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A systematic approach to magnetic resonance imaging evaluation of epiphyseal lesions

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ABSTRACT

Magnetic Resonance Imaging (MRI) is the preferred modality of choice to image epiphyseal lesions. It provides excellent soft tissue resolution and extent of disease. A wide spectrum of tumor and tumor like lesions can involve the epiphysis. Early and accurate diagnosis as well as appropriate management of epiphyseal lesions is critical as these conditions may lead to disabling complications such as, limb length discrepancy, angular or joint surface deformities and secondary osteoarthritis. In this article, we discuss the role of conventional sequences, such as T1W, fluid sensitive T2W and intravenous (IV) Gadolinium enhanced sequences as well as the additional value of problem solving MRI sequences such as, chemical shift and diffusion weighted imaging. Based on the imaging findings on various MRI sequences and lesion characteristics, a systematic approach directed to the diagnoses of epiphyseal lesions is presented and discussed. MRI features of clinically and biopsy proven examples of the epiphyseal lesions, such as osteomyelitis, intra-osseous abscess, infiltrative malignancy, metastases, transient osteoporosis, subchondral insufficiency fracture, avascular necrosis, osteochondral fracture, osteochondritis dissecans, eosinophilic granuloma and geode are demonstrated. Using this systematic approach, the reader will be able to better characterize epiphyseal lesions with a potential to positively affect patient management.

1. Introduction

A wide variety of pathological processes can affect the epiphysis including benign and malignant tumors as well as tumor-like lesions [1,2]. Management strategies differ widely depending upon the specific diagnosis. Hence, early and accurate diagnosis as well as appropriate management of epiphyseal lesions is critical as these conditions may lead to disabling complications such as, limb length discrepancy, angular or joint surface deformities and secondary osteoarthritis [1]. The lesions may cause symptoms, or may be observed as incidental findings in studies performed for other reason or during work-up of a known malignancy. Plain radiography is the initial imaging modality for a bone lesion characterization; however the lesion may not be always visible on radiographs. Computed Tomography (CT) is helpful in special situations, such as detection of mineralization or fat within the lesion [3]. MRI is considered the best non-invasive method for soft tissue characterization and bone marrow evaluation [1]. In this article, we discuss the role of conventional sequences, such as T1W, fluid sensitive T2W, and intravenous (IV) Gadolinium enhanced sequences as well as the additional value of problem solving MRI sequences such as chemical shift and diffusion weighted imaging. Based on the imaging findings on various MRI sequences and lesion characteristics, a systematic approach directed to the diagnoses of epiphyseal lesions is presented and discussed.

2. MRI technique

MRI provides unparalleled multiplanar imaging with excellent soft tissue resolution enabling clear depiction of the detailed anatomy as well as pathology in the epiphysis [4]. One of the major advantages of MRI is the lack of ionizing radiation. High field strength MRI (1.5 or 3 T) systems are ideal for the evaluation of epiphyseal lesions, as a multitude of techniques can be applied and

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Table 1
A typical epiphyseal lesion protocol on a high field strength, 3 T magnet

Sequence	TR (ms)	TE (ms)	Turbo factor	ST (mm)	Base resolution
T1 COR without FS	750	9.7	5	3-4	384
3D STIR SPACE	1500	103	61	1-1.5	320
T1 AX	700	10	5	3-4	384
SPAIR AX	4500	80	17	3-4	320
VIBE COR	6.3	1.6	2	3	320
CSI AX	465	3.69	2	5-6	256
DWI AX	7700	80	2	5	120

Abbreviations: ms — milliseconds, mm — millimeters, TR — Time of Repetition, TE — Time of Echo, ST — Slice Thickness, Cor — Coronal, Sag — Sagittal, Ax — Axial, FS — Fat Saturation, STIR — Short Tau Inversion Recovery, SPAIR — Spectral Adiabatic Inversion Recovery, SPACE — Sampling Perfection with Application optimized Contrasts by using varying flip angle Evolutions, DWI — Diffusion Weighted Imaging, CSI — Chemical Shift Imaging, VIBE — Volume Interpolated Breathhold Examination..

are sometimes needed for the imaging characterization of various lesions [5] (Table 1). We use phased array surface coils and parallel imaging on the high field scanner. A combination of body and spine array coils is used for axial imaging, while joint specific coils or flex (surface) coils are used for the extremity imaging. For the purpose of this article, we have arbitrarily grouped the MRI techniques in two. The first group comprises of conventional (routine, widely available) sequences, such as T1W; fluid sensitive (T2W, fat suppressed T2W / Proton density, Short Tau Inversion Recovery (STIR); and T1W images following IV Gadolinium. Anatomical sequences such as T1W images (spin echo and gradient echo) show exquisite detail and allow accurate assessment of the extent of the lesion based on the replacement of expected epiphyseal fatty tissue. Fluid sensitive sequences are very sensitive to detect areas of hyperintensity due to edema and fluid signal within the majority of tumor and tumor-like conditions of the epiphysis [6]. High quality fat suppression is critical for demonstration of pathology. STIR provides homogenous fat suppression, however, better signal to noise ratio may be achieved with SPAIR (Spectral-Adiabatic Inversion Recovery, Siemens, Erlangen, Germany). In addition, three dimensional sequence such as STIR SPACE (Sampling Perfection with Application-optimized Contrasts by using varying flip angle Evolutions, Siemens, Erlangen, Germany) provides isotropic voxel resolution with high contrast on 3 T scanners within acceptable imaging times of 5–6 min. Dixon type fat suppression generates superior quality fat suppression images but there is added time penalty to the sequence. IV Gadolinium is helpful as different enhancement patterns (intense rim enhancement of infections, heterogeneous enhancement of tumors, peripheral enhancement of geode, or lack of enhancement in inactive lesions) help in narrowing the differential [7]. Post contrast T1 weighted imaging is usually acquired with fat suppression in a 2D or 3D fashion. IV Gadolinium also allows depiction of small areas of tumor involvement which might be otherwise missed. While using subtraction imaging, fat suppression may not be required for contrast imaging. Dynamic contrast enhancement (DCE) is useful in assessing treatment response in tumors,, evaluation of the

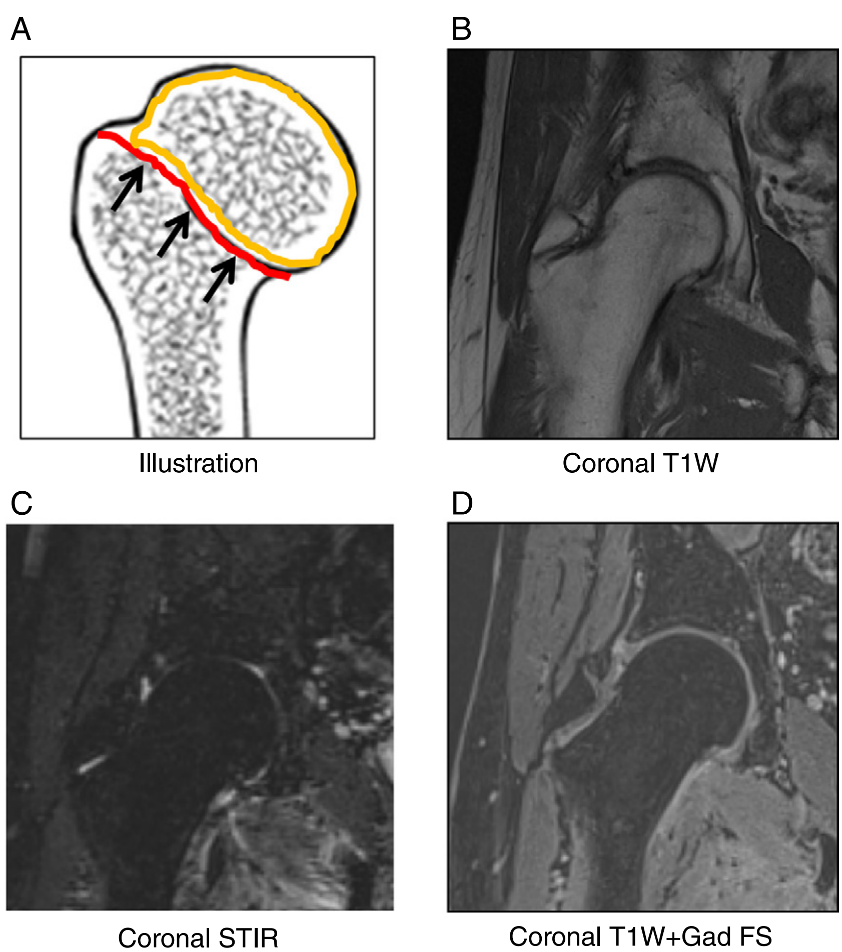

Fig. 1. Normal Epiphysis — MRI appearance on conventional techniques. (A) Illustration shows the physeal scar (red line and arrows) and epiphysis; the rounded end of a long bone, beyond the physeal scar (outlined between golden yellow line). (B) Coronal T1-weighted image shows a normal epiphysis contains mostly fatty marrow. (C) Coronal STIR image does not show any abnormal high signal. (D) Coronal T1-weighted image with fat saturation after IV Gadolinium does not show any abnormal enhancement.