Chapter 5

The Skeletal System: Osseous Tissue and Skeletal Structure

PowerPoint® Lecture Slides
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Introduction

- The skeletal system is made up of the skeleton and the cartilages, ligaments, and other connective tissues that stabilize them.

- Bone tissue, or osseous tissue, is the major component of the skeletal system.

- Bones are dynamic organs made up of several tissues types.
The skeletal system has a variety of functions:

- **Support**—bones are the body’s infrastructure
- **Storage of minerals**—calcium salts, 98% of the body’s calcium is in the bones
- **Blood cell production**—the bone marrow produced new blood cells
- **Protection**—many delicate organs are surrounded by bone
- **Leverage**—muscles pull on bone to produce movement
Structure of Bone

- Bone (or osseous tissue)
  - Supporting connective tissues
    - Specialized cells
    - Solid matrix containing calcium salts
  - Outer covering called **periosteum**
    - Continuous with the deep fascia
  - Inner cellular lining called the **endosteum**
Structure of Bone

- The Histological Organization of Mature Bone
  - The matrix
    - 2/3 calcium phosphate
      - Hydroxyapatite crystals
        - very resistant to compression
  - Collagen fibers
    - 1/3 of the bone matrix.
      - Very resistant to stretch
  - Collagen and hydroxyapatite make bone tissue extremely strong.
  - Cells = about 2–3% of bone tissue
Structure of Bone

- **The Cells of Mature Bone**
  - **Osteocytes** = mature cells
    - Maintain bone tissue
  - **Osteoblasts** = immature, active cells
    - Found on inner and outer surfaces of bones
    - Osteoblasts produce osteoid
    - The process of making new bone is called osteogenesis.
  - **Osteoprogenitor cells**
    - Found on inner and outer surfaces of bones
    - Divide and differentiate to form new osteoblasts
  - **Osteoclasts** are giant multinucleated cells
    - Perform osteolysis
**Figure 5.1a  Histological Structure of a Typical Bone**

Osteocyte: Mature bone cell that maintains the bone matrix

Osteoblast: Immature bone cell that secretes organic components of matrix

Osteoprogenitor cell: Stem cell whose divisions produce osteoblasts

Osteoclast: Multinucleate cell that secretes acids and enzymes to dissolve bone matrix

(a) Cells of bone
Figure 5.1b  Histological Structure of a Typical Bone
Structure of Bone

Figure 5.1c  Histological Structure of a Typical Bone
Figure 5.1d  Histological Structure of a Typical Bone
Structure of Bone

- **Compact and Spongy Bone**
  - Same matrix composition but different three-dimensional arrangement of osteocytes, canaliculi, and lamellae
  - Compact bone is dense and solid; its basic functional unit is the osteon
  - Spongy bone forms an open network of struts and plates (trabeculae)
Figure 5.2  The Internal Organization in Representative Bones

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Structure of Bone

- Functional Differences between Compact and Spongy Bone
  - Epiphyses, or ends
  - The diaphysis, or shaft
  - The metaphysis
    - connecting region between the epiphyses and diaphysis
Figure 5.3a  Anatomy of a Representative Bone
Structure of Bone

Figure 5.3b,c  Anatomy of a Representative Bone
Structure of Bone

- The **periosteum** serves several functions:
  - It isolates and protects the bone from surrounding tissues.
  - It provides a route and a place for attachment for circulatory and nervous supply.
  - It actively participates in bone growth and repair.
  - It attaches the bone to the connective tissue network of the deep fascia.
Figure 5.4  Anatomy and Histology of the Periosteum and Endosteum

(b) The endosteum is an incomplete cellular layer containing osteoblasts, osteoprogenitor cells, and osteoclasts.
Bone Development and Growth

- Before six weeks of development the skeleton is cartilage.

- **Osteogenesis** is bone formation.
  - Ossification is bone replacing existing tissue

- **Calcification** is the process of depositing calcium salts into tissues.
Bone Development and Growth

Figure 5.5  Histology of Intramembranous Ossification

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Figure 5.6 Fetal Intramembranous and Endochondral Ossification
Figure 5.7  Anatomical and Histological Organization of Endochondral Ossification
Endochondral Ossification

Step 5: Capillaries and osteoblasts migrate into the epiphyses, creating secondary ossification centers.

Step 6: Soon the epiphyses are filled with spongy bone. An articular cartilage remains exposed to the joint cavity; over time it will be reduced to a thin superficial layer. At each metaphysis, an epiphyseal cartilage separates the epiphysis from the diaphysis.
Bone Development and Growth

Figure 5.8 Epiphyseal Cartilages and Lines

(a) Hand of a Young Child

(b) Hand of an Adult
(b) Appositional growth and remodeling

Figure 5.9 Appositional Bone Growth
Figure 5.10  Circulatory Supply to a Mature Bone
Bone Development and Growth

- **Factors Regulating Bone Growth**
  - **Ions**
    - Calcium, phosphate, magnesium, citrate, carbonate, sodium
  - **Vitamins**
    - Vitamins A and C
    - Vitamin D derivatives
Factors Regulating Bone Growth

- *Parathyroid hormone* (PTH) acts to increase the overall availability of calcium ions in the blood.
  - Increased osteoclast activity is the direct result of PTH levels.

- *Calcitonin* is the antagonist of PTH.

- *Growth hormone* and *thyroxine* increase osteoblast activity leading to bone growth.

- *Sex hormones* increase bone growth dramatically during puberty.
**Figure 5.11 Fracture Repair**

**STEP 1**
Immediately after the fracture, extensive bleeding occurs. Over a period of several hours, a large blood clot, or fracture hematoma, develops.

**STEP 2**
An internal callus forms as a network of spongy bone unites the inner edges, and an external callus of cartilage and bone stabilizes the outer edges.

**STEP 3**
The cartilage of the external callus has been replaced by bone, and struts of spongy bone now unite the broken ends. Fragments of dead bone and the areas of bone closest to the break have been removed and replaced.

**STEP 4**
A swelling initially marks the location of the fracture. Over time, this region will be remodeled, and little evidence of the fracture will remain.
Figure 5.12 The Effects of Osteoporosis

(a) Normal spongy bone  (b) Spongy bone in osteoporosis
Anatomy of Skeletal Elements

Figure 5.13  Shapes of Bones

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Figure 5.14a,d  Examples of Bone Markings (Surface Features)
Figure 5.14b  Examples of Bone Markings (Surface Features)
Anatomy of Skeletal Elements

Figure 5.14c  Examples of Bone Markings (Surface Features)
Figure 5.14e  Examples of Bone Markings (Surface Features)
### TABLE 5.1 Common Bone Marking Terminology

<table>
<thead>
<tr>
<th>General Description</th>
<th>Anatomical Term</th>
<th>Definition and Example (See Figure 5.14)</th>
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<tbody>
<tr>
<td>Elevations and projections (general)</td>
<td>Process</td>
<td>Any projection or bump (b)</td>
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<td></td>
<td>Ramus</td>
<td>An extension of a bone making an angle to the rest of the structure (b, e)</td>
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<td>Processes formed where tendons or ligaments attach</td>
<td>Trochanter</td>
<td>A large, rough projection (a)</td>
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<tr>
<td></td>
<td>Tuberosity</td>
<td>A rough projection (a)</td>
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<tr>
<td></td>
<td>Tubercle</td>
<td>A small, rounded projection (a, d)</td>
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<tr>
<td></td>
<td>Crest</td>
<td>A prominent ridge (e)</td>
</tr>
<tr>
<td></td>
<td>Line</td>
<td>A low ridge (e)</td>
</tr>
<tr>
<td></td>
<td>Spine</td>
<td>A pointed process (e)</td>
</tr>
<tr>
<td>Processes formed for articulation with adjacent bones</td>
<td>Head</td>
<td>The expanded articular end of an epiphysis, often separated from the shaft by a narrower neck (a, d)</td>
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<tr>
<td></td>
<td>Neck</td>
<td>A narrower connection between the epiphysis and diaphysis (a, d)</td>
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<tr>
<td></td>
<td>Condyle</td>
<td>A smooth, rounded articular process (a, d)</td>
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<tr>
<td></td>
<td>Trochlea</td>
<td>A smooth, grooved articular process shaped like a pulley (d)</td>
</tr>
<tr>
<td></td>
<td>Facet</td>
<td>A small, flat articular surface (a)</td>
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<tr>
<td>Depressions</td>
<td>Fossa</td>
<td>A shallow depression (d, c)</td>
</tr>
<tr>
<td></td>
<td>Sulcus</td>
<td>A narrow groove (d)</td>
</tr>
<tr>
<td>Openings</td>
<td>Foramen</td>
<td>A rounded passageway for blood vessels and/or nerves (b, e)</td>
</tr>
<tr>
<td></td>
<td>Fissure</td>
<td>An elongated cleft (b)</td>
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<tr>
<td></td>
<td>Meatus or canal</td>
<td>A passageway through the substance of a bone (c)</td>
</tr>
<tr>
<td></td>
<td>Sinus or antrum</td>
<td>A chamber within a bone, normally filled with air (c)</td>
</tr>
</tbody>
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A Classification of Fractures

A Peri's fracture occurs at the ankle and affects both the tibia and the fibula.

Comminuted fractures, such as this fracture of the femur, shatter the affected area into a multitude of bony fragments.

Transverse fractures, such as this fracture of the ulna, break a bone across its long axis.

Spiral fractures, such as this fracture of the tibia, are produced by twisting stresses that spread along the length of the bone.

Displaced fractures, such as this malleolar fracture, produce new and abnormal bone arrangements; no displaced fractures retain the normal alignment of the bones or fragments.

A Colles' fracture, a break in the distal portion of the radius, is typically the result of reaching out to cushion a fall.

In a green-stick fracture, such as this fracture of the radius, only one side of the shaft is broken, and the other is bent. This type generally occurs in children, whose long bones have yet to ossify fully.

Epiphyseal fractures, such as this fracture of the femur, tend to occur where the bone matrix is undergoing calcification and chondrocytes are dying. A clean transverse fracture along this line generally heals well. Unless carefully treated, fractures between the epiphysis and the epiphyseal cartilage can permanently stop growth at this site.

Compression fractures occur in vertebrae subjected to extreme stresses, as when you land on your seat in a fall. They are more common when bones are weakened by osteoporosis.
Integration with Other Systems

- The skeletal system is closely linked to other body systems.
- The skeletal system is a reservoir for calcium, phosphate, and other minerals.