Chapter 42: Orthopaedics: Skeletal Growth and Physiology

SKELETAL GROWTH AND PHYSIOLOGY

The skeletal system is initially formed as cartilage with the exception of the craniofacial bones and clavicle. These bones do not have a cartilaginous analogue and are formed directly from membranous tissue. The process of bone formation without an intermediate cartilage form is called *intramembranous bone formation*. The majority of an adult's bone is formed by intramembranous bone formation because diaphyseal bone grows circumferentially by the apposition of bone by the surrounding periosteum without cartilage being produced. *Enchondral ossifications* is the formation of bone through the initial formation of a cartilage model that then becomes bone. The skeletal system is formed in utero as cartilage; however, prior to birth, some of these prebone structures are well on their way to bone formation. This happens first in the *middle of the diaphysis*, known as the primary center of ossification. Later, at the secondary ossification center, bone will begin to form at the ends of the prebone structures. The secondary center of ossification has articular cartilage surrounding it on the side facing the joint and epiphyseal cartilage on the side facing the primary ossification center. The bone grows in length through the epiphyseal growth plate, which produces cartilage that undergoes enchondral ossification (Fig. 42-1).

The epiphyseal growth plate is made up of proliferating cartilage cells that eventually die. After the cartilage cells die, osteoblasts line the calcified cartilage matrix previously produced by the chondrocytes, thus forming bone. The epiphyseal growth plate is divided into zones. The number of zones often varies in the literature dependent upon the author; however, a general consensus specifies five zones. The first zone is the resting or reserve zone, followed by the proliferative zone, the maturation zone, the degeneration zone, and the zone of calcification. The zones of maturation, degeneration, and calcification are often referred to as the *hypertrophic zone*. The initial bone formed consists of spicules of bone with a calcified cartilaginous core and is called the *primary spongiosa*. The calcified cartilage will be removed entirely as the bone continues to remodel. The area of the bone with the primary spongiosa is called the *metaphysis*. This bone remodels to become the narrower diaphysis (Fig. 42-2). The initial bone formed during this process is referred to as *woven bone*. This bone is unorganized both grossly and microscopically. As it remodels and matures, it becomes *lamellar bone*. It can be either cortical bone with a blood supply and a Haversian system, or trabecular bone, which does not have a Haversian system (Fig. 42-3).

Bone is produced by osteoblasts, which become osteocytes once they are trapped within a matrix of bone. Osteoclasts are multinucleated cells that have the capability of resorbing bone. Osteoblast and osteocytes are recognized under the microscope by the matrix they produce. Chondrocytes are cells responsible for making cartilage and live within the cartilage matrix. (Use of the term chondroblast for the cartilage-producing cells lining a surface of cartilage production is appropriate, but rarely used.)

Bone remodels constantly, primarily under the influence of a mechanical load. During the first 30 years of life, a person's overall skeletal mass perpetually increases; however, after 30 years of age, overall skeletal mass decreases, with women experiencing a period of accelerated loss just

after menopause (Fig. 42-4). The more bone an individual has acquired by age 30, the less likely she or he are to develop osteoporosis.

Osteoporosis is defined as a loss of bone per unit of volume. A more strict definition is bone with a bone mineral density (BMD) as measured by a dual-energy x-ray absorptiometry (DEXA) scan of more than 2.5 below the norm. The norm is based on a series of bone mineral density analyses done on healthy women who were at the peak bone mass. *Osteomalacia* (disorder in adults) and rickets (disorder in children) are the inadequate mineralization of bone. *Osteopenia* is the term used to describe the radiographic appearance of a bone with less density than expected. Osteoporosis should be prevented by having young persons, especially women, take adequate amounts of calcium and vitamin D, as well as exercise to build their skeletal system to its maximum. Osteomalacia is treated by restoring a normal calcium metabolism. Abnormal calcium metabolism may be caused by a congenital disorder, dietary abnormalities, gastrointestinal disorders, by-pass surgery, parathyroid dysfunction, or renal disease.

Chapter 42: Orthopaedics: Spine Disorders: Low Back Pain

Low Back Pain

Pain in the lumbar area and buttock is one of the most common complaints heard in medicine. The majority of adults will have at least one episode of low back pain during their life, and many adults have recurrent episodes.Most instances of low back pain will not have a specific diagnosis and the cause is generally muscular strain and spasm. More significant abnormalities need to be excluded when a patient with low back pain is evaluated. The most important spinal diagnosis to exclude is a neoplasia; however it is also the least likely cause. Patients with aortic aneurysms and pancreatic cancer can present with low back pain and these diagnoses must be considered. Degenerative arthritis is a more common cause of low back pain, but a delay in making this diagnosis is not significant. Herniated disc with nerve compression is a relatively common cause of back pain associated with leg pain and should be recognized from the patient's history and physical examination.

The initial evaluation includes the taking of a history to determine how the pain started, how long it has persisted, how severe it is, what makes it worse, and what makes it better. The abdomen should be examined. The patient's back is examined for tenderness, masses, muscular spasm, alignment, and motion. A neurologic examination should be done and a rectal examination is recommended. If no abnormalities are noted, except decreased motion and muscular spasm, the patient can be treated with a few days of rest and mild pain medication. If pain persists, a more complete evaluation is indicated.

Patients with a herniated disc without compression of a nerve root do not need specific treatment. They present with low back pain and virtually all will improve with nonoperative care. Those with compression of a nerve root will have pain that is distributed in the dermatome of the compressed nerve root (Fig. 42-73). The patient usually has a positive straight-leg-raise test. Initially, nonoperative treatment is recommended, and most patients will have relief. Those with persistent pain or recurrent pain should undergo disc removal.

Discitis is an infection of the disc. This is not uncommon is children but is unusual in adults unless they are immunosuppressed or IV drug users. These patients will have unremitting back

pain. On a radiograph there will be a loss of disc height; however, this may not be apparent until sometime after the patient has sought medical treatment.

Degenerative arthritis occurs in the elderly, and typically can be managed with physical therapy and anti-inflammatory medication. Some patients will develop spinal stenosis as a result of compromise of the spinal canal. These patients may require decompression.

Another common cause of back pain, although usually seen more in the mid-back than in the lower back, is a compression fracture. Most compression fractures occur in osteoporotic bone and are caused by minimal trauma (Fig. 42-74). Compression fractures can occur in patients with normal bone and are usually caused by significant trauma. However, the most common scenario is an elderly female who complains of acute onset back pain after a minor fall or automobile accident. There will be anterior wedging of a mid-thoracic vertebra. These patients are treated nonoperatively, usually with an extension brace.