



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

Thesis

*Submitted for Partial Fulfillment of MD degree
in Radiodiagnosis*

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2019

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

لَسْبَدَانِكَ لَا نَعْلَمُ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ
الْعَلِيمُ الْعَظِيمُ

صدق الله العظيم

سورة البقرة الآية: ٣٢

Acknowledgment

*First and foremost, I feel always indebted to **ALLAH**, the Most Kind and Most Merciful.*

*I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Ahmed Mostafa Mohamad**, Professor of Radiodiagnosis Faculty of Medicine - Ain Shams University for his keen guidance, kind supervision and continuous encouragement, which made possible the completion of this work.*

*I am also delighted to express my deepest gratitude and thanks to **Prof. Dr. Samer Malak Botros**, Professor of Radiodiagnosis Faculty of Medicine - Ain Shams University, for his kind care, valuable instructions, constant help and great assistance throughout this work.*

*I am deeply thankful to **Dr. Ahmed Mohamed Osman**, Assistant Professor of Radiodiagnosis Faculty of Medicine - Ain Shams University, for his great help, valuable instructions, active participation and guidance.*

*I would also like to thank **General Dr. Moustafa El-Maghloob**, Head of radiology department in Al-Galaa Military Hospitals for his continuous support and generosity through this work.*

All my love and appreciation to my family whom I owe my achievement & for their endless love and support.

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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
OSTEOGENIC TUMOURS Osteoid osteoma Osteoblastoma Osteosarcoma Conventional Chondroblastic Fibroblastic Osteoblastic Telangiectatic Small cell Secondary Parosteal, Periosteal High grade surface	SMOOTH MUSCLE TUMOURS
	Leiomyoma
	Leiomyosarcoma
	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 histiocyoma	Erdheim-Chester disease
Malignant fibrous histiocyoma	Chest wall hamartoma
EWING SARCOMA/PRIMITIVE NEUROECTODERMAL TUMOUR	JOINT LESIONS
	Synovial chondromatosis
Ewing sarcoma	Metastasis

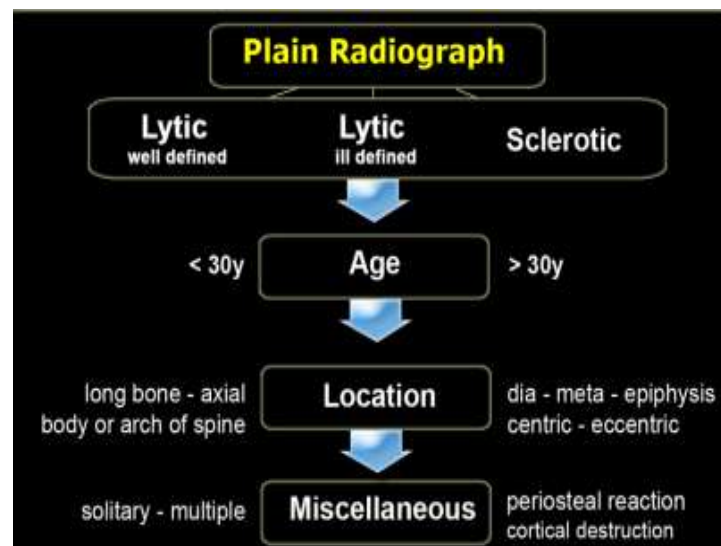


Fig. (1): Systematic approach for bony lesions types (*Henk & Robin, 2010*).

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