The role of magnetic resonance imaging in the staging and the follow-up of the osteosarcomas

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In recent years, limb salvage surgery has been more widely used in the surgical treatment of osteosarcoma. Limb salvage surgery enables the patient use his extremity for the rest of his life and provides a better quality of life. The most important prerequisite for a successful limb salvage surgery is the exact delineation of the tumor invasion, bone marrow invasion and skip metastases. Definition of the involved muscle groups has indispensible importance of Magnetic Resonance Imaging in the preoperative staging and postoperative follow-up of the osteosarcoma cases has been discussed along with our findings in our patients. [Turk J Med Res 1994; 12(2):62-65]

Key Words: Osteosarcomas, Magnetic Resonance Imaging, Limb Salvage Surgery

Excluding multiple myeloma, osteosarcoma is the most common primary cancer of bone. Almost 50-75 % of all these tumors arise close to the knee (1).

Today, in the surgical treatment of osteosarcomas, limb salvage surgery is preferable to amputations. The aim of this operation technique is protecting maximal limb part by minimal possible resection border (2). The limb salvage operations combined with adjuvant chemotherapy and radiotherapy are as succesful as radical surgical treatments such as amputations.

The application of limb salvage operation which **is** a conservative surgical technique enabling the patient to use his limb by the help of metallic prosthesis is dependent on these conditions:

-The intramedullary invasion of tumor can be defined clearly

-The intramedullary skip metastases can be defined clearly

-The nujuscle groups infiltrated by the tumor can be defined clearly and resectable.

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On the basis of these conditions the limb can be resected leaving a free margin of at least 4-5 cm. of the proximal border of the medullary invasion. The infiltrated muscle groups must be resected to protect the non-infiltrated ones. The operation ends by replacement of resected bone by metallic prosthesis. After a femoral resection by this tecchnique, the patient is able to make flexion of about 110 degree to his knee and can live more comfortably compared to amputation.

In the diagnosis of the osteosarcomas there are classic and well known advantages of Magnetic Resonance Imaging (MRI) over other modalities. These include higher soft tissue contrast and multiplanar imaging abilities. For this reason MRI has an important place in the diagnosis and preoperative staging of osteosarcomas by its exact delination of medullary invasion, skip metastases and the involved muscle groups.

In this study the role of MRI in the planning of limb salvage operations for osteosarcomas is investigated.

MATERIALS AND METHODS

Sixteen of the 29 patients referred to the MRI section of Radiology Department of Giilhane Military Medical Academy (GMMA) between October 1991 and August 1993 with a presumptive diagnosis of bone neoplasm have been evaluated. The mean age of patients was 20 (range 12 to 26) years. 14 of 16 were male and 2

Table 1. Distribution of the cases according to involved bones.

Bone	Number
Femur	12
Ilium	2
Humerus	1
Tibia	1

Table 2. Findings detected by other modalities other than MRI

	DR	CT	DSA
Periostal reaction	15	15	
Cortical destruction	15	16	—
Soft tissue invasion	7	13	—
New boneformatioin within soft tissue	13	13	—
Irregular calcification	11	11	—
Hypervascularity	—	—	7
Articular invasion	—	—	—

were female. All patients were diagnosed histopathologically as osteosarcoma.

All patients were examined by direct radiography, computed tomography (CT), bone scintigraphy and MRI. 9 of 16 were examined also by digital subtraction angiography (DSA).

In all patients, coronal and sagittal T1 weighted images, axial T2 weighted images, magnetic resonance angiographic (MRA) and in some patients gradient echo sequences were obtained using the 1.5 Tesla superconductive Siemens Magnetom MRI system. After intravenous (IV) Gadolinium DTPA (Gd-DTPA) injection, axial, sagittal and coronal T1 weighted images were obtained in all patients.

The MRI findings were examined by comparison of CT, DSA, direct radiography and scintigraphy findings.

RESULTS

The distribution of the lesions in 14 male and 2 female are shown in Table 1. Common clinical complaints were pain, tenderness and gradual swelling of the affected parts. The patients were diagnosed as probable osteosarcoma by CT and direct radiography prior to MRI examination. In 15 of 16 patients, periosteal reaction and cortical destruction were defined by direct radiography and CT. In one case, an indistinct cortical erosion at the distal end of the femur was defined . In CT images of this patients, cortical erosion could be seen more clearly. In CT and direct radiography of 13 cases, soft tissue invasion or new bone formation-in soft tissue were determined. In 11 patients, irregular calcifications were present. Hypervascularity of the tumor and tumoral deplacemenrt of adjacent vasculature were shown in 7 of 9 cases in DSA. No invasion of articular surfaces was shown in CT or plain radiography. Skip metastases could not be determined by CT. Intramedullary tumoral extend could be determined by CT but distinct border could not be defined clearly. However in the security, margins, the border several cm. below the proximal of bone marrow that showed pure fat density was indicated as tumoral border. The findings of all modalities except MRI is shown in Table 2. In all patients, presence of lung metastases were searched by CT. There were no lung metastases. MRI samples of patients are shown in Figures 1-4.

By MRI the upper and lower borders of the medullary invasion and soft tissue infiltration were shown clearly. After the injection of paramegneti c contrast material, the soft tissue masses shown heterogeneous enhancement helping in the determina-

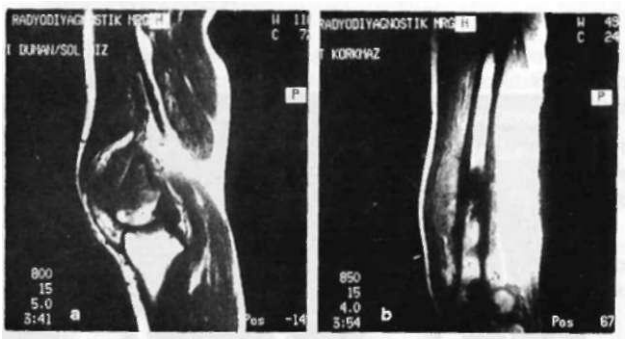

Figure 1. a) T1 weighted sagittal image of a femoral osteosarcoma showing hypointense intramedullary tumoral invasion spreading 7 cm. proximal to the distal articulation, b) T1 weighted sagittal image of another femoral osteosarcoma showing hypointense intramedullary tumoral invasion spreading 18 cm, proximal to the distal articulation. Tumoral tissue destructs the cortex spreading into adjacent soft tissues.

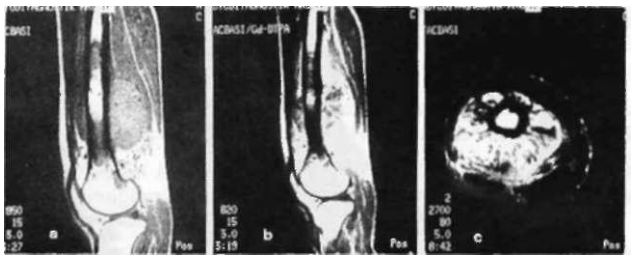

Figure 2. a) T1 weighted sagittal image showing hypointense tumoral invasion spreading 17 cm. proximal to the distal femoral articulation. Hypointense tumoral component is shown in adjacent soft tissue.

b) In Gd-DTPA weighted sagittal image the soft tissue component surrounding the femur is shown as homogeneous enhancement.

c) In T2 weighted axial image heterogeneous hyperintense tumoral invasion in adjacent soft tissue of bone is shown, signal void areas are shown in soft tissue representing new bone formation.

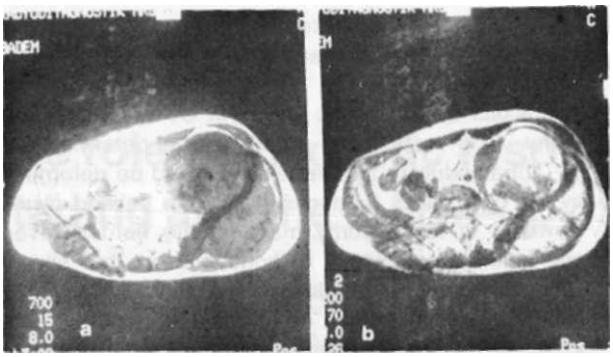

Figure 3. a) T1 weighted axial image: osteosarcoma invaded left ilium totally. Soft tissue component of the tumor extending to the iliac fossa and gluteal region are shown as hypointense areas.

b) T2 weighted axial image of the same case: Soft tissue components of the tumor are shown as heterogeneous hyperintense areas.

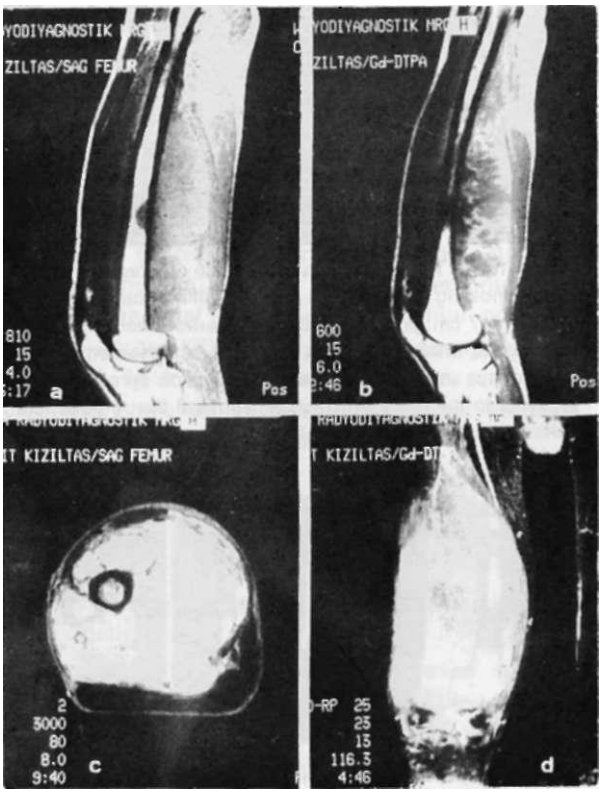

Figure 4. a) T1 weighted image of a femoral osteosarcoma: Hypointense tumoral lesion spreading 25 cm. proximal to distal articulation is shown as big soft tissue tmor.

b) In Gd-DTPA T1 weighted image of the same case soft tissue lesions are shown as heterogeneous enhancement.

c) In T2 weighted image of the same cases big soft tissue lesions are shown as high signal intensity areas.

d) MR angiography sequence of the same case: Vasculature is surrounding and displaced by tumoral tissue.

Table 3. MRI findings.

	(˙)	
Intramedullary invasion	16	
Soft tissue invasion	16	
Skip metastases		16
Calcification	9	7
Cortical bone erosion or periostal reaction	16	
Vascular impression/deplacement	12	4
Vascular thrombosis		16
Articular invasion		16

tion of the border of soft tissue invasion. Although sagittal and coronal images showed the whole length with details of the related bone, skip metastases could not be found in any case. MRA sequences were obtained In all cases and tumoral déplacement and impression of adjacent vasculature were shown in 12 of 16 patients. Neither MRA nor spin echo sequences showed tumoral thrombosis. In 3 of 12 patients, tumor surrounded by vasculature. MRI findings of cases are shown in Table 3.

Except two cases with tumor localized at iliac bones and one case who rejected operation, limb salvage operation were done In 11 cases. Preoperative neoadjuvant chemotherapy for 3 days and 35 Gy radiotherapy for 10 days were given. Tumoral bone tissue and involved muscle groups resected with a wide free margin. Custom-made metalic prosthesis were placed at the same operation. The last 2 cases are preparing for limb salvage operation after the adjuvant chemotherapy and radiotherapy.

DICCUSSION

Osteosarcomas are among the most common cancers of bone and almost 50-75 % of them arise close to the knee joint. Direct radiogram and CT have great value in showing minor calcifications, periosteal reactions, early cortical erosions and internal matrix configuration. In staging, thorax CT is an important modality in showing the lung metastases. Infection of distant lesions and metastatic bone tumors, radionuclide imaging is an important modality (3).

Osteosarcomas prolonges T1 and T2 times and are shown as hypointense in T1 weighted sequences and as hyperintense in T2 weighted sequences. Short time inversion recovery (STIR) technique is one of the fat supression techniques and has an important role in the evaluation of bone lesions. By this technique, osteosarcomas are shown as hypertense lesions. Normal bone marrow fat is supressed and is shown as hypointense. The infiltrated bone

marrow is shown as hyperintense. and medullary invasion can be is shown clearly. MRI can show bone marrow invasion, skip metastases and vascular and soft tissue infiltration. Bone marrow invasion can be shown definitely in T1 weighted sequences by the loss of high signal intensity of normal bone marrow (4)- In all our cases, the extent of medullary invasion an soft tissue involvement were shown definitely.

The role of MRI in the staging of the osteosarcomas can be listed as below: Vertical (longitudinal) tumoral infiltration in the limbs can be best shown in coronal and sagittal T1 weighted MR images (3,5,6). Small, isolated metastatic areas (skip metastases) can be best shown in coronal and sagittal MR images (7). In our study none of them showed skip metastases. Axial T2 weighted sequences show invasion of adjacent soft tissue ie. muscle groups and vasculature (6,8). MRI has a great value also in detection of vascular invasion due to its ability to show the vasculature without contrast material injection. Definition of involved muscle groups specifically leads to resection of them leaving the non-involved muscle groups specifically leads to resection of them leaving the non-involved ones. MRA is also important in planning of the surgery by showing déplacement of vasculature and the peresence of tumoral thrombosis. In our study MRA showed pathology in 12 of 16 cases while in 4 there were no pathology. Showing the invasion of articular surfaces in staging of limb osteosarcomas is very impportant. The early sign of articular invasion is minimal effussion. Showing minimal effusion is very difficult by CT. Using T2 weighted MR images, this can be shown easily (9). In our study we don't see any articular invasion. The diagnostic contributions of paramagnetic contrast material injection are listed as above. Tumoral invasion and peripheral edema cause a higher signal intensity of the soft tissues in T2 weighted images. But in post-gadolinium T1 series, soft tissue parts showing enhancement possibly indicate a real tumoral invasion (10). The soft tissue parts showing enhancement are important in planning the biopsy because it's the indicator of vital tumloral tissues (10). Another feature of the contrast material is to help in the differential diagnosis of tumoral recurrences with postoperative scar tissues. Except fresh granulation tissue, scar tissue does not show an enhancement while tumoral recurrences (11,12).

Metalic prostheses replacing resected bones cause widespread artefacts in MRI. Nonferromagnetic prostheses such as those made from titanium provide much more results in MR postoperatively (8). MRI is more sensitive in the differential diagnosis of postoperative fibrosis and recurrent tumoral tissue (8,13).

Osteosarkomlann evrelondiril meşinde ve takibinde magnetik rezonans görüntülemenin yeri

Osteosarkomların cerrahi tedavisinde son yıllarda ekstremite kurtarıcı ameliyatlar gündeme gelmiştir. Ekstremite kurtarıcı ameliyatlar hastaya ekstremitesini hayatının sonuna kadar kullanarak daha konforlu bir yaşam kalitesi sunmaktadır. Ekstremite kurtarıcı ameliyatlarda en önemli konu tümörün yayılım sınırlarının ve kemik iliği invazyonu ile skip metaztazlarının net bir şekilde belirlenmesidir. Ayrıca tutulan kas gruplarının belirlenmesinin de ameliyat planlamasında tartışmasız yeri vardır. Bu çalışmada kemik tümörlerinin tanısında tartışılmaz bir önemi olan Magnetik Rezonans Görüntüleme yönteminin osteosarkomlarda preoperatif evrelendirme ve takibindeki önemi osteosarkomlu olgulardaki bulgular ışığında tartışılmıştır. [Türk J Med Res 1994; 12 (2): 62-65]

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