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Basic Radiology Concepts for the Athletic Trainer

Number of Contact Hours: 1

Description

An ATC must understand the basics of radiology. This paper will discuss the growth and development of bone, radiographic evaluation of bone and joints, types of radiology, and common characteristics of pathologies in athletics.

List of Objectives

1. The participant will be able to list and describe the ABC's of radiographic evaluation.
2. The participant will be able to list and describe the different types of basic radiology.
3. The participant will be able to describe the basics of bone growth and development.

Outline

I. Introduction
II. Growth and Development of Bone
    a. Anatomy
    b. Terms
    c. Wolff's Law
III. Radiographic Evaluation of Bone and Joints
    a. Alignment
    b. Bone Density
    c. Cartilage Spaces
    d. Soft Tissue
IV. Types of Radiology
V. Characteristics of Common Radiology Pathologies in Athletics
VI. Conclusion

Basic Radiology Concepts of the Athletic Trainer

Introduction

Radiology is often an important part of being a Certified Athletic Trainer (ATC).
It is necessary to understand the basics of radiology in order to communicate as an ATC with supporting staff members. This paper will discuss the components of growth and development of bone, radiographic evaluation of bone and joints, the different types of radiology, and characteristics of common radiology pathologies in athletes.

Growth and Development of Bone Anatomy

There are 206 bones in the skeletal system. All of these bones are different shapes and sizes, from short to long bones, flat to irregular bones, sesamiod bones, and accessory bones. The bone structure can be seen as both an anatomic structure and as a physiologic organ. As an anatomic structure, the bone provides, “the architectural framework that protects the vital organs, serves as a leverage system for muscles, and allows for functional movement.” When viewing bone as a physiologic organ, it “stores reserves of calcium, phosphorus, magnesium, and sodium and contains the marrow that produces erythrocytes, granular leukocytes and platelets.” (McKinnis, 1997).

The structure of bone exsists in two main forms, compact and spongy. The cortex or outer shell of the bone is formed by dense compact bone. There is also a tubular space inside the bone termed the medullary or morrow cavity (McKinnis, 1997).

Terms

There are several other terms related to the anatomy of the bone that becomes important when examining the growth and development of the bone. The periosteum is, “a specialized dense fibrous tissue, containing blood vessels, nerves, and lymthatic’s, which envelopes the cortex.” The endosteum is what, “lines the inner aspect of the cortex and medullary cavity.” Both of these tissues have a part in the maturing skeleton and in response to fracture healing. Finally, the three terms, diaphysis, metaphysic, and epiphysis, refer to the shaft, flared expanse, and the end of the bone. (McKinnis, 1997).

Bone ossification, or replacement of cartilage by calcified bone, takes place at both primary and secondary centers of ossification. The primary centers are located in the centers of newly developing bone and advances outward. The secondary centers are located at the cartilaginous ends or epiphysis of the bone (McKinnis, 1997).

As longitudinal bone growth occurs, do does remodeling of the bone. The epiphysis moves further away from the shaft, while the metaphysic is remodeled by depositing bone on one surface and reabsorbing bone on another surface. A growing child has a positive bone balance because bone deposition exceeds bone resorption. In the adult years, there is a negative bone balance because bone deposition is not as great as bone resorption. However, throughout life there is constant remodeling at different levels as both destruction and regeneration take place (McKinnis,1997).

Wolff’s Law

Wolff’s Law is the term used to refer to the bone remodeling as it relates to function, Julius Wolfe in 1892 described this as, “Every change in the form and the function of bones, or in their function alone, is followed by certain definite change in their internal architecture, and equally definite changes in their external conformation, in accordance with mathematical laws,” (McKinnis, 1997). Basically, this is translated that bone deposited in sites subjected to stress. The bone cells will then align to most efficiently withstand the stress.

This is important in the athletic population in two ways. First, bone hypertrophy can occur in athletes. This is a result of weight-bearing forces or the forces of tension from muscles and other soft tissues that athletes endue. The reverse is also true when bone atrophy develops. This occurs when there is a lack of physical stress and results in bone resorption. Often this happens after long periods of bed rest or inactivity, for example, following surgery (McKinnis, 1997).

Radiographic Evaluation of Bones and Joints

A systematic approach to the radiographic evaluation of bones and joints exist in the form of ABC's. This acronym stands for alignment, Bone density, Cartilage spaces, and Soft tissues (Daffner, 1993 & Swain, 1994). The analysis of the alignment includes the evaluation of several different parts. First, the gross normal size and appearance of the anatomic form should be assessed. For example, any gross enlargements, extra hones, congenial anomalies, or the absence of any bones should be noted. Any development or congenital deformities (including scoliosis or genu valgum) should also be noticed. Secondly, the general contour of the bone should be assessed for normal shape and contour. The cortical outline of the bone should be smooth and continuous. Any bones spurs, contical fractures, or sharp angles on the cortex, should also be assessed. Another area to look for includes the sites for attachment of muscles, tendons, and ligaments. This is important in cases of trauma, like an avulsion fracture. Any past surgical making sites should also be documented (McKinnis, 1997).

Thirdly, the alignment f the bone and how it related to adjusted bone should be assessed. A normal alignment of bone indicates that the position of the bone is disrupted by a fracture, or by joint subluxation or dislocation. Trauma is the most common cause of abnormal alignment, in this case a fracture and/or dislocation alters the normal bone and joint relationships. Other causes for abnormal alignment include any of the inflammatory arthritis or degenerative joint diseases that erode articular cartilage and promote joint laxity (McKinnis, 1997).

The evaluation of bone density includes examining the general bone density, texture abnormalities, and local bone density. The normal bone density is seen when there is a sufficient amount of radiographic contrast between the skeleton and the surrounding soft tissues. If there is a loss of contrast between the bone and soft tissues, then a loss of bone mass is indicated. Texture abnormalities should be noted. If the mineralization of one is altered, so is the appearance of the trabeculae. An altered appearance of the trabeculae in the bone is often a good indicator of the disease process occurring. Local bone density can also be compromised with an injury. As mentioned earlier, normal local increases in bone density are seen in areas in increased stress. However, an increase in bone density can also indicate injury. The healing site of a fracture is often callused as new bone is remodeled. Another reason for an increase in bone density could be the bone attempting to block off a diseased area, such as a tumor or infection (McKinnis, 1997).

The evaluation of the cartilage spaces includes the joint spaces width, subchondral bursa, and two ephihpseal plates. Due to their watery density, the articular cartilages of joints are not seen well on plain x-rays. Often, cartilages and discs are analyzed by examining the space or spaces they occupy. If a joint space is described as well preserved, then the cartilage or disc is of normal thickness. If a joint space is decreased, then the catilege or disc is thinning due to degenerative processes. The subchondral bone should also be evaluated when examining cartilage space. If there subchondral is abnormal, it could indicate osteoarthristis, cysts, other inflammatory arthritides or other pathologies. The epiphyseal plates can also be examined. This pertains more to a growing child because the plates are cartilaginous. It is recommended to look at the size of the epiphyseal plate in relation to skeletal maturity and chronologic age (McKinnis, 1997).

The last part f the systematic approach to evaluation is soft tissue. Muscles should be assessed. If a muscle shows significant wasting, primary muscle disease, paralysis, or disuse, atrophy secondary to trauma could be present. IF muscles are swollen, inflammation, edema, hemorrhage, or a tumor could be present. Absence or displacement of a fat line from normal position in the soft tissues could indicate swelling or some type of abnormality. If a joint capsule is visible, there could also be a problem, specifically effusion. Also, the perosteum becomes evident when there are abnormal conditions. Finally, any gas, calcifications, or foreign bodies in the soft tissues and surrounding areas may indicate trauma to the area (McKinnis, 1997).

Evaluation of bones, joints and other structures may include several other basic pieces of information. First, to identify tissue, it is necessary to examine the radiographic density of the images. Air shows up as black and is the least radio-dense substance in the human body. Air is present in the lungs, stomach, and digestive tract and is the black surrounding background of many radiographs. Fat shows up as gray-black and is more radiodense than air. Thus, fat can be seen subcutaneously, along muscle sheaths, and surrounding organs. Substances that are water-based show up as gray because they are more radiodense then fat. These structures include blood, muscle, cartilage, tendons, ligaments, nerves and fluid-filled organs. Bone happens to be the most radiodense substance that occurs naturally in the human body. Due to their high calcium content, the teeth are the whitest of

all the bones. Finally, there are two additional substances which are often used but are not naturally made in the body. A contrast media such as barium sulfate (used in upper and lower gastrointestinal studies) show up as a bright white outline. This bright white outline contrasts to the normal radiodensity of bone. Also, heavy metals show up as white. Examples of heavy metals include teeth fillings, prosthetic devises used in total joint replacements, and pins or wires used for fracture fixation.

Types of Radiology

There are many different and advanced types of radiology. The following will discuss common types of radiology and possible types that ATC's will have contact with. A plain film x-ray is used to identify any fractures and dislocations. Serious disease included infections and neoplasms may also be ruled out with a plain x-ray. A procedure which shows the disruption of the soft tissue and loose bodies in the joint is known as arthrography. This process includes visually studying a joint by x-ray following injection of an opaque dye, air, or both dye and air. Arthroscopy is used in surgery by orthopedics. This procedure is more accurate than arthrography but much more invasive. It requires anesthesia and a small incision into the joint space. However, a surgeon can complete repairs and removal of loose bodies during the process, when examining the spinal cord, a type of radiology that is used includes myelography. Again an opaque dye is used and is placed in the spinal canal. Conditions such as tumors, nerve root compression, and dish disease may be detected with this technique (Arnheim, 2006).

ACT scan, a bone scan, and an MRI are more common tests that an athletic trainer may come into contact with. Computed Tomography (CT) or what ATC's know as a CT scan is a common test that athletic trainers may see. A CT scan allows an image to be viewed from multiple views or from many angles. This produces a cross-sectional view of the tissues. Issues including bone lesions with inflammation and stress fractures are often detected with a bone scan. A bone scan also includes introducing a radioactive dye into the body (Arnheim, 2006). Areas of bone that are undergoing remodeling will appear up as darkened spots on the image. However, some caution must be used with a bone scan because it can produce a false positive test in some endurance athletes (Starkey, 2002). Magnetic resonance imaging (MRI) is expensive but is often a test of choice by physicians because it produces a clearer image than a CT scan. Electromagnetic fields are used to create different images of the body structure (Arnheim, 2006).

An echocardiogram is a more specific test and uses ultrasound to record internal cardiac structures. An arteriogram can be used for almost any blood vessel. With this procedure, a contrast material is injected into a specific blood vessel and radiographs are taken. Finally, Doppler ultrasonography can assist in examining the blood flow in the major insufficiency, or even blood flow caused by narrowing of vessels (Arnheim, 2006).

Characteristics of Common Pathologies in Athletics

There are common pathologies that are seen in athletics. Below are two of them and characteristics of each one.

Fracture
Fracture refers to a, "traumatic injury to a bone in which the continuity of the tissue is broken," (Mosby, 1994). The bone involved the part of the bone, and the nature of the break assist in clarifying the fracture. Fractures on plain x-rays films require multiple views, at least two views. Seven elements are identified that should be included when a complete radiographic evaluation is done.

These seven elements include:

1. The anatomic site and extent of the fracture.
2. The type of fracture, whether complete or incomplete.
3. The alignment of the fracture fragments.
4. The direction of the fracture line.
5. The presence of special features of the fracture, such as impaction or avulsion.
6. The presence of associated abnormalities; such as joint dislocations.
7. The special types of fractures that may occur as a result of abnormal stresses or secondary to pathologic processes in the bone, such as stress fractures or pathologic fractures. (McKinnis, 1997)

The anatomic site extent of the fracture must be referenced. There are several ways that this can be accomplished. The location can be referenced by the proximal, middle, or distal third of the bones shaft. Also, any bone can be stated by standard anatomical landmarks or parts. The type of fracture should be included. The fracture can be complete in which all cortices of the bone have been broken. The fracture can also be incomplete where there is only one portion of the cortex disrupted. Incomplete fractures are often stable and without added stress will maintain their position. The alignment of the fracture refers to the, “relationship of the longitudinal axis of one fragment to the other,” (McKinnis, 1997). Fragments that are fractured are in alignment when the longitudinal axis of both fragments line up together.

The direction of the fracture is also important. Fracture lines can be transverse, oblique, spiral, or longitudinal. If a fracture is transverse, the fracture occurs at the right angle to the bone. An oblique fracture is oblique to the axis. A spiral fracture forms a spiral on the long axis of the bone. If a fracture is longitudinal, then it is parallel or almost parallel to the shaft of the bone. Fracture can also have a special feature such as impaction or avulsion. Impaction is when one piece or fragment of bone is driven into another piece or fragment of bone. An avulsion fracture is when a piece of bone is pulled away as a result of muscle contraction or the resistance of a ligament. Abnormities associated with fractures, including subluxations and dislocations, should be examined. Finally, fractures due to abnormal stresses should also be taken into special consideration. For example, a stress fracture occurs because of repetitive trauma to normal bone (McKinnis, 1997).

Tumor

Tumor refers to a “mass of autonomous growth” (McKinnis, 1997). Tumors are classified as either benign or malignant. Benign tumors are normally not recurrent or progressive. However, malignant tumors are progressive. Classification of tumors is often by their tissue of origin. Several radiographic techniques which assist in making a radiological diagnosis are as follows. Some tumors affect specific bones or specific sites on individual bones and this may assist with diagnosis. The type of border of the tumor also can help differentiate between slow-growing and fast growing tumors. A slow growing tumor is usually benign and has a narrow zone around it. A fast-growing tumor, usually malignant, has a wider zone around it. The extension into the soft tissue surrounding the tumor is a good indication of a benign or malignant tumor. A benign tumor, generally, does not exhibit extension into the soft tissue. A malignant tumor, however, is usually aggressive and extends into the soft tissue. The type of bone destruction that occurs is also helpful with the tumor. Benign tumors exhibit sharp borders of destruction. Malignant tumors exhibit a moth-eaten appearance or poorly defined borders (McKinnis, 1997; Taber’s, 2001).

Conclusion

In summary, radiology is an area that athletic trainers should be familiar with. This is important when communicating with team physicians, parents, couches, physical therapists, and other athletic trainers. As noted above, it is necessary for athletic trainers to understand the basics of radiology as well as to know what to look for when using radiographic testing.

Take the Quiz Below.

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Basic Radiology Concepts for the Athletic Trainer

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19. A B C D
20. A B C D

Mark Answers Above.

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Quiz

1. Which of the following is a type of radiology used to examine the spinal cord?

   a. Arteriogram
   b. Myelography
   c. Arthrography
   d. Ultrasound

2. Which of the following is not a part of the systematic approach to evaluation?

   a. Alignment
   b. Bone density
   c. Soft tissue
   d. Transparent structures

3. What is the correct term for the shaft of the bone?

   a. epiphysis
   b. metaphysic
   c. diaphysis
   d. endosteum

4. What is the term for the end of the bone?

   a. epiphysis
   b. metaphysic
   c. diaphysis
   d. endosteum

5. What is the most common cause of abnormal alignment of bone?
   a. pressure
   b. overuse
   c. fatigue
   d. trauma

6. What color does bone show up as on an x-ray?
   a. black
   b. gray
   c. white
   d. gray-black
7. What color does air show up as on an x-ray?
   a. black
   b. gray
   c. white
   d. gray-black

8. Which of the following radiographic tests is often the preferred test of physicians?
    a. arteriogram
    b. MRI
    c. Ultrasound
    d. CT scan

9. An adult has a positive bone balance?
    a. True
    b. False

10. What do blood and nerves show up as on an x-ray?
    a. black
    b. gray
    c. white
    d. gray-black

11. A bone scan may produce a false positive test in some endurance athletes.
    a. True
    b. False

12. Which of the following show up as a bright white outline on a radiographic test?
    a. bone
    b. tendons
    c. contrast media
    d. air

13. Which type of fracture occurs when the fracture forms a right angle to the bone?
    a. spiral
    b. oblique
    c. longitudinal
    d. transverse

14. The healing site of a fracture is often callused as new bone is remodeled.
    a. True
    b. False

15. A slow-growing tumor, usually malignant, has a wider zone around it.
    a. True
    b. False

16. Cartilage happens to be the most radiodense substance that occurs naturally in the human body.
    a. True
    b. False

17. Plain x-ray films only require one view.
    a. True
    b. False

18. the evaluation of the cartilage spaces include the following except:
    a. epiphyseal plates
    b. subchondral bursa
    c. surrounding edges
    d. joint space width

19. What makes teeth the whitest bone in the body when viewed on a radiographic test?
    a. calcium
    b. phosphorus
    c. magnesium
    d. sodium

20. Which of the following tests show the disruption of the soft tissue and loose bodies in the joint?
    a. MRI
    b. Arthrograph
    c. Arteriogram
    d. CT scan

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