

DIAGNOSTIC ACCURACY OF CONTRAST ENHANCED MRI IN DETECTION OF VASCULAR INVASION BY LIMB SARCOMAS: EXPERIENCE FROM A TERTIARY CARE CANCER HOSPITAL

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ABSTRACT

INTRODUCTION: Vascular invasion by primary soft tissue or bony sarcomas is rare yet very important feature in terms of management decisions. MRI is considered modality of choice in most of the musculoskeletal tumors because of its capability to better delineate anatomy, extent of intraosseous and intramuscular tumor involvement and tumoral relationship with adjacent neurovascular bundles. In the past years, vascular invasion was evaluated by angiography was considered as imaging modality of choice. However, since the past decade, contrast enhanced MRI is largely replacing the angiography as imaging modality as it is cheaper, non-invasive and does not use ionizing radiations and reduced imaging time. **PURPOSE:** To evaluate the diagnostic accuracy of contrast-enhanced MRI in the detection of vascular invasion in cases of bone and soft tissue sarcomas of limbs taking surgical findings as gold standard. **MATERIALS AND METHODS:** After the approval from the ethical review board, retrospective study was performed from the period of 1st January 2018 to 30th June 2018 using the database of Shaukat Khanum Memorial Cancer Hospital and Research Center. Patients with biopsy-proven sarcoma of bone or soft tissues of limbs were taken and their pre-operative MRI scans were re-evaluated for the MRI features of vascular invasion. Findings of MRI will then be correlated with surgical findings and will be labelled as positive or negative on the basis of per-operative presence or absence of vascular invasion. **RESULTS:** A total of 50 sarcoma patients were included in this study. Out of these 50 patients, vascular encasement by tumor was reported in 7 cases (14%) on baseline MRI; while 8 patients (16%) had vascular encasement on surgery. 1 case (2%) was reported as positive for vascular encasement on MRI but was negative on surgery (false positive). 2 cases (4%) were reported to be negative for vascular encasement on MRI but were positive on surgery (false negative). 40 cases (80%) showed no vascular involvement on both MRI and on surgery. Pearson chi-square p-value was calculated to be 0.000 which confirms the significance of the results). The sensitivity of MRI in detecting vascular invasion was calculated to be 77.78%, specificity was 97.56% and diagnostic accuracy was 94.00%. **CONCLUSION:** Contrast enhanced MRI proved to be reliable and an accurate imaging modality in the evaluation of neurovascular encasement.

Key Words: Sarcoma, vascular invasion, MRI.

Introduction

Sarcoma, a mesenchymal origin tumor, accounts for the burden of about 21% of pediatric population and

less than 1% of adult solid malignant cancers. It is basically a representative of a number of malignancies

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rather than a single tumor. According to one of the publication, more than 50 histologic subtypes exist, the two most common groups are malignant bone tumors and soft tissue sarcomas.¹ Another study stated that bone sarcomas accounts for 0.2% of all malignant tumors with 5 year survival rate of 67.9%. Certain bone tumor subtypes are associated with inherited syndromes while some are linked with non-neoplastic precursors and develop in the pre-existing benign tumors.²

MRI plays a great role in local staging and helps in surgical planning as it assesses the intramedullary extension/dimensions, articular extension and invasion of adjacent structures including physal plates, muscular and neurovascular bundles. It also helps in restaging after neoadjuvant therapy and the post therapy followup.³

Many studies have published in the account of the role of MRI in local staging of sarcomas, most of the studies show high sensitivity and specificity of MRI in the assessment of osseous, articular and neurovascular invasion. However, the criteria of neurovascular bundle encasement determined by MRI has not been clearly defined. Most of the studies state that, if the fat or tissue planes between the tumor and neurovascular structures are preserved, it is not considered as invasion and complete neurovascular encasement is considered as invasion. The indeterminate level of contact between the tumor and neurovascular structure is still uncertain. According to one of the study by Panicek and coworkers, an encasement of more than 180° is a good predictor of neurovascular invasion.⁴

The purpose of our study is to evaluate the diagnostic accuracy of MRI in the detection of vascular invasion in cases of bone and soft tissue sarcomas of limbs taking surgical findings as gold standard.

Material and Methods

The study was approved by our institutional review board which waived the requirement for informed consent. The clinical data of patients treated for sarcoma at Shaukat Khanum Memorial Cancer Hospital and Research Center, Lahore between 1st January 2018 and 30th June 2018 were retrospectively evaluated. Only patients fulfilling the inclusion criteria

were included in the study. Inclusion criteria were: (a) biopsy proven bony or soft-tissue sarcoma; (b) tumor localized to the extremities; (c) preoperative baseline MR examination following intravenous contrast administration; and (d) surgery in our hospital (local resection or amputation). After the initial search, 68 patients were retrieved from the hospital database; of which 50 passed the inclusion criteria and were inducted in the study. The remaining 18 patients were excluded from the study as they did not fall under the inclusion criteria.

MRI imaging was performed at 1.5 Tesla (Philips Ingenia) and 3.0 Tesla (Siemens Magnetom Vida) systems. Dedicated surface coils were used depending upon the tumor location. The MRI protocol comprised orthogonal plane imaging with axial and longitudinal plane sequences, with the latter being either coronal or sagittal depending on the tumor location. The standard dose of intravenous contrast gadobutrol (Gadovist®) was given to all patients (i-e 0.1 mmol per kilogram of body weight)

MRI images of these 50 patients were then retrospectively evaluated by 2 radiology fellows independently; supervised by 1 consultant musculoskeletal radiologist for the MRI features of neurovascular invasion. Both the fellows were blinded to previous MRI reports and surgical outcome. Neurovascular encasement was evaluated on T2 weighted and T1 post contrast fat saturated images first by observing the spatial relationship between the tumor and the major neurovascular bundle i-e if there was distance between the tumor and adjacent major neurovascular bundle <5 mm or not and if the fat plane between the tumor and adjacent neurovascular bundle is preserved or lost. If the distance was < 5mm then the extent of tumor contact to the adjacent neurovascular bundle was observed using 3 point scale i-e ≤ 90°, 91°-180° or > 180°. Furthermore, it was also noted if the tumor is causing displacement of vessel or resulting in any degree of vascular occlusion/stenosis. Findings of MRI were then correlated with surgical findings and labelled as positive or negative on the basis of pre-operative presence or absence of vascular invasion.

Results

A total of 50 sarcoma patients were included in this study. Out of these 50 patients 28 were males (56%)

and 22 were females (44%) (Fig. 1). Age range was from 02-80 years with mean age of presentation of 78 ± 19.7 years. Upper extremity was involved in 09 cases (18%) while lower extremity was involved in 41 cases (82%) (Fig. 2). Limb saving surgery was performed in 43 patients (86%) while 7 patients underwent amputation (14%) (Fig. 3). The most common histological type of sarcoma observed in our study was spindle cell sarcoma 18 cases (36%)

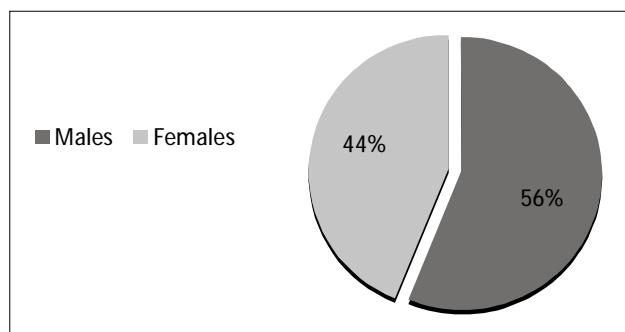


Figure 1: Male : Female Ratio

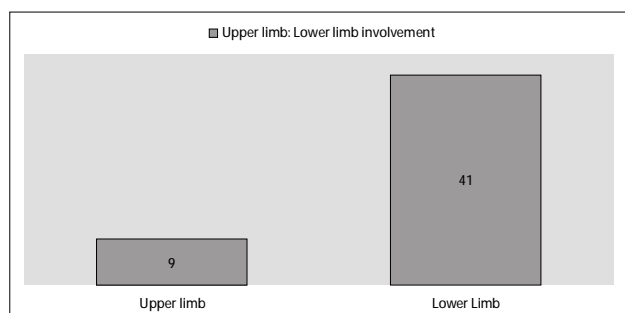


Figure 2: Upper limb : Lower limb involvement

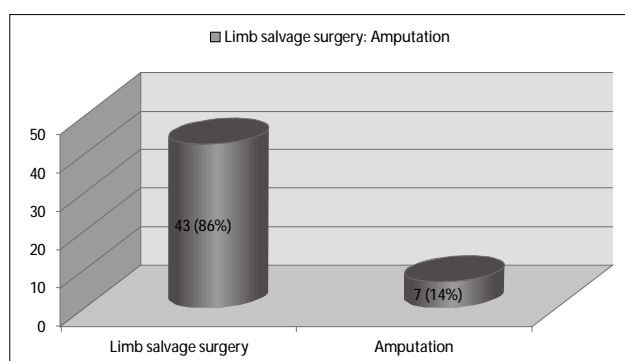


Figure 3: Limb salvage surgery: Amputation

followed by osteosarcoma 9 cases (18%), synovial sarcoma 9 cases (18%), ewing's sarcoma 4 cases (8%), undifferentiated pleomorphic sarcoma 4 cases (8%), myxoid liposarcoma 2 cases (4%), chondrosarcoma 1 case (2%) and miscellaneous (dermato-

fibrosarcoma, rhabdomyosarcoma and myxoid fibrosarcoma) were 01 each (2% each) (Fig. 4). Vascular encasement by tumor was reported in 7 cases (14%) on baseline MRI; while 8 patients (16%) had vascular encasement on surgery. 1 case (2%) was reported as positive for vascular encasement on MRI but was negative on surgery (false positive).

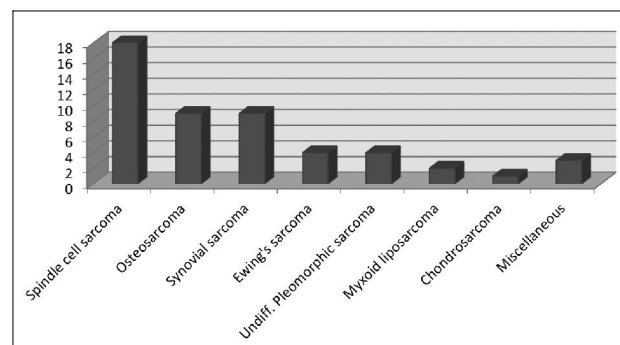


Figure 4: Histological types

2 cases (4%) were reported to be negative for vascular encasement on MRI but were positive on surgery (false negative). 40 cases (80%) showed no vascular involvement on both MRI and on surgery. Pearson chi square p-value was calculated to be 0.000 which confirms the significance of the results (Tab. 1a). The sensitivity of MRI in detecting vascular invasion was calculated to be 77.78%, specificity was 97.56 %, positive predictive value (PPV) was 87.50%, negative predictive value (NPV) was 95.24% and diagnostic accuracy was 94.00% (Tab. 1b)

| | | Vascular involvement on MRI | | Total | p |
|--------------------------|---------|-----------------------------|---------|--------|------|
| | | Absent | Present | | |
| Per-op Vascular invasion | Absent | 40 | 1 | 41 | .000 |
| | Present | 2 | 7 | 9 | .000 |
| | | 80.0 % | 2.0 % | 82.0 % | |
| | | 4.0 % | 14.0 % | 18.0 % | |
| Total | | 42 | 8 | 50 | |
| | | 84.0% | 16.0% | 100.0% | |

Table 1a: Diagnostic accuracy of Contrast enhanced MRI in detection of vascular invasion by limb sarcomas

Discussion

Sarcomas are rare mesenchymal tumors⁵ which affects extremities in approximately 50% of the cases⁶; out of which a vast majority (80%) involves the lower

| Statistics | Estimate |
|---------------------------------|----------|
| Sensitivity | 77.78% |
| Specificity | 97.56% |
| Positive Predictive Value (PPV) | 87.50% |
| Negative Predictive Value (NPV) | 95.24% |
| Diagnostic accuracy | 94.00% |

Table 1b: Diagnostic accuracy of Contrast enhanced MRI in detection of vascular invasion by limb sarcomas

extremities.⁷ These tumors can occur at any age without any gender predilection.⁶ The most common histological type of sarcoma is Undifferentiated pleomorphic sarcoma (malignant fibrous histiocytoma).⁷ MRI is the modality of choice for the evaluation of sarcoma and its local staging; with its excellent contrast resolution it is extremely useful in depicting the characteristics of sarcoma, extent of lesion and its relationship with adjacent structures including joints and neurovascular bundles⁸ resulting in significant increase in limb salvage surgeries.⁴ Usually, the pulse sequences used to image sarcomas include an initial localizer of large field which helps in immediate assessment of the tumor location and extent which in turn helps in further image planning for remaining sequences i-e T1 and T2 weighted, fluid sensitive or fat suppressed and post contrast sequences.

Sarcoma is evaluated locally on the basis of its size, location i-e superficial or deep to fascia; inter-or intramuscular or osseous, perilesional edema, involved muscular compartment, its relationship with adjacent neurovascular bundles, bone and joint.^{6,9} Nodal involvement is rare in sarcoma.¹⁰ Neurovascular involvement can be assessed by carefully evaluating the intervening fat between the tumor and neurovascular bundles; loss of fat planes between the mass and neurovascular bundles is considered as involved. Furthermore, it is also important to define the exact degree of vascular invasion i-e if the tumor is partially or completely encasing the adjacent vessels because it has significant impact on the surgical planning and approach to select between an amputation or limb conservation and reconstruction surgery. In cases where the tumor completely encases the major neurovascular bundle, it is often sacrificed resulting in significant functional deficit but this can be minimized by newer techniques like distal nerve transfer and

nerve grafting or vascular reconstruction.¹¹ Since these techniques require additional surgical expertise; pre-operative knowledge of the extent of neurovascular involvement is very essential.

Surgery is the mainstream treatment option for sarcomas and is considered as the gold standard in those tumors in which resection can be performed without sacrificing adjacent structures like major blood vessels, nerves or bone with clear margins.⁶ Unfortunately, this approach is limited only to the small tumors that are superficial to the fascia; but it should also be kept in mind that those superficial lesions which appear infiltrative or multinodular or are associated with significant perilesional edema or adjacent to the bone are treated with radiation as well in addition to the surgery to prevent local recurrence.¹² On the contrary, larger lesions deep to the fascia and lesions which occur in extracompartment regions like axilla, popliteal fossa, cubital fossa and femoral triangles lack muscular fascia are always treated with radiotherapy in addition to the surgery to prevent local recurrence as surgery alone is likely to spare microscopic disease.^{6,13} Low grade lipomatous lesions are an exception to this criteria because they usually do not recur or metastasize; however, radiation can be considered if there is any local recurrence. The prime goal of surgery is to achieving adequate resection with wide clear margins is to minimize the risk of disease recurrence for which it is important to resect pseudocapsule as well as normal tissue surrounding the tumor.¹⁴ It is important to understand that the peritumoral edema which often extends far beyond the main tumor can also contain microscopic tumor.¹⁵ The wide clear resection margin is defined as resection of tumor along with 1-2 cm of normal tissue i-e skin, muscle or fat in all planes or 1 mm of fascia as it provides an excellent barrier to the inter-compartment tumor spread.^{6,15} Alternatively, radical excision can also be performed in which there is complete resection of the involved compartment. This provides an excellent control to the local tumor spread but at the cost of significant functional compromise.⁶ In our study, we evaluated 50 patients of biopsy proven sarcoma on baseline contrast enhanced MRI. Contrast enhanced MRI not only helps in easy identification of the direct tumoral vascular invasion¹⁶ but also helps in accessing the tumor vascularity (Fig. 5a, b, c).¹⁷ On MRI we reported 07 cases as positive

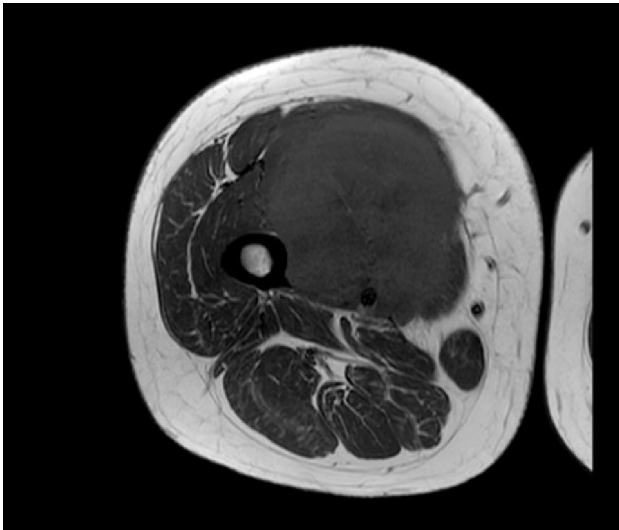


Figure 5a: MRI axial T1WI showing large mass involving the vastus medialis muscle in anteromedial aspect of right thigh; Note the tumor is completely encasing the adjacent femoral vessels and nerve and is closely applied to medial surface of femur with intact cortex.

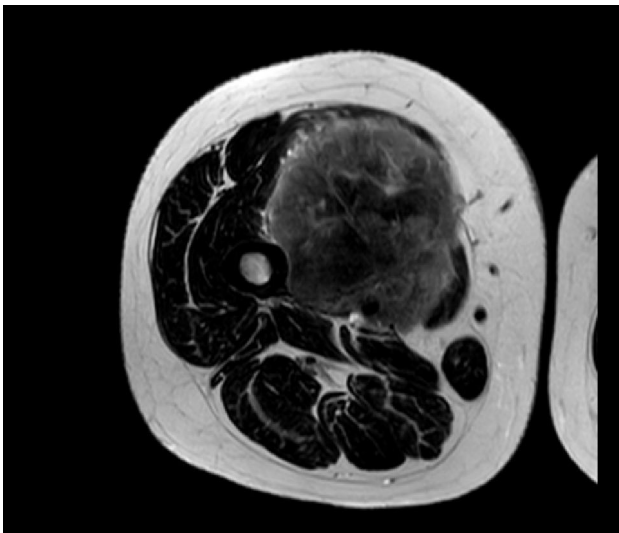


Figure 5b: MRI axial T2WI showing large heterogenous mass involving the vastus medialis muscle in anteromedial aspect of right thigh; Note the tumor is completely encasing the adjacent femoral vessels and nerve and is closely applied to medial surface of femur with intact cortex.

for vascular encasement and 40 patients negative for vascular encasement; whereas, surgical findings confirmed presence of vascular encasement in 08 patients and 42 patients were negative for vascular encasement. These results show that contrast enhanced MRI is an excellent technique to identify vascular encasement correctly pre-operatively. We observed several limitations in our study which needs to be

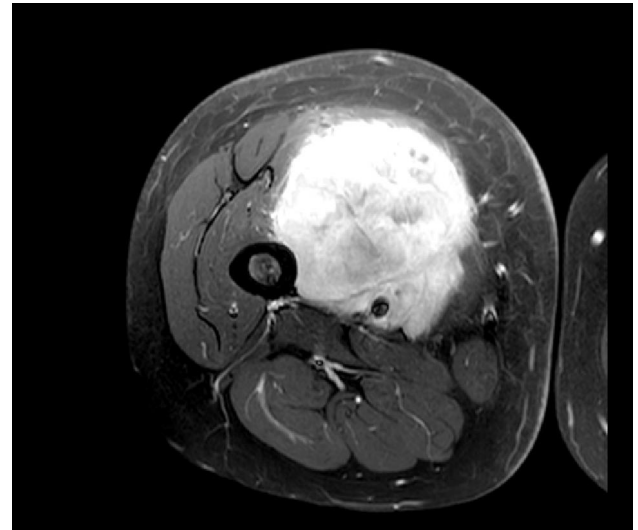


Figure 5c: MRI axial T1 post contrast showing large heterogeneously enhancing mass involving the vastus medialis muscle in anteromedial aspect of right thigh; Note the tumor is completely encasing the adjacent femoral vessels and nerve and is closely applied to medial surface of femur with intact cortex.

considered. Firstly, the design of study we conducted was retrospective. Secondly, the number of patients was limited. Thirdly, surgeons were not blind to the MRI findings as a result of this certain abnormalities might have been influenced.

Conclusion

Contrast enhanced MRI proved to be reliable and an accurate imaging modality in the evaluation of sarcomas and is highly sensitive and specific in the evaluation of neurovascular encasement.

Conflict of Interest: None

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