Introduction

Musculoskeletal tumors are a rare and diverse group. Sarcomas of the bone and cartilage comprise only 0.5% of all malignancies in humans. Their incidence is considerably higher in children than adults. The incidence of soft tissue sarcomas is 3 to 4 times higher and the majority of these cases are seen after the fifth decade. Benign bone and soft tissue tumors are 100 times more common than malignant tumors, with an overall incidence of 300 per 100,000 population. As the survival of patients with carcinomas is gradually extending, presentation with bone metastases will also rise ***(Onder et al., 2010)***.

Magnetic resonance (MR) imaging plays a vital role in the characterization of musculoskeletal lesions, particularly in defining their composition, extent, compartmental involvement and relationship to the adjacent viscera and neurovasculature***(Frassica et al., 2000)***.

Conventional MR imaging relies primarily on a qualitative interpretation of variations in the T1 and T2 relaxation properties of normal and pathologic tissue. However, there is considerable overlap in the signal characteristics of neoplasms (both benign and malignant) and

non-neoplastic reactive or inflammatory lesions. Furthermore, it is often difficult to distinguish hyperintense tumor from reactive peritumoral edema with fluid-sensitive sequences ***(White et al., 2005)***.

Consequently, contrast material enhancement characteristics are a key component of the conventional MR imaging assessment of masses in terms of differentiating solid tumors from cysts, delineating mass margins, and defining the amount of tumor necrosis***(Verstraete and Lang, 2000)***.

However, contrast material administration requires intravenous access, is relatively contraindicated in pregnant patients, and may be prohibited by an allergy to contrast material or by poor or deteriorating renal function due to the risk of nephrogenic system fibrosis***(Perez et al.,2009)***.

Diffusion-weighted (DW) imaging is a functional magnetic resonance (MR) imaging technique that can readily be incorporated into a routine non–contrast material–enhanced MR imaging protocol with little additional scanning time. DW imaging is based on changes in the Brownian motion of water molecules caused by tissue microstructure. The apparent diffusion coefficient (ADC) is a

quantitative measure of Brownian movement: Low ADC values typically reflect highly cellular microenvironments in which diffusion is restricted by the presence of cell membranes, whereas acellular regions allow free diffusion and result in elevated ADC values ***(Subhawong et al., 2014)***.

Thus, with ADC mapping, one may derive useful quantitative information regarding the cellularity of a musculoskeletal lesion using a non-enhanced technique. The role of localized DW imaging in differentiating malignant from benign osseous and soft-tissue lesions is still evolving; when carefully applied, however, this modality has proved helpful in a subset of tumor types, such as non-myxoid soft tissue tumors. Studies of the use of DW imaging in assessing the treatment response of both osseous and soft-tissue tumors have shown that higher ADC values correlate with better response to cytotoxic therapy ***(Subhawong et al., 2014)***.

Aim of work

Evaluation of the role of diffusion weighted MR imaging for characterization of musculoskeletal tumors.

Anatomy

Skeletal System

The skeleton contains two subgroups, the axial skeleton and the appendicular skeleton. The axial skeleton incorporates the bones of the skull (cranium), vertebral segment, ribs, and sternum, though the appendicular skeleton incorporates the bones of the upper and lower appendages **(Fig. 1)** ***(Drake et al., 2015)***.

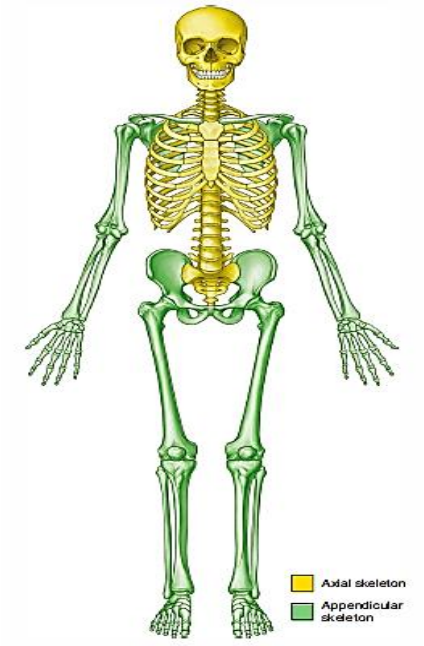

Figure (1): The axial skeleton and the appendicular skeleton ***(Drake et al., 2015)***.

The skeletal system includes cartilage and bone***(Drake et al., 2015)***.

Cartilage

Cartilage is an avascular connective tissue comprising of extracellular filaments installed in a framework which contains cells in little pits ***(O'Rahilly et. al., 2004)***.

The sum and kind of extracellular filaments in the grid changes relying upon the sort of cartilage. In substantial weight bearing territories or regions inclined to pulling powers, the measure of collagen is expanded and the cartilage is practically inextensible. Conversely, in ranges where weight bearing requests and stress are less, cartilage contains elastic fibers and less collagen fibers***(Yücel, 2012)***.

The functions of cartilage are to:

- Giving backing to delicate tissues,
- Provide a smooth, coasting surface for bone explanations at joints, and
- Allow the development and advancement of long bones to occur ***(Drake et al., 2015)***.

There are three sorts of cartilage:

- Hyaline-most common; lattice contains a moderate amount of collagen fibers (e.g. , articular surfaces of bones) **(Fig. 2)**;
- Elastic-lattice contains collagen fibers with a countless elastic fibers (e.g. , external ear) **(Fig. 2)** ;
- Fibrocartilage-lattice contains a set number of cells and ground substance with a significant measure of collagen fibers (e.g., intervertebral discs) **(Fig. 3)** ***(Garg, 2009)***.

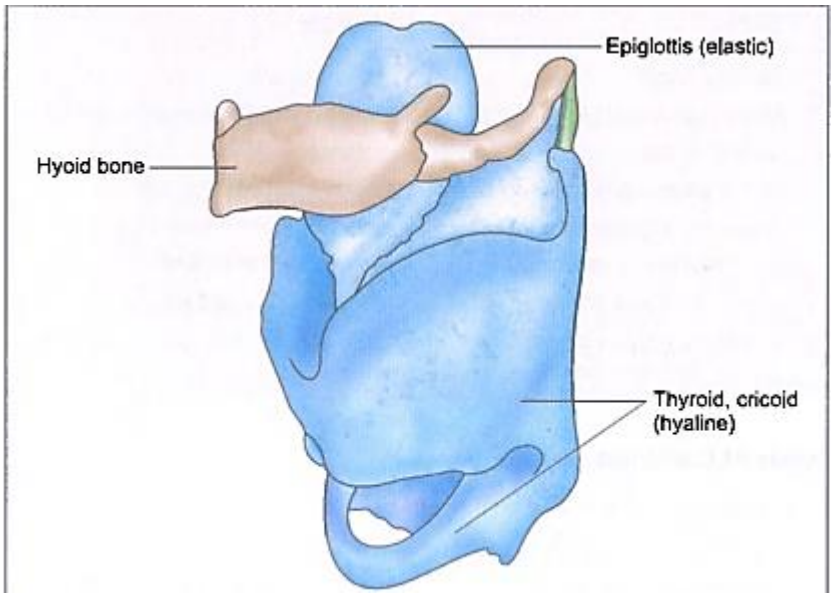

Figure (2): Hyaline and elastic cartilages ***(Garg, 2009)***

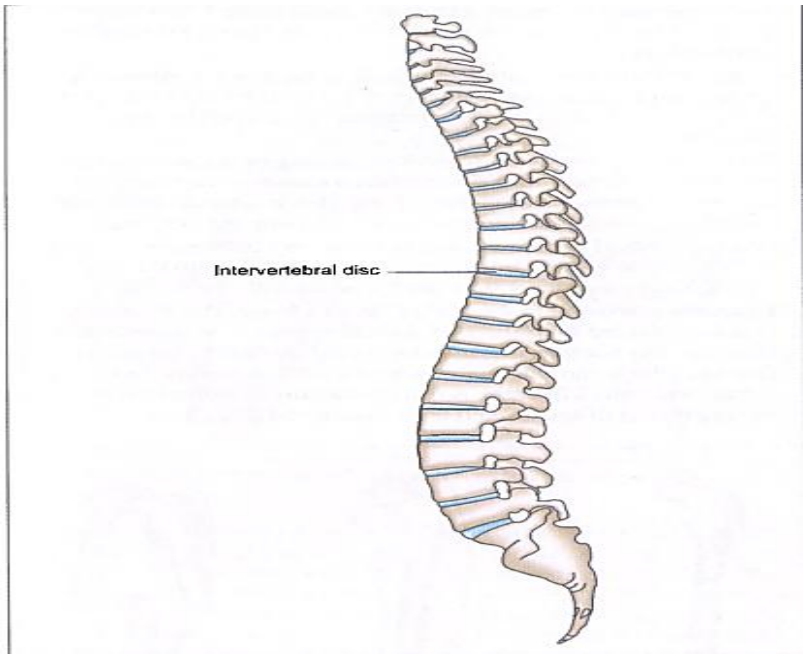

Figure (3): Fibrocartilage: Intervertebral disc ***(Garg, 2009)***.

Cartilage is nourished by dispersion and has no blood vessels, lymphatics, or nerves***(Drake et al., 2015)***.

Bone

Bone is a calcified, living, connective tissue that makes most of the skeleton. It comprises of an intercellular calcified matrix, which also has collagen fibers, and several types of cells within the matrix***(Yücel, 2012)***.

Bones works as:

1. Bones give shape and support to the body, and resist any forms of stress.

2. These provide surface for the attachment of muscles, tendons, ligaments, etc.
3. These serve as levers for muscular actions.
4. The skull, vertebral column and thoracic cage protect brain, spinal cord and thoracic viscera, respectively.
5. Bone marrow manufactures blood cells.
6. Bones store 97% of the body calcium and phosphorus.
7. Bone marrow contains reticuloendothelial cells which are phagocytic in nature and take part in immune responses of the body.
8. The larger paranasal air sinuses affect the timber of the voice ***(Garg, 2009)***.

There are two sorts of bone, compact and spongy (trabecular or cancellous) ***(Yücel, 2012)***.

Compact bone is dense bone that structures the external shell of all bones and encompasses spongy bone. Spongy bone comprises of spicules of bone enclosing cavities containing blood-forming cells (marrow)***(Drake et al., 2015)***.

Classification of bones is by shape

1. Long bones: Each long bone has an elongated shaft (diaphysis) and two expanded ends (epiphyses) which are smooth and articular. The shaft typically has 3 surfaces separated by 3 borders, a central medullary cavity, and a nutrient foramen directed away from the growing end. Examples:

   (a) Typical long bones like humerus, radius, ulna, femur, tibia and fibula;

   (b) Miniature long bones have only one epiphysis like metacarpals, metatarsals and phalanges; and

   (c) Modified long bones have no medullary cavity like clavicle **(Fig. 4)**.

2. Short bones: Their shape is usually cuboid, cuneiform, trapezoid, or scaphoid. Examples: tarsal and carpal bones **(Fig. 5)**.

3. Flat bones resemble shallow plates and form boundaries of certain body cavities. Examples: bones in the vault of the skull, ribs, sternum and scapula**(Fig. 6)**.

4. Irregular bones: Examples: vertebra, hip bone, and bones in the base of the skull**(Fig. 7)**.

5. Pneumatic bones: Certain irregular bones contain large air spaces lined by epithelium Examples: maxilla, sphenoid, ethmoid, etc. They make the skull light in weight, help in resonance of voice, and act as air conditioning chambers for the inspired air**(Fig. 8)**.

6. Sesamoid bones: These are bony nodules found embedded in the tendons or joint capsules. They have no periosteum and ossify after birth. They are related to an articular or nonarticular bony surface, and the surfaces of contact are covered with hyaline cartilage and lubricated by a bursa or synovial membrane. Examples: patella, pisiform, fabella, etc.**(Fig. 9)**.

Functions of the sesamoid bones are:

(a) To resist pressure;

(b) to minimise friction;

(c) to alter the direction of pull of the muscle; and

(d) to maintain the local circulation.

7. Accessory (supernumerary) bones are not always present. These may occur as ununited epiphyses developed from extra centers of ossification. Examples: sutural bones, ostrigonum (lateral tubercle of talus), os vesalianum

(tuberosity of 5th metatarsal), etc. In medico-legal practice, accessory bones may be mistaken for fractures. However, these are often bilateral, and have smooth surfaces without any callus.

8. Heterotopic bones: Bones sometimes develop in soft tissues. Horse riders develop bones in adductor muscles (rider's bones) ***(Garg, 2009)***.

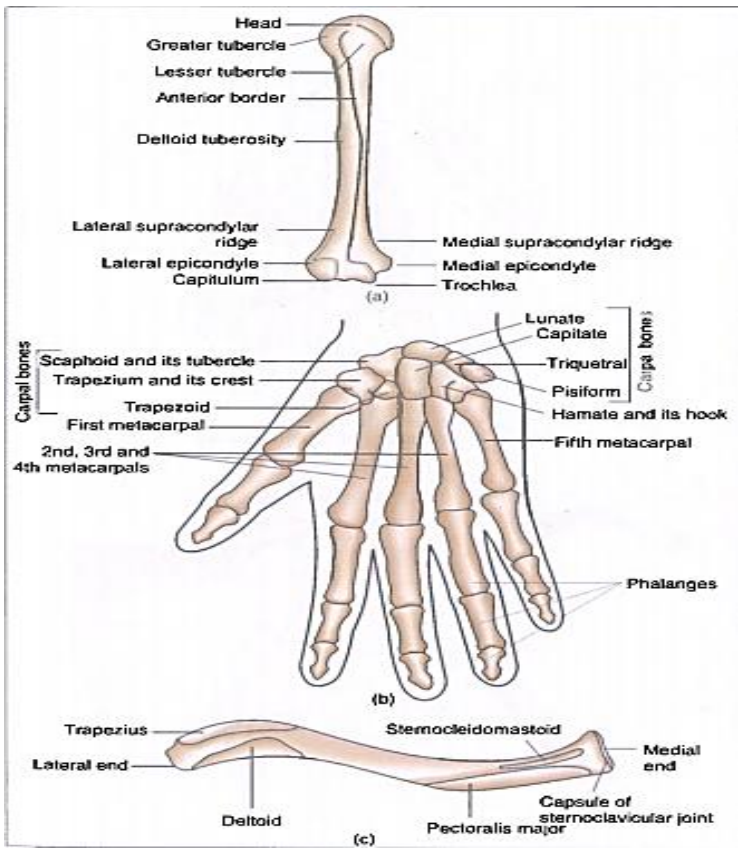

Figure (4): Long bones: (a) Humerus, (b) Metacarpals, (c) Clavicle ***(Garg, 2009)***

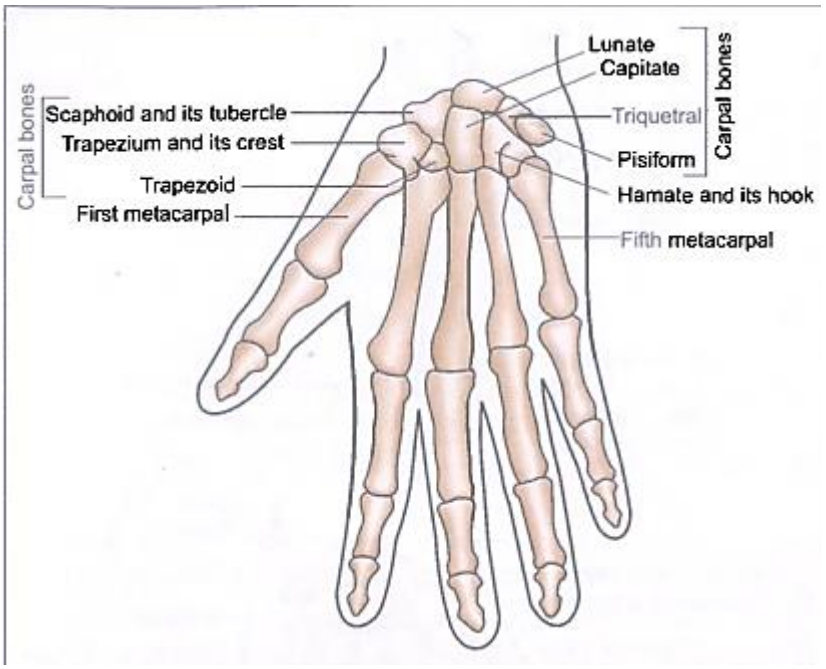

Figure (5): Small bones: Carpal bone ***(Garg, 2009)***.

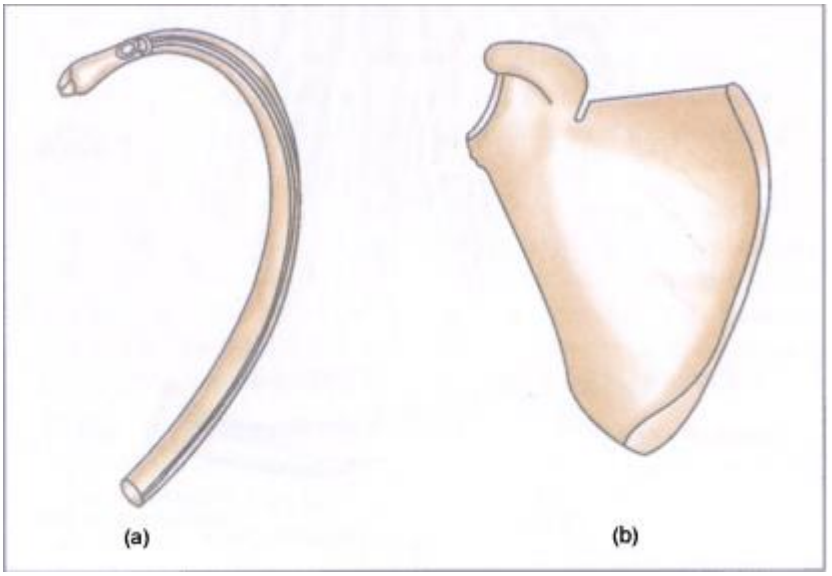

Figure (6): Flat bones: (a) Rib, (b) Scapula ***(Garg, 2009)***.