Original Article

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Radiology Section

Multi-Detector Computed Tomography in Evaluating Locally Aggressive and Malignant Bone Tumours

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ABSTRACT

Objective: To evaluate the ability of Multi-Detector Computed Tomography in preoperative evaluation of locally aggressive and malignant bone tumours in correlation with histopathological findings.

Materials and Methods: Twenty patients suspected of malignant bone tumours on the basis of their clinical profile were selected. Following a plain radiograph evaluation, all of them were subjected to CT scan examination. Multi Planar Reconstruction (MPR) was done in sagittal and coronal planes and also three-dimensional Volume Rendering (VR) and Maximum Intensity Projection (MIP) images were obtained.

Results: Of the 20 patients, 18 underwent surgery, and their histopathological findings were compared and correlated with MDCT findings. MDCT was 92.8% sensitive and 100% specific in determining the vascularity of the tumour and also can detect displacement/ encasement/ involvement of adjacent vessels. It has a sensitivity and specificity of 100% in determining cortical break, calcification and periosteal reaction. However, it is less sensitive in detecting joint involvement. Post contrast enhancement gives details of the extent of the soft tissue component.

Conclusion: Although MRI is a preferred modality in preoperative evaluation of bone tumours, CT may be used an alternative in case of non-availability of MRI, which has faster acquisition time and better resolution. Using three dimensional MPR imaging, the location and extent of the tumour can be studied. It is also useful in determining cortical discontinuity, periosteal reaction, and calcification. By virtue of MIP and VR imaging, vascularity of the tumour and its relationship with the adjacent vasculature can be established. However, it is inferior to MRI in soft tissue characterization and has poor sensitivity in detecting marrow and joint involvement.

Keywords: Histopathology, MRI, Radiograph

INTRODUCTION

The location, extent and nature of the musculoskeletal tumours is determined by imaging techniques like radiography, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). These modalities are essential for staging the tumours by evaluating their intra and extra osseous spread. Multi Detector CT (MDCT) is now preferred over conventional CT in the evaluation of bone tumours since it has faster acquisition time and better resolution. Using three-dimensional MPR imaging, the location and extent of the tumour can be studied. It is also useful in determining cortical discontinuity, periosteal reaction and calcification. By virtue of MIP and VR imaging, vascularity of the tumour and its relationship with the adjacent vasculature can be established. CT angiography is easily created from the raw data acquired by dynamic enhanced axial sections without any additional scans. It is useful in establishing the relationship of the tumour with major vessels and also in indentifying the source of vascularity of the tumour. It also detects vascular displacement, encasement, occlusion and encasement. Exquisite three dimensional images are attractive and intelligible to orthopedicians providing excellent preoperative assessment of the tumour resulting in better surgical management. The volume rendering technique is used to set multiple thresholds and each target organ, such as bone, vessels, muscles and tumours can be separately demonstrated. MRI is useful in determining the extent of tumour involvement in bone and soft tissues with high contrast resolution. It is also an excellent modality to demonstrate marrow involvement, neurovascular bundle and joint involvement. However, it has high false positive rate in detecting cortical break and matrix calcification. Overall, MRI is the modality of choice for determing the local extent and tumor staging [1-5].

Aims and Objectives

To evaluate the ability of Multi-Detector Computed Tomography in conjunction with plain radiography in preoperative evaluation of locally aggressive and malignant bone tumours using parameters like cortical break, periosteal reaction, calcification, soft tissue involvement and vascular invasion and correlation of the above parameters with histopathological findings of the postsurgical specimens.

MATERIALS AND METHODS

Patients who have presented with a suspected primary musculoskeletal tumour on the basis of clinical profile and plain radiography were selected. The lesions were studied by CT scan with intravenous administration of iodinated contrast material. CT was performed on Siemens Somatom 16-slice Multi-detector scanner and Philips 40 slice CT scanner. Contrast of 2-3ml/kg at 3-4ml/sec was given using a power injector. Plain and enhanced images were acquired in arterial and delayed venous phases. Multi Planar Reconstruction (MPR) was done in sagittal and coronal planes and also three-dimensional Volume Rendering (VR) and Maximum Intensity Projection (MIP) images were obtained. The histopatholgical findings of the post surgical specimens were correlated with the imaging parameters.

OBSERVATIONS AND RESULTS

All the patients underwent a plain radiograph, at least in two projections including the adjacent joint and contrast enhanced CT. Out of 20, 18 patients underwent surgery; the other 2 patients underwent non-surgical management, as one of them was a poor candidate for surgery and the other one had distant metastases at the time of diagnosis. The histopathological findings of the operative specimens were used to assess the utility of plain radiograph, MDCT in preoperative evaluation of the tumours. Age of the patients included in the study ranged from 10-66 y with mean age of 25.5 y. Maximum number of patients was in age group 11-20 y. (9). Out of 20 patients included in the study, 14 (70%) were males and 6 (30%) were females.

Preoperative radiological evaluation of locally aggressive and malignant bone tumours was done using the following parameters.

	Present	Absent	N/A	Total
X-ray	8	12	0	20
CT	10	10	0	20
Histopathology	9	9	2	20

[Table/Fig-1]: Cortical discontinuity

	Present	Absent	N/A	Total
X-ray	5	15	0	20
CT	9	11	0	20
Histopathology	9	9	2	20

[Table/Fig-2]: Calcification within the tumour mass

Cortical Break: Presence or absence of cortical discontinuity was looked and reported as either 'Present' or 'Absent' [Table/Fig-1].

Calcification: Calcification within the tumour mass and within the surrounding soft tissue was noted [Table/Fig-2]. The pattern of calcification can suggest the type of underlying matrix and thus, the diagnosis. Bone-forming tumours have fluffy, amorphous and cloudlike calcifications, whereas punctuate, flocculent, comma-shaped, or arclike or ring like pattern is classical of chondral tumours like enchondroma, chondrosarcoma, or chondroblastoma [6].

Periosteal Reaction: Presence of periosteal reaction was evaluated on X-ray and CT and reported as either 'Present' or 'Absent [Table/Fig-3]. The pattern of periosteal reaction also helps in characterizing a bone tumour. A solid pattern is suggestive of a slow growing, non aggressive lesion, a multilayered or "onion skin" pattern is indicative of an intermediate aggressive pathology. Whereas, a sunburst, spiculated or "hair on end" appearance is the most aggressive pattern and is a tell tale sign of malignancy. Benign entities like osteomyleitis may also show an aggressive pattern of periosteal reaction and must be considered in the differential diangnosis [6].

	Present	Absent	N/A	Total
X-ray	9	11	0	20
CT	11	9	0	20
Histopathology	11	7	2	20

[Table/Fig-3]: Periosteal reaction

	Present	Absent	N/A	Total
X-ray	15	5	0	20
CT	17	3	0	20
Histopathology	18	0	2	20

[Table/Fig-4]: Involvement of the surrounding soft tissues

	Uninvolved	Displaced	Encased	Involved	N/A
CT	3	12	2	1	2
Histopathology	1	11	4	2	2

[Table/Fig-5]: Relationship of the tumour with the adjacent vascular bundle

s.no	Parameter	Sensitivity (%)	Specificity (%)
1.	Cortical break	77.8	100
2.	Calcification	55.5	100
3.	Periosteal reaction	82	100
4.	Soft tissue involvement	93.8	--

[Table/Fig-6]: X ray vs. Histopathology

Soft tissue involvement: Involvement of the surrounding soft tissues was noted as either 'Present' or 'Absent [Table/Fig-4].

Vascular involvement: Relationship of the tumour with the adjacent vascular bundle was evaluated on CT and noted as either 'Uninvolved', 'Displaced', 'Encased' or 'Involved' [Table/Fig-5]. The vessels were considered 'uninvolved' when they are far away from the tumour, 'displaced' when the vessels are shifted away by the mass effect of the tumour but have their fat planes intact. When the tumour surrounds the vessels with complete or partial loss of fat planes, it was considered 'encased' and cases where there was invasion of the vessel wall with luminal narrowing or intraluminal tumour thrombus formation were considered 'Involved'.

S.no	Parameter	Sensitivity (%)	Specificity (%)
1.	Cortical break	100	100
2.	Calcification	100	100
3.	Periosteal reaction	100	100
4.	Soft tissue involvement	100	--
5.	Vascular involvement	86.6	100

[Table/Fig-7]: CT vs. Histopathology

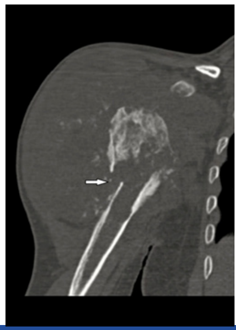
The comparison of all the parameters, as in X-Ray, Histopathology and CT are given in [Table/Fig-6,7].

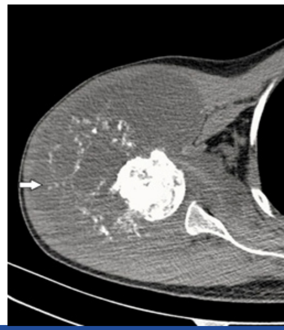
DISCUSSION

Preoperative imaging plays a major role in planning the treatment in patients with musculoskeletal neoplasms. The radiologist must have a thorough knowledge of the modalities and techniques available to select the most efficient imaging protocol to solve the diagnostic problem. MRI is generally considered to be the imaging modality of choice in the preoperative evaluation and staging of musculoskeletal neoplasms, however in a developing country like India, where the relative non availability of and high cost of MR imaging makes it impossible to evaluate every case. This study was done to evaluate the utility of MDCT as an alternative to MRI in a subset of cases who may need early surgery, as patients in our hospital usually have to wait for months for an MRI appointment whereas CT could be done within few days, paving way for an early surgery, which results in better survival. Also, CT thorax to rule out lung metastases could be done in the same setting in malignant tumours that are notorious for early metastatic spread. CT scan gives important clues regarding the anatomic extent of the tumour, like dimensions of the tumour, depth of the tumour from the skin, adjacent vascular bundles and also detects specific areas of the tumour, like enhancing bone/ soft tissue, areas devoid of necrosis or fluid, from where biopsy should be obtained [7]. It also provides information regarding the presence of calcification and the nature of matrix mineralization. MDCT is preferred over conventional CT in the evaluation of bone tumours since it has faster acquisition time and better resolution [8]. Using three-dimensional MPR imaging, the location and extent of the tumour can be studied. It is also useful in determining cortical discontinuity, periosteal reaction and calcification. By virtue of MIP and VR imaging, vascularity of the tumour and its relationship with the adjacent vasculature can be established [9-13].

The sensitivity of detecting cortical break was 77.8% on radiography and 100% on CT. Cortical break signifies the extent of bony involvement and the need to stabilize the fractured fragment thus preventing further damage. Both the modalities have found to be 100% specific in determining the cortical break.

CT was found out to be 100% sensitive and specific in determining the presence of calcification. Radiography was 55.5% sensitive and 100% specific.

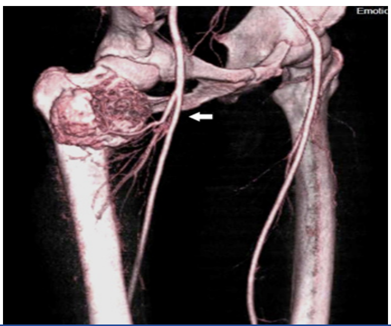
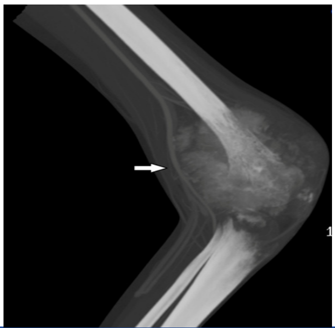





[Table/Fig-8a]: Plain radiograph of a case of chondrosarcoma of right humerus showing destruction of the humeral head with pathological fracture at the neck and proximal shaft **[Table/Fig-8b]** Coronal CT of the same case. (Arrow showing the cortical discontinuity) **[Table/Fig-9]:** Plain radiograph of a chondrosarcoma of left clavicle depicting chondroid matrix **[Table/Fig-10]:** Another case of chondrosarcoma involving the right proximal humerus, revealing “ring and arc” type of calcification (arrow) on axial CT **[Table/Fig-11a]:** Plain radiograph of a case of osteosarcoma of left proximal tibia showing osteoblastic matrix **[Table/Fig-11b]** Coronal CT of the same case shows the matrix mineralization (arrow) along with adjacent soft tissue mass




[Table/Fig-12]: Plain radiograph demonstrating sunburst-type periosteal reaction in a case of osteosarcoma of distal left femur. **[Table/Fig-13]:** Sagittal CT image of another case of osteochondroma involving the distal femur, shows hair-on-end type (arrow) of periosteal reaction **[Table/Fig-14a]:** Plain radiograph in a case of Ewings sarcoma of the left femur demonstrating permeative bone destruction with a large soft tissue mass **[Table/Fig-14b]** Axial CT image at the level of the proximal femur of the same case, showing an enhancing soft tissue mass (arrow)


[Table/Fig-15a] : Plain radiograph depicting a lytic expansile lesion involving the proximal right femur which turned out to be a chondrosarcoma **[Table/Fig-15b]:** VRT image of the same case showing the lesion being supplied by branches of the right profunda femoris artery (arrow) **[Table/Fig-16]:** MIP image of a case of osteosarcoma involving the distal femur, which illustrates posterior displacement of popliteal artery **[Table/Fig-17]** VRT image of a fibular osteosarcoma that shows involvement of anterior tibial artery (arrow)

Irrespective of the type, periosteal reaction was graded as ‘Present’ or Absent’ on X-ray and CT. CT was found to be superior to radiography with the former showing a sensitivity of 82% and latter showing 100% sensitivity. However both of them have found to be 100% specific.

The soft tissue involvement especially in bone tumours is an indicator of the aggressiveness of the mass lesion, which was graded on X-ray and CT as either ‘Present’ or ‘Absent’. CT was found to be superior to radiography in determination of soft issue involvement with 100% sensitivity and the latter with 93.8% sensitivity. Multiplanar imaging using MDCT can produce excellent three dimensional images similar to that of MRI, thus resulting in better soft tissue detail.

The relationship of vascular bundle with the tumour mass and the extent of involvement on CT and was graded as either ‘Displaced’, ‘Encased’ and ‘Involved’. The sensitivity and specificity of CT were found to be 86.6% and 100 % respectively. CT was found to quite effective not only in determining the vascular bundle involvement, but, also the vascular channels supplying the mass, and extent of displacement and encasement of the blood vessels by the tumour by virtue of VRT and MIP techniques.

Few representative images from the cases that were studied have been illustrated [Table/Fig 8-17].

CONCLUSION

Conventional radiography is the first line of investigational strategy for musculoskeletal tumours. The radiograph can localize the lesion and determine its degree of aggressiveness enabling the radiologist to make a differential diagnosis and in many cases a specific diagnosis. Although, MRI is considered the imaging modality of choice in staging bone tumours and is an excellent modality to demonstrate marrow involvement, neurovascular bundle and joint involvement, it has high false positive rate in detecting cortical break and matrix calcification. MDCT may be considered as an alternative to MRI because of its easy availability, faster imaging time and better contrast resolution. Using three-dimensional MPR imaging, the location and extent of the tumour can be studied. It is also useful in determining cortical discontinuity, periosteal reaction and calcification. By virtue of MIP and VR imaging, vascularity of the tumour and its relationship with the adjacent vasculature can be established.

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