Role of Diffusion MRI in differentiation between Benign and Malignant Bone Tumors

Thesis

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بسم الله الرحمن الرحيم

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العليم الحكيم

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List of Abbreviations

Abb.	Full term
ABC	Aneurysmal bone cyst
CMF	Chondromyxoid fibroma
ADC	Apparent diffusion coefficient
DWI	Diffusion weighted imaging
EPI	Echo Planar imaging
ES	Ewing sarcoma
FOV	Field of view
FS	Fat saturation
Gd	Gadolinium
Max	Maximum
Min	Minimum
MR	Magnetic resonance.
MRI	Magnetic resonance imaging
NOF	Non-ossifying fibroma
OS	Osteosarcoma
ROI	Region of interest
SBC	Simple bone cyst
SD	Slandered deviation
SE	Spin echo
SI	Signal intensity
STIR	Short tau inversion recovery.
T	Tesla
T1	Inversion time
T1WI	T1 weighted imaging
T2WI	T2 weighted imaging
TE	Echo time
TR	Time of repetition
TSE	Turbo spin echo

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INTRODUCTION & AIM OF THE WORK

Worldwide, cancer is the second cause of death following heart disease, accounting for 23% of all deaths. Primary malignancy of bone and joints is ranked as third leading cause of death in patient with cancer who is younger than 20 years ***(Siegel et al., 2013)***.

Improvement of treatment and outcome of bone tumors requires development of diagnostic tools that can help in differentiation between benign and malignant lesions in a noninvasive and reliable manner ***(Wang et al., 2001).***

Radiographs provide critical information regarding lesion location, margin, matrix mineralization, cortical involvement and adjacent periosteal reaction. MRI is the best modality for focal extent and local staging ***(George et al., 2002).***

Most bone tumors have classical radiographic appearances and they can be diagnosed and correlated with patient age and clinical data. MRI can detect non-mineralized tumor tissue, evaluate the local extent of a malignant process for the purpose of staging and assess bone tumor therapeutic responses. However, lesions of high T2 signal and low enhancement constitute diagnostic challenge in daily practice ***(Pekcevik et al., 2014 & Hayashida et al., 2006).***

In addition, a few benign and malignant tumors show atypical features and need further investigation. Some benign lesions in patients with known primary malignancies also constitute a diagnostic problem ***(Yakushiji et al., 2009).***

MRI is the most sensitive imaging modality for detection of bony tumors. It is considered the gold standard for characterization of these lesions and can detect occult intra-medullary lesions with negative bone scan ***(Kaplan et al., 2001).***

Diffusion-weighted magnetic resonance imaging (DWI) is a recent addition to the MR sequences conventionally employed. DWI provides qualitative and quantitative functional information concerning the microscopic movements of water at the cellular level ***(Khoo et al., 2011).***

Diffusion MRI measures the random movements of water molecules in the body (Brownian motion). Water molecule motion is assessed in vivo in the extracellular, intracellular, and transcellular compartments, as well as in the intravascular compartment (microcirculation-perfusion) ***(Baur et al., 2000).***

Restriction of water-molecule diffusion within biological tissues correlates negatively with tissue cellularity and membrane integrity ***(Lang et al., 1998).***

Restriction is greater in highly cellular tissues that have intact cell membrane and a small extracellular compartment.

Tumors differ regarding their cellular characteristics and the differences can serve to differentiate tumor types ***(Costa et al., 2011 & Van Rijswijk et al., 2002).***

The advantage of evaluating diffusion is the ability to probe the Apparent diffusion coefficients (ADC) cellularity of neoplasm, different ADC values corresponding to changes in restricted diffusion ***(Pearce et al. 2012 & Jaramilo et al., 2010).***

The purpose of this prospective study is to elucidate the ability of diffusion MRI in differentiation between benign & malignant bone tumors and to correlate diffusion patterns & ADC values of different lesions with their pathological nature.

Chapter 1

PATHOLOGY OF BONE TUMORS

Pathological and systematic approach of bone tumors:

Excluding lymphoma and myeloma, primary malignant bone tumors constitute to about 0.2% of all malignancies in adults and approximately 5% of childhood malignancies. Bone tumor classification is based on morphologic findings: cell type, matrix production, and architecture. An overlap may occur between the morphologic features of benign and malignant as well as non-neoplastic conditions. Many bone tumor entities in clinical setting such as age and anatomic site distribution show a striking consistency. The final diagnosis of bone tumors should be based on a synthesis of histopathologic findings, clinical presentation, and imaging characteristics ***(Davies et al., 2009).***

The two most important aspects in evaluating bone tumors are the tumor location and the patient age **(Fig. 1)**. Knowledge of this information alone narrow the differential diagnosis without even looking at any images. The specific radiographic criteria should help to narrow the list and often leading to the single diagnosis correctly ***(Limeme et al., 2015).***

WHO classification of bone tumors is shown in table (1):

Table (1): WHO classification of soft tissue and bone tumors ***(Kotb et al., 2014).***

CARTILAGE TUMOURS	**HAEMATOPOIETIC TUMOURS**
Osteochondroma Chondroma Enchondroma Multiple chondromatosis Chondroblastoma Chondromyxoid fibroma Central, primary, and secondary Peripheral Dedifferentiated Clear cell	Plasma cell myeloma
	Malignant lymphoma, NOS
	GIANT CELL TUMOUR
	Giant cell tumor Malignancy in giant cell tumor
	NOTOCHORDAL TUMOURS
	Chordoma
	VASCULAR TUMOURS
	Hemangioma Angiosarcoma
	SMOOTH MUSCLE TUMOURS
OSTEOGENIC TUMOURS	Leiomyoma Leiomyosarcoma
Osteoid osteoma Osteoblastoma Osteosarcoma Conventional Chondroblastic Fibroblastic Osteoblastic Telangiectatic Small cell Secondary Parosteal, Periosteal High grade surface	**LIPOGENIC TUMOURS**
	Lipoma Liposarcoma
	NEURAL TUMOURS
	Neurilemmoma
	MISCELLANEOUS TUMOURS
	Adamantinoma Metastatic malignancy

FIBROGENIC TUMOURS	**MISCELLANEOUS LESIONS**
Desmoplastic fibroma	Aneurysmal bone cyst
Fibro sarcoma	Simple cyst
FIBROHISTIOCYTIC TUMOURS	Osteofibrous dysplasia
	Langerhans cell histiocytosis
Benign fibrous histiocytoma	Erdheim-Chester disease
Malignant fibrous histiocytoma	Chest wall hamartoma
EWING SARCOMA/PRIMITIVE NEUROECTODERMAL TUMOUR	**JOINT LESIONS**
	Synovial chondromatosis
Ewing sarcoma	**Metastasis**

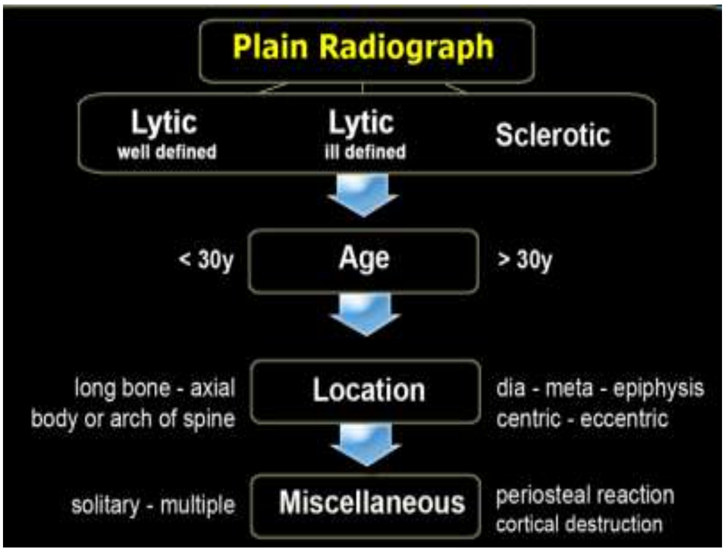

Fig. (1): Systematic approach for bony lesions types ***(Henk & Robin, 2010).***

The approach to the radiographic diagnosis of bone tumors is done by analyzing the lesion in an organized method, with attention to several specific radiographic features: Tumor location, patient age, margins and zone of transition, periosteal