MUSCULO-SKELETAL SYSTEM - 1

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BONES AND JOINTS

RESPONSE TO MECHANICAL FORCES AND INJURY

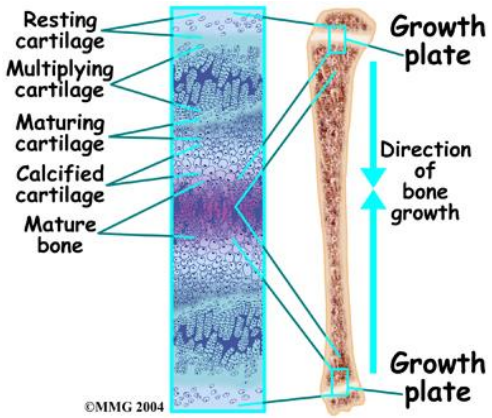
- The cells of bone tissue are capable of the same basic cellular responses as most other tissues, including *atrophy, hypertrophy, hyperplasia, metaplasia, neoplasia, degeneration, and necrosis.*
- Bones have an excellent capacity for repair or modification in response to a wide range of injurious stimuli or changes in mechanical demand.
- Depending on the stimulus, the response may be localized or generalized
- in general, the magnitude of skeletal response is greater in young growing animals than in adults.
- If the response is generalized, it is likely to be most prominent at sites of rapid bone growth or modeling.

Mechanical forces as Stress

- Bone adapts or remodels in response to the mechanical demands placed upon it.
- In young individuals, increased mechanical stress on the skeleton increases the density of metaphyseal trabecular bone and the thickness of cortices.
- Increased mechanical usage in adults does not lead to an increase in bone mass,
- Decreased activity accelerates bone loss
  - Reduced mechanical stress on bones due to partial or complete immobilization, as occurs during fracture repair, leads to increased resorption, resulting in decreased bone strength and stiffness.

Growth plate damage

- In young growing animals, the growth plate is the weakest structure in the ends of long bones and is prone to traumatic injury
- In general, *the fastest growing growth plates are the most susceptible to injury*
- Growth plates of major limb bones, particularly the distal radius and ulna, are also susceptible to crushing injuries
- *When the lesion is confined to one side of the growth plate, as it often is, continued growth on the other side leads to* angular limb deformity.



http://www.orthopediatrics.com/docs/Guides/blounts.html

Periosteal damage

- *Periosteal damage due to trauma stimulates rapid formation of new or* **reactive bone** following activation and proliferation of osteoblasts.
- *Localized outgrowths of new bone beneath the periosteum are referred to as* **exostoses**

Fracture repair

- *Bone fractures are very common in animals*
- occur either when a bone is subjected to a mechanical force beyond that to withstand, or when there is an *underlying disease process that has reduced its normal breaking strength.*
  - The localized bone disease (e.g., neoplasia) or a generalized disorder (e.g., osteoporosis) should be considered if bone fracture occur without trauma.

Types of fractures

- Fractures are classified as simple, if there is a clean break separating the bone into two parts,
- comminuted , if several fragments of bone exist at the fracture site.
- When one segment of bone is driven into another the fracture is referred to as an impacted
- When there is a break in the overlying skin, usually due to penetration by a sharp fragment of bone, the fracture is referred to as compound .
- If there has been minimal separation between the fractured bone ends, and the **periosteum remains intact**, the lesion is classified as a greenstick fracture.
- An avulsion fracture occurs when there is **excessive trauma** at sites of **ligamentous** or **tendinous** insertions and a fragment of bone is torn away.

Process of fracture repair

- bone is capable of repair by regeneration
- successful repair of a fracture can return the bone both to its original shape and strength.
- The process of fracture repair follows a consistent pattern, but can be influenced by factors, such as infection or the presence of an underlying bone disease.
- The initial event in uncomplicated fracture repair is *the formation of a hematoma* between the bone ends.
- With disruption of the blood supply, *ischemic necrosis of bone* and other tissues in the vicinity of the fracture is inevitable.
- An *acute inflammatory response* is triggered by mediators released from the hematoma and from necrotic tissues.

- Neutrophils and macrophages are the first cells to arrive
- mesenchymal cells from the medullary cavity, endosteum, and periosteum rapidly proliferate in and around the hematoma, forming a **callus** consisting initially of loose connective tissue.
- Sub-periosteal new bone formation commences on the bone surface adjacent to the bone ends
- primitive mesenchymal cells in the fracture gap differentiate into **chondroblasts** and replace the loose connective tissue with chondroid matrix.
- **osteoclasts** appear and start to remove the dead bone.
- **Osteoblasts** producing new bone in the medullary callus are seen as early as 24 hours after fracture.
- Evidence suggests that some of these osteoblasts are derived from transformed endothelial cells from capillaries and small venules in the vicinity of the fracture.

- The **early callus**, consisting predominantly of hyaline cartilage, forms very rapidly
- As revascularization of the fracture site occurs, endochondral ossification (Bony callus) within the callus occur
- *The **final phase*** may take several months, or even years, and *involves the replacement of woven bone in the callus with **mature lamellar bone**,*
- modeling of the callus to eventually restore the bone to its original shape is the final step.
- Modeling of the callus is more rapid in young animals than in adults and is more likely to result in complete resolution.

SKELETAL DYSPLASIAS

- A variety of genetic abnormalities primarily affecting bone formation or remodeling have been reported.
- collectively known as **skeletal dysplasias** and are *usually associated with short stature, abnormal shaped bones, and/or increased bone fragility.*

Osteogenesis imperfect

- is inherited connective tissue disorders that *occurs rarely in domestic animals.*
- The disease is characterized by ***excessive bone fragility,*** which in severe cases may result in
  - multiple intrauterine fractures,
  - marked skeletal deformity,
  - either stillbirth or perinatal death.
- Milder forms may be in-apparent at birth but lead to an increased incidence of postnatal fractures and bowing of the limbs.

Osteopetrosis (marble bone disease),

- is a group of rare disorders characterized by *defective osteoclastic bone resorption and the accumulation of primary spongiosa in marrow cavities.*
- In cattle, is inherited as an *autosomal recessive trait.*
- Clinically, calves show brachygnathia inferior, impacted molar teeth and protruding tongue
- The long bones are shorter than normal and easily fractured.

METABOLIC BONE DISEASES

- Metabolic bone diseases, also referred to as **osteodystrophies,** are the result of disturbed bone growth, modeling, or remodeling due to either nutritional or hormonal imbalances.
- Genetic defects involving specific enzymes or receptors critical to the activity of hormones or cells participating in bone formation are also reported
- Metabolic bone diseases are traditionally classified as
  - **osteoporosis.**
  - **rickets,**
  - **osteomalacia,**
  - **fibrous osteodystrophy,**
- *All they can occur in combination in the same individual.*

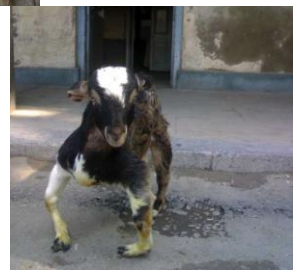
Osteoporosis

- is the most common of the metabolic bone diseases
- There is reduction in the quantity of bone, the quality is normal.
- Is an imbalance between bone formation and resorption in favor of the latter,
- In farmed livestock, there may be an unusually high incidence of fractures in the herd or flock, suggesting increased bone fragility.
- approximately 30-50% of skeletal calcium must be lost before the change can be reliably detected by x-rays
- *Gross lesions* of osteoporosis are generally most marked in bones, or areas of bones, which consist predominantly of ***cancellous bone,***
- Osteoporotic bones are usually light and fragile

- Most cases of osteoporosis in animals, are nutritional in origin and may be due to deficiency of a specific nutrient, such as
  - calcium,
  - phosphorus,
  - copper,
  - starvation,
- **lactational osteoporosis** occurs when rations marginally deficient in calcium, and with normal or excess phosphorus, are fed over extended periods during gestation and/or lactation.
- Osteoporosis is often present in animals with severe **gastrointestinal parasitism,**
- **Disuse osteoporosis** is a loss of bone mass due to muscular inactivity

Rickets and Osteomalacia

- *similar in etiology and pathogenesis, differing only in the **age** at which they occur.*
- **Rickets** is a disease in young animals and is accompanied *by abnormal endochondral ossification at growth plates, in addition to defective bone formation.*
- **Osteomalacia** occurs only in adults
- The pathogenesis of both rickets and osteomalacia involves defective mineralization.
- *most cases in animals result from dietary deficiencies of either vitamin-D or phosphorus.*



Fibrous Osteodystrophy

- is a relatively common metabolic bone disease characterized by extensive bone resorption accompanied by proliferation of fibrous tissue and poorly mineralized, immature bone.
- The pathogenesis involves persistent elevation of plasma PTH
- Primary hyperparathyroidism is usually the result of a functional parathyroid gland adenoma
- Secondary hyperparathyroidism is a more common cause than primary hyperparathyroidism and *may be due to either chronic renal disease or a dietary imbalance of calcium and phosphorus.*
- Impaired glomerular filtration in renal failure leads to progressive hyperphosphatemia due to reduced renal clearance of phosphate.
  - Hypocalcemia develops as a result of the inverse relationship

- Nutritional secondary hyperparathyroidism may be due to a simple dietary deficiency of calcium, excess dietary phosphorus, or to a deficiency of vitamin D.

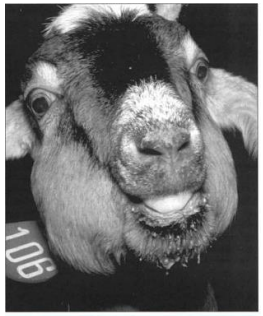


Figure 1.73 Fibrous osteodystrophy, goat. Bilateral swelling of maxillary bones and mandibles.

OSTEONECROSIS (osteosis)

- *It can occur in ischaemia*
- bone ischemia is most often associated with trauma - fractures,
- Ischamia can occurs in many acute inflammatory diseases of bones
- Other causes can be infiltrating neoplasms, thromboembolism and peripheral vasoconstriction in association with ergotism, or chronic anemia.
- Necrotic bone is slowly but progressively resorbed by osteoclasts

INFLAMMATORY DISEASES OF BONES

- inevitably originates in vascular areas of either the medullary cavity (**osteomyelitis)** or the periosteum (**periostitis)**
- **Osteitis** is a more general term for inflammation of bones
- Most inflammatory diseases are caused by bacterial infections, although mycotic and viral agents can also infect bones.
- Noninfectious osteitis also occurs,

Mandibular osteomyelitis

- is primarily a disease of cattle caused by *Actinomyces bovis*,
- In cattle, the disease is known as **actinomycosis** or **"lumpy jaw"** and *the classic lesion is confined to the mandible.*

Actinomycosis or **"lumpy jaw"**

- *The* maxilla is rarely involved
- *A. bovis* is probably an obligate parasite of the oropharyngeal mucosa in a number of animal species,
- *Actinomyces bovis* may invade bone directly though the periosteum, but *osteomyelitis usually develops from periodontitis*, presumably via lymphatics, which drain into the mandibular bone.
- Once in the bone, *A. bovis* causes a chronic, pyogranulomatous inflammatory reaction.
- Suppurative tracts permeate the medullary spaces leading to multiple foci of bone resorption and proliferation.
- Fistulae often extend into the overlying soft tissue and may discharge through the skin or mucous membranes.
- Periosteal proliferation is excessive and the bone may become enormously enlarged

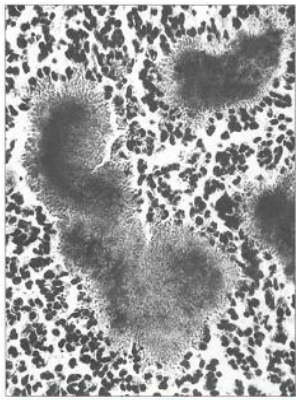


Figure 1.92 Colonies of *Actinomyces bovis* with characteristic club formation. The colonies are surrounded by neutrophils.

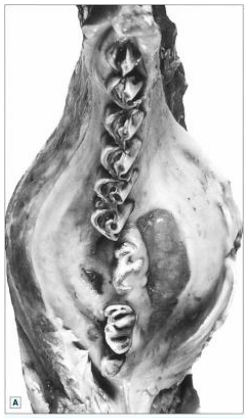


Figure 1.91 Mandibular osteomyelitis, cow. *Actinomyces bovis* infection.

- The **teeth** in the affected portion of the jaw become loosened, lost, or buried in **granulation tissue**.
- On cut surface, the affected mandible has a "**honeycomb**" appearance with reactive bone surrounding pockets of inflammatory tissue
- Fragments of necrotic trabecular bone accumulate in purulent exudate as "**bone sand**."
- The **pus** is also likely to contain many 1-2-mm diameter, soft, light yellow granules referred to as "**sulfur granules**."
- These consist of an internal mass of tangled, gram-positive filaments mixed with some bacillary and coccoid forms, and a periphery consisting of closely packed, club-shaped, gram-negative bodies
- the colonies in actinomycosis are much larger and the clubs are smaller than in **actinobacillosis**.

Mycotic infections of bones

- Mycotic infections of bone are less common but certain pathogenic fungi, in particular the yeasts *Coccidioides immitis, Blastomyces dermatitidis, Cryptococcus neoforrnans,* and *Histoplasma capsulatum* may cause osteomyelitis following inhalation of spores and haematogenous dissemination.

Viral infections of bones

- Several viruses are known to cause distinctive lesions in bones.
- Zones of metaphyseal sclerosis may be associated with *Canine distemper virus* infection and the pestiviruses of **bovine viral diarrhea** and *Classical swine fever*

TUMORS AND TUMOR-LIKE LESIONS OF BONES

Benign tumors
- Chondroma
- Feline osteochondromatosis
- Hemangioma
- Myxoma of the jaw
- Ossifying fibroma
- Osteoma
- Osteochondroma

Tumor-like lesions
- Aneurysmal bone cyst
- Epidermoid cyst of the phalanx
- Exuberant fracture callus
- Fibrous dysplasia
- Solitary (unicameral) bone cyst
- Subchondral (juxtacortical) bone cyst

Malignant tumors
- Central
  1. Chondrosarcoma
  2. Fibrosarcoma
  3. Giant cell tumor of bone
  4. Hemangiosarcoma
  5. Liposarcoma
  6. Multilobular tumor of bone
  7. Osteosarcoma
     a. poorly differentiated
     b. osteoblastic
        – nonproductive
        – productive
     c. chondroblastic
     d. fibroblastic
     e. telangiectatic
     f. giant cell type
- Peripheral
  1. Maxillary fibrosarcoma (dogs)
  2. Parosteal osteosarcoma
  3. Periosteal chondrosarcoma
  4. Periosteal fibrosarcoma
  5. Periosteal osteosarcoma
- Tumors of bone marrow
  1. Malignant lymphoma
  2. Plasma cell myeloma

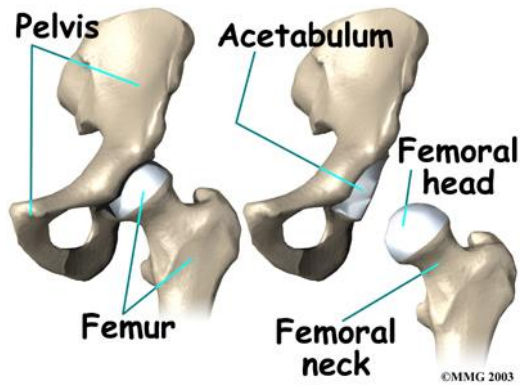
DEVELOPMENTAL DISEASES OF JOINTS

Osteochondrosis

- Occur in many animal species
- Young, fast-growing animals are most susceptible, especially breeds selected for rapid growth.
- It is characterized by multifocal abnormalities in endochondral ossification involving articular-epiphyseal cartilage complexes and growth plates

Hip dysplasia

- Mainly occur in dog breeds
- occasionally reported in cats, cattle, and horses.
- The disease is characterized by a lack of conformity between the femoral head and acetabulum, resulting in **subluxation** and, invariably, **degenerative joint disease**.



DEGENERATIVE DISEASES OF JOINTS

(osteoarthrosis and **degenerative arthropathy**).

- It can be either monoarticular or polyarticular and may be classified as either primary or secondary.

Ringbone

- Degenerative diseases of interphalangeal joints are commonly referred to as *ringbone.*
- *High* or *low* ringbone refers to involvement of the *proximal or distal interphalangeal joints* respectively.
- The *lesions are typically bilateral and primarily involve the forelimbs.*

Bone spavin

- *This is a degenerative disease of the **tarsus** of the **horse** and occasionally the **ox**.*
- Structural changes in this disorder are essentially the same as those occurring in high ringbone.
- The *major lesions develop on the **medial side of the tarsus**,*

Navicular syndrome (navicular disease)

- *This is a degenerative disorder involving the distal half of the flexor surface of the navicular bones of the fore legs of mature horses*

INFLAMMATORY DISEASES OF JOINTS

- Inflammatory diseases of joints are generally referred to as either arthritis or synovitis.

Noninfectious (immune-mediated) arthritis

- Group of inflammatory but noninfectious diseases of joints.
- is typically a polyarthritis and occurs most often in dogs and cats.
- Erosive and non-erosive forms of the disease are recognized.

Rheumatoid arthritis

- In dogs, it typically affects small and toy breeds,
- Affected animals initially have episodes of anorexia, depression, and fever, with generalized or shifting lameness associated with swelling around one or more joints.

- The prominent gross features of early rheumatoid arthritis are thickening and brown discoloration of the **joint capsule**, with hypertrophy and hyperplasia of **synovial villi**
- *deposition of **immune complexes** in articular structures is central to the pathogenesis of rheumatoid arthritis*
- *Local* activation of the **complement cascade** by these immune complexes leads to generation of pro-inflammatory peptides such as **C3a** and **C5a**, which are chemotactic for **neutrophils** and induce their degranulation.
- ***Rheumatoid factors,*** autoantibodies directed against **altered host IgG**, are found in synovial fluid, and sometimes in the serum, of dogs with rheumatoid arthritis.