions were categorized correctly.

Philipp Lang, Gordon Honda et al[18] evaluated the utility of fast contrast enhanced, sequential MR imaging in differentiating between extra-osseous tumour and perineoplastic edema. Differences in initial slope between all neoplastic and non neoplastic tissues were statistically significant. Within individual patients initial slope of edematous muscle was always 20% or more lower than that of neoplastic tissue. Slope images highlighted areas of viable extra osseous tumour and infiltrated muscles against edematous and normal tissues. David G. Disler, Thomas R. MC Cauley et al[19] studied 31 suspected bone marrow lesions by gradient-echo MR imaging with TEs selected with fat and water in phase and out of phase. The relative signal intensity ratios were 1.03 ± 0.13 for neoplastic group and 0.62 ± 0.13 for the non-neoplastic group. They concluded that in phase and out of phase gradient echo MR imaging of bone marrow signal intensity abnormalities could help predict the likelihood of neoplastic or non-neoplastic lesions. J. Shannon Swan, Thomas M. Grist et al[20] assessed the ability of MR Angiography to depict vascularity of musculoskeletal neoplasms. They compared 2D TOF MR Angiography with conventional arteriography in 23 cases. PC MR Angiography was also performed in 19 cases and evaluated as a possible supplement to 2D TOF imaging. Of the named vessels, 92% in proximity to tumour were noted on 2D TOF. the PC technique provided supplemental data in 47% of cases, related to better delineation of in plane feeders and areas with pulsatile blood flow. Of the 28 branch feeder vessels, 23 were noted on both conventional arteriograms and MR angiograms but 16 were difficult to distinguish as feeders because of lack of associated tumour blush. They concluded that MR Angiography had promise to replace conventional arteriography for orthopaedic preoperative planning.

Herman SD, Mesgaradeh M et al[21] studied the role of magnetic resonance imaging in giant cell tumour of bone. In six cases of giant cell tumour the MR images obtained the various pulse sequences and field strengths were compared to the corresponding CT scans and plain roentgenograms. MRI was superior to CT and plain films in demonstrating areas of tissue inhomogeneity within the tumour as well as soft tissue extension. CT was superior in demonstrating cortical thinning. Multiplanar imaging capability and visualization of articular cartilage may demonstrate intra- articular spread. Hindman B W, Seeger L L et al[22] reported five cases of Multicentric giant cell tumours. Patients with Multicentric giant cell tumours are likely to be younger than those with a solitary lesion and Multicentric variety is more often associated with pathological fracture.

CONCLUSION

MRI is very sensitive in detecting cortical involvement but less sensitive in detecting the periosteal reaction, tumour osteoid and calcification when compared to plain radiography. MRI is the preferred modality to image musculoskeletal tumours and should be obtained after radiographic evaluation. The multiplanar imaging capability of MRI helps delineation of tumour and its extent in bone and soft tissues.

REFERENCES

1. Zimmer WD, Berquist TH, Mcleod RA, Sim FH, Pritchard DJ, Shives TC, Word L E, May GR. Bone tumours: Magnetic Resonance versus Computer Tomography. Radiology. 1985;155:709-718.
2. Shumann WP, Patten RM, Baron RL, Liddell RM, Conrad EV, Richardson ML. Comparison of STIR and Spin-Echo MR imaging at 1.5T in 45 suspected Extremity tumours: Lesion conspicuity and extent. Radiology. 1991:179:247-252.
3. Erlmann R, Reiser MF, Peters PE, Vasallo P, Nommensen B, Kusnierz-Glanz CR, Ritter J, Roessner A. Musculoskeletal neoplasms: Static and Dynamic Gd-DTPA- enhanced MR imaging. Radiology. 1989;171:767-773.
4. Norton KI, Hermann G, Abdelwahab IF, Klein MJ, Granowetter LF, Rabihowitz JG. Epiphyseal Involvement in Osteosarcoma. Radiology. 1991;180:813-816.
5. Panicek DM, Gatsonis C, Rosenthal DI, Seegar LL, Huvos AG, Moore SG, Candry DJ,Palmer WE, McNeil BJ. CT and MR imaging in the local staging of Primary Malignant of Musculoskeletal Neoplasms: Report of Radiology Diagnostic Oncology group. Radiology. 1997:202:739-744.
6. Loralic D Ma, Frassica FJ, Mc Cartny EF, Bhiemke DA, Zerhouni EA. Benign and Malignant Musculoskeletal masses: MR imaging Differentiation with Rim to center Differential Enhancement ratios. Radiology. 1997;203:739-744.
7. Murali Sundaram, Mc Guire MH. Computed Tomography

or Magnetic Resonance for evaluating the Solitary Tumour or Tumour like lesion of Bone? Skeletal Radiol. 1988;17:393-401.
8. Redmond OM, Stack JP, Dervan PA, Hurson BJ, Carney DN, Ennis JT. Osteosarcoma: Use of MRI and MR Spectroscopy in Clinical Decision Making. Radiologyy. 1989;172:811-815.
9. Jelinek JS, Murphey MD, Kransdorf MJ, Shmookler BM, Malawer MM, Hur RC. Perosteal Osteosarcoma: Value of MR Imaging and CT in the prediction of Histologic Grade. Radiology. 1996;201:837-842.
10. Zimmer WD, Berquist TH, Mcleod RA, Sim FH, Pritchard DJ, Shives TC, Wold LE, May GR. Magnetic Resonance Imaging of Osteosarcomas: Comparision with Computed tomography. Clinical orthopaedics and related research. 1986;208:289-299.
11. Pan G, Raymond AK, Carrasco CH, Wallace S, Kim EE, Shirkhoda A, Jaffe N, Murray JA, Benjamin RS. Osteosarcoma: MR Imaging after preoperative chemotherapy. Radiology. 1990;174:517-526.
12. Bokyo OB, Cory DA, Cohen MD Provisor A, Mirkin D, De Rosa GP. MR Imaging of Osteogenic and Ewing's sarcoma. AJR. 1987;148:317-322.
13. Fronge C, Vanel D, Coffre C, Couanet D, Contesso G, Sarrazin D. The role of Magnetic Resonance Imaging in the evaluation of Ewing's sarcoma. Skeletal Radiology. 1988;17:393-401.
14. Cohen EK, Kressel HY, Frank TS, Fallon M, Burk DL, Dalinka MK, Schiebler ML. Hyaline Cartilage- Origin Bone and Soft tissue Neoplasms: MR appearance and Histologic Correlation. Radiology. 1988;167:477-481.
15. Geirnaerdt MJA, Bloem JL, Eulderink F, Hogendoorn PCW, Taminiau AHM. Cartilagenous tumours: Correlation of Gadolinium enhanced MR Imaging and Histopathologic Findings. Radiology. 1993;186:813-817.
16. Blacksin MF, Siegel JR, Benevenia J, Aisner SC, Synovial Sarcoma. Frequency of Non aggressive MR Characteristics. JCAT. 1997;21:875-889.
17. Dehdashti F, Siegel BA, Griffeth LK, Fusselman MJ, Trask DD, Mc Guire AH, Mc Guire DJ. Benign versus Malignant Intraosseous Lesions: Discrimination by means of PET with 2-[F-18] fluoro-2-deoxy-D-glucose. Radiology. 1996; 200:243-247.
18. Lang P, Honda G, Roberts T, Vahlensienk M, Johnston JO, Rosenan W,Matrur A, Peterfy C, Gooding CA, Genant HK. Musculoskeletal Neoplasms: Perineoplastic Edema versus Tumour on dynamic Postcontrast MR Images with Spatial Mapping of Instantaneous Enhancement rates. Radiology. 1995;197:831-839.
19. Davis G. Disler, Thomasr Mc Cauley, Lee M Ratner, Craig D Kesack, Jeffrey A. Cooper. In-Phase and Out Phase MR Imaging of Bone Marrow: Prediction of Neoplasia Based on the detection of Coexistent Fat and Water. AJR. 1997:169;1439-1447.
20. Swan JS, Grist TM, Sproat IA, Heiner JP, Wiersma SR, Heisey DM. Musculoskeletal neoplasms: Preoperative Evaluation with MR Angiography. Radiology. 1995: 194:519-524.
21. Herman SD, Mesgarzadeh M, Bonakdarpour A. Et al: The role of Magnetic Resonance Imaging in Giant Cell Tumour of bone: Skeletal Radilo. 1997;16:635-653.
22. Hindman Bw, Seegar LL, Stanley P, Forrester DM, Schwinn CP, Tan SZ; Multicentric Giant Cell Tumour of Bone: Report of five new cases. Skeletal Radiology. 1994;23:187-190.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 30-05-2016; **Published online**: 30-06-2016