PATHOLOGY OF JOINTS
NOTES
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TEXTBOOK:

References:
Website: http://people.upei.ca/lopez/
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TYPES OF JOINTS

DEFINITION: Joints or articulations are structures in which two or more bones or cartilages are united (JKP).

Fibrous Joints (Synarthroses): Bones or cartilages united by fibrous tissue. There are three main types of fibrous joints: 1. Sutures (cranial sutures). 2. Syndesmosis (tibia-fibula) and 3. Gomphosis (i.e., tooth-socket)

Cartilaginous (Amphiarthrosis): Bones or cartilages united by hyaline cartilage (i.e., costochondral joints) or fibrocartilage (i.e., pelvic and mandibular symphysis).

Synovial (Diarthrosis / True joints): These types of joint unite two bone ends covered by articular cartilage and all surrounded by a thick articular capsule. Examples of synovial joints are those in the appendicular skeleton and vertebral joints.

Most recently, veterinary histologists simply classify joints as Synovial and Non-Synovial joints.

THE MOST IMPORTANT DISEASES IN DOMESTIC ANIMALS AFFECT THE SYNOVIAL JOINTS

JOINT STRUCTURE AND POSTMORTEM EXAMINATION

- **Articular cartilage:** The surface of a normal joint should be smooth, moist, and glistening with a bluish color. The articular cartilage is formed by type II collagen and proteoglycans, and lacks blood and lymphatic vessels and nerves. It has a poor capacity for regeneration and therefore necrosis of the cartilage (chondromalacia) remains generally unrepaird.

- **Synovial membrane:** It is a thin membrane with discrete villi superficially lined by a continuous layer of highly specialized cells called synoviocytes. There are two main types of synoviocytes: *Synoviocytes type A* have phagocytic activity, while *synoviocytes type B* are responsible for the production of the synovial fluid. Both types of synoviocytes proliferate rapidly in response to injury (reactive hyperplasia). When injury is severe and chronic, synovial villi become elongated and covered with hyperplastic synoviocytes (synovial villous hyperplasia). Hyperplasia is best observed by placing the synovial membrane under water.

- **Synovial fluid:** It is a clear, viscous, colorless or slightly yellow fluid produced by synoviocytes; it has low cellularity and low protein content. Its main functions are to reduce friction (lubricate) and to nourish the articular cartilage. Synovial fluid notably increases in many joint diseases and this is called a synovial effusion. In inflammatory joint diseases the synovial fluid becomes turbid because of an increase in protein content and the presence of leucocytes.

- **Synovial fossae:** These are bilateral depressions not covered by cartilage. The function of synovial fossae is not known but it may be involved in the lubrication of the joint. Not present at birth, synovial fossae appear in the first few months of life. Inexperienced persons may mistake synovial fossae as an articular lesion.

- **Articular Capsule:** This is a thick sack of connective tissue that covers the entire joint and provides additional joint stability. A thin synovial membrane internally lines the articular capsule. In chronic arthritis the articular capsule often becomes thickened due to fibrosis and the deposition of exudate.

- **Ligaments:** These are bands of fibrous tissue connecting joints serving to support and strengthen the joints.
Injury to Articular Cartilage:

**Fibrillation**: It is an early degenerative change of the articular cartilage due to the loss of proteoglycans, the unmasking of collagen fibres and increased water content in chondrocytes. Fibrillation is the equivalent of a superficial erosion of the cartilage. Affected cartilage becomes dull with a yellowish discoulouration taking a characteristic *ground-glass appearance*.

**Eburnation**: This is the complete loss (ulceration) of articular cartilage, which is generally accompanied by a thickening of the subchondral bone (osteosclerosis). Exposed bone surfaces take an ivory-like appearance (hard and polished). It is a permanent lesion since lost cartilage cannot be repaired.

"**Joint Mice**": This is a conventional term used to describe viable and often growing fragments of cartilage and/or bone floating free in synovial fluid. The formation of joint mice occurs when pieces of degenerating cartilage detach from the subchondral bone. Joint mice are commonly seen in degenerative joint diseases particularly in “Osteochondrosis dissecans.”

**Osteophytes**: These are multiple bone outgrowths derived from chondrification of fibrous tissue. Osteophytes are mainly found in the junctions of cartilage with periesteum or along the insertions of synovial capsules to the bone. Osteophyte formation can start as early as three days after injury but are only detected grossly around two weeks and radiographically in five weeks. If the source of injury ceases, osteophytes no longer grow but remain as multiple periarticular spurs of bone causing variable degree of joint deformity. The process of osteophyte formation is known as osteophytosis. It is not a specific lesion and occurs in degenerative and inflammatory joint diseases.

Injury to Synovial Membrane and Articular Capsule

**Villous hyperplasia ( hypertrophy)**: This is a common and but non-specific reaction of synovial membrane to persistent injury. The synovial membrane takes on a "velvety" appearance particularly if immersed in water. This appearance is due to the formation of tongue-like synovial villi covered with hyperplastic synoviocytes. In some chronic cases, particularly in infectious arthritis, there are also aggregates of lymphoplasmacytic cells around the synovial blood vessels. In chronic intra-articular hemorrhage, the synovial membrane takes on a tan color due to the deposition of hemosiderin pigment (pigmented synovitis).

**Capsular Fibrosis**: This is thickening of the capsule due to the proliferation of connective tissue and deposition of exudate.
**Pannus**: Formation of granulation on the synovial membrane or eroded articular cartilage. Granulation tissue often undergoes chondral or osseous metaplasia (osteophytes – joint mice).

"End-stage joint": This is a generic term used to describe several chronic articular changes in the same joint. End-stage joints show various degrees of fibrillation, eburnation, osteophytes, deformation, villous hypertrophy, pannus, capsule fibrosis and occasionally ankylosis (fixation, immobility).

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**Degenerative joint diseases** (Osteoarthrosis or “Osteoarthritis”)

Degenerative joint diseases, common in all domestic animals, are often called osteoarthrosis or osteoarthritis. These conditions are primarily characterized by degenerative changes with almost no inflammation (sterile injury). Because there is no severe inflammatory response, the term osteoarthrosis is perhaps more appropriate than osteoarthritis. Degenerative joint diseases can affect one or many joints and can be symptomatic (pain, malfunction) or a simple incidental finding at necropsy. In general, degenerative joint diseases are chronic conditions eventually leading to end-stage joints and ankylosis. Many forms of degenerative joint diseases have underlying physical (biomechanic) injury to the articular cartilage, often as result of loss of joint stability or repeated trauma. These are only a few of the most common examples of osteoarthrosis in veterinary medicine.
Important Degenerative Joint Diseases affecting the Axial Skeleton

Cervical Vertebral Stenotic Myelopathy in Horses (Cervicospinal arthropathy, equine sensory ataxia, "Wobbler syndrome"). This is an important equine condition characterized by compression of the spinal cord and ataxia. This is a primary degenerative change affecting the vertebral joint that eventually causes narrowing of the vertebral canal and myelomalacia. Clinical signs are incoordination and locomotion disturbances. There are two distinct pathologic syndromes in horses:

1. **Cervical Vertebral Instability** occurs in young horses (8-18 months). During ventroflexion, instability of the cervical vertebral joints (C$_3$-C$_5$) causes a dynamic narrowing of the vertebral canal and compression of the spinal cord. The articular facets of affected vertebrae may show fibrillation, eburnation and osteophyte formation. The pathogenesis is not clear but current literature suggests that rapid growth due to nutrition or genetics are important predisposing factors. A perennial question regarding the pathogenesis is whether the degenerative changes in the vertebral joints cause the instability or the other way around. Regardless, the result is ataxia. Gross diagnosis is difficult and requires examination of the cervical vertebrae and spinal cord compressive myelomalacia.

2. **Cervical Static Stenosis** occurs in older horses (1-4 years) in which, hypertrophy of ligamentum flavum causes dorsal narrowing of the vertebral canal at the C$_5$-C$_7$. This static type of compression of the spinal cord does not require vertebral movement (ventroflexion). The spinal cord also has a compressive myelomalacia. Fibrillation, eburnation, osteophytes in articular facets are often present (secondary lesions?). The pathogenesis of cervical static stenosis is not clearly understood but factors such as hereditary, nutrition, environment, vertebral malformation, articular subluxation have been incriminated.

Cervical spondylomyelopathies. ([Wobbler Syndrome in Dogs](/content), cervical spondylopathy, cervical vertebral instability, caudal cervical vertebral malformation). These are a heterogeneous group of conditions or syndromes with similar pathogenesis to those affecting horses. Cervical spondylomyelopathies are characterized by abnormalities in the cervical vertebrae causing chronic compression, myelomalacia and gait deficits. It is most commonly seen in Dobermans, Great Danes and other large breeds. Male dogs may be more commonly affected. The age of the onset is variable, from weeks to years. Compression and malacia generally occur at C$_6$-C$_7$. Radiography is the most accurate method of diagnosis in the live dog. Gross and histological changes in the spinal cord are typical, however, abnormalities in the vertebrae and joints may be difficult to evaluate during postmortem examination.

Intervertebral Disk Diseases. With the exception of the atlas (C$_1$) and axis (C$_2$), all other vertebral bodies are united by intervertebral disks. These disks have typically an external fibrous ring (annulus fibrosus) and a central soft tissue (nucleus pulposus). There are different types of intervertebral disk diseases in domestic animals.
- **Dorsal Protrusion (prolapse) of Intervertebral Disks** occurs in chondrodystrophoid dogs such as the Dachshund, the Pekingese, and to a lesser extent in other breeds such as Beagle and Cocker Spaniel. The annulus fibrosus degenerates and allows a dorsal protrusion of nucleus pulposus into the spinal canal causing compressive myelomalacia. The degenerated disk material frequently mineralizes. The onset is variable (3-6 years), most frequently affecting the thoracolumbar and to a lesser extent the cervical regions. Longitudinal sections of vertebrae reveal disk material in the spinal canal and localized malacia at the point of compression.

- "**Disk explosion**" is another form of disk disease in which the disk suddenly disintegrates and herniates into the spinal canal. This is due to a severe compressive trauma to the spinal column such as in “hit by car” accidents.

- **Emboli of nucleus pulposus** The third type of intervertebral disk disease is the in the spinal cord. There are no gross lesions but microscopic examination of the spinal cord reveals fibro-cartilaginous material in the spinal arteries or veins. This type of necrotizing myelopathy has been reported in dogs, and to a lesser extent in horses, cats, pigs and humans.

**Ankylosing Spondylitis**: (Spondylitis deformans, ankylosing spondylo-sis(-itis)). This is a chronic degenerative disease affecting the vertebral joints. It is most commonly seen in old bulls (LT), sows (LT) and dogs (TS). Lesions include degeneration of intervertebral disks, periosteal stimulation, osteophyte formation (ventral and lateral vertebral bodies), bridging between vertebrae and finally ankylosis. It has been suggested that abnormal mobility of intervertebral joints is the primary problem.

**Important Degenerative Joint Diseases Affecting the Appendicular Skeleton**

**Hip Dysplasia (Acetabular dysplasia):** It is an important problem in dogs and humans (>females). The canine form affects mainly large and giant breeds and seems to be closely related to genetic (polygenic) and environmental factors such as nutrition and rapid growth. Dogs are normal at birth. In severe cases radiographic changes can be detected as early as seven weeks. It starts with edema and hemorrhage in the teres ligament followed by coxofemoral subluxation. In time, the coxofemoral joint shows fibrillation, eburnation, microfractures of the dorsal acetabular rim (pain), thickening of the capsule, and the formation of osteophytes. In the most advanced cases, the articular surfaces are flat (end-stage joint). The pathogenesis is still controversial. It has been proposed that hip dysplasia is the result of a reduced pelvic muscle mass, which causes instability and abnormal movement of the coxofemoral joint. Another theory suggests that affected dogs have an intrinsic defect in the hip joint which leads to secondary degenerative joint disease.
**Patellar Luxation and Subluxations**: Orthopedic problem seen in dogs (most toy breeds) and sporadically in cats. It is corrected by orthopaedic surgery.

**Arthropathies**: (osteoarthritis, osteoarthrosis). These are a heterogeneous group and nonspecific degenerative joint diseases affecting primarily the appendicular skeleton. Some of arthropathies have specific names and pathogenesis. It is not possible to discuss each, so these are a few examples of the most common forms.

- **Osteochondrosis** (Dyschondroplasia) is a heterogeneous group of degenerative joint disease initiated by an abnormal growth or maturation of cartilage (cartilage dysplasia). It affects the cartilage of the metaphyseal growth plate and the articular epiphyseal cartilage complex of the growing bone. Dogs, pigs, horses, and poultry are the animal species most commonly affected with osteochondrosis. Although changes in the dysplastic cartilage (Dyschondroplasia) are not that spectacular, secondary changes in the joints and bone are readily visible (i.e., eburnation, cartilage collapse, end-stage joint, etc.). The etiology of osteochondrosis is still unclear but genetic, biomechanic, and toxicoses have been proposed. In rapidly growing pigs on some farms, the incidence of osteochondrosis may be close to 100%. Many joints are affected in the same animal. In the most severe cases the entire articular cartilage collapses into the subchondral bone.

- **Osteocheondrosis (itis) dissecans** (OCD) is a specific form of osteochondrosis and it is typically characterized by the separation of a piece of articular cartilage from the subchondral bone. The dissected flap of cartilage generally becomes a joint mouse. OCD is most commonly seen in medium size dogs affecting males more often than females, and involves most frequently shoulders and elbows. OCD is a very important in equine medicine and it is seen in young horses with lameness, the distal tibia being the most commonly affected joint. Equine OCD also affects the hip and shoulder joints.

- **Tibial Dyschondroplasia**: Commonly seen in rapidly growing chickens.

**INFLAMMATORY JOINT DISEASE** (Arthritis and Synovitis)

**INFECTIOUS** (Septic Arthritis):

- Most commonly seen in farm animals, rare in dogs and cats.
- **Pathogenesis**: Hematogenous bacteria, mycoplasmas, Chlamydophila and to a much lesser extent, viruses.
- Secondary to omphalitis, Sepsis, Failure of Passive Transfer of colostrum (FPT)
- Several joints may be involved (polyarthritis) and infections may also involve the serosal surfaces (polyserositis) such as the meningitis, peritonitis pleuritis, pericarditis, endocarditis, or aqueous humour and vitreous body of the eye (hypopyon). Omphalitis is a common cause infectious arthritis in newborn farm animals.
- **Lesions**: Swelling, synovial effusion, exudate in joints (fibrin, purulent)
Most common bacterial isolated from septic arthritis:

- **Arcanobacterium (Actinomyces) pyogenes**: Purulent arthritis in cattle and swine.

- **Erysipelothrix rhusiopathiae**: (Swine > sheep, birds). Acute septicemic erysipelas results in death due to vasculitis and thrombosis (diamond lesions in skin, glomerulitis, and serosal haemorrhages). Survivors may develop the chronic form characterized by arthritis and endocarditis.

- **Escherichia coli**: (Coliform polyarthritis). Seen in newborn calves surviving *E. coli* septicemia / bacteraemia. The port of entry could be the umbilicus, pharynx, or intestine.

- **Streptococcus suis**: Generally seen in pigs 2-10 weeks old. Involves septicaemia with acute death or bacteraemia with subsequent meningitis and polyarthritis.

- **Haemophilus suis** or **Haemophilus parasuis**: Glasser’s disease. Generally occurs after stress in 5-12 week old pigs: polyarthritis and polyserositis.

- **Mycoplasma hyorhinis**: Pigs 3-10 weeks old: slow progressive polyarthritis and polyserositis.

- **Mycoplasma hyosynoviae**: Pigs more than 10 weeks old: slow progressive polyarthritis but no polyserositis.

- **Histophilus somni** (*Haemophilus somnus*): Cattle: septicemia-abortion/pneumonia. Polyarthritis is often seen in animals dying of Thrombotic Meningoencephalitis (TME).

- **Mycoplasma bovis**: Cattle. Pneumonia, septicemia, arthritis.

- **Borrelia burgforferi** (Lyme Disease). Spirochetal infection transmitted by ticks (humans and dogs).

**Routes of Infection in Septic Arthritis:**

- Hematogenous (most common type)
- Spread from soft tissues
- Penetrating wound (skin laceration)
- Extension from osteomyelitis
- Diagnostic techniques (arthrocentesis)

**Viral Arthritis**

- **Caprine arthritis-encephalitis** (CAE): Slow progressive chronic arthritis caused by a retrovirus. The same virus produces respiratory and neurological syndromes. Joint lesions are characterized by a lymphocytic hyperplastic synovitis with the formation of carpal hygromas that are cysts containing sero-sanguinolent or gelatinous fluid found over the anterior carpus.
BURSITIS (Inflammation of Synovial Bursa)

Bursas are cushions filled with synovial-fluid that are strategically located around some tendons vulnerable to friction-injury. Bursas are lined by a synovial membrane and may undergo inflammation in response to injury or hemato-genous infections as synovial joints. These are some important bursitis in domestic animals and the following are just some examples:

- **Fistulous Withers** (T₂) and **Poll Evil** (Atlanto-occipital) are two important forms of equine bursitis affecting the bursas in the supraspinous (T₂) and atlantal (C₁-C₂) joints along the nuchal ligament. These bursas develop pyogranulomatous inflammation and the exudate eventually escapes through the skin (fistula). The etiopathogenesis of these two types of equine bursitis is still unknown, but *Onchocerca cervicalis* (Nematode; family: Filaridae), *Actinomyces bovis* and *Brucella abortus* infections, and trauma have been suggested as predisposing factors.

- **Carpal bursitis** referred also as **carpal hygromas** is found in ruminants with Brucellosis and in goats with Caprine Arthritis-Encephalitis (retrovirus).

### Non-Infectious Arthritis

**Metabolic Arthritis**

**Laminitis**: (inflammation of the hoof laminae)
- Affects horses (Ponies most susceptible) and cattle.
- Acute or chronic.
- The etiopathogenesis is still controversial:
  - Nutritional (grain diets, carbohydrate overload, allergy to feed proteins)?
  - Histamine?
  - Endotoxin?
  - Traumatic?

The basic underlying mechanism in laminitis is reduced vascular perfusion of the lamina (P3). There is congestion, edema, and separation of the laminae in acute cases, and hyperplasia of laminae, rotation of P3, penetration of sole by P3 and osteomyelitis in chronic cases.

**Gout** is a metabolic disease characterized by the deposition of urates in membranes. It is most commonly seen in poultry, reptiles and humans (lack of uricase). There are two distinct forms:

- **Articular gout**: chronic condition of "normal" animals fed large amounts of protein, or chickens with a genetic impairment in kidney to secrete uric acid resulting in deposition of uric acid in synovial capsules.
• **Visceral Gout**: Primary kidney failure resulting in deposition of uric acid in the kidney, heart, and other viscera.

**Immune-Mediated Arthritis**

• **Erosive Arthritis (Rheumatoid-like arthritis)** is a rare but a well-described entity in dogs characterized by lameness, the swelling of joints, anorexia and fever. It generally affects small and toy breed particularly Shetland sheep dogs; there is no sex nor age predilection. The lesions are bilateral, only affecting joints of the appendicular skeleton. The pathogenesis is still poorly understood but involves the formation of IgG/IgM immune complex (rheumatoid factor). There is activation of Complement, leucotaxis, release of lysosomal enzymes and the presence of rheumatoid factor (RF -IgM type) in .25 % of dogs with rheumatoid arthritis. RF is present in a small proportion of normal dogs. Lesions include chronic proliferative lympho-plasmacytic synovitis with pannus formation and fibrosis. Differential diagnosis includes Lupus Erythematosus.

• **Non-erosive arthritis** includes several distinct syndromes of noninfectious and nonerosive arthritis seen in dogs and cats. It is caused by the deposition of immune-complex in the synovial membranes generally associated with chronic diseases involving other organs such as the kidney (glomerulonephritis), heart (heartworm), chronic metritis and otitis, lupus, etc.

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**TUMORS OF BONES AND JOINTS**

Primary skeletal tumors are relatively rare in domestic animals but are most commonly seen in dogs. Neoplastic diseases of the skeleton arise from bone, cartilage, synovial tissue, and with less frequency from connective, vascular or other cell types (i.e., fat, hemopoietic, etc). Like any other tissue, skeletal neoplasia can be benign or malignant.

**Primary Tumors:**

• **Osteoma**: (> horse and cattle). *Tumors vs hamartoma* ?. Osteomas are smooth, solitary, monostotic nodules formed by intramembranous ossification (cancellous > compact) found generally in the skull.

• **Osteochondromas Multiple Cartilaginous Exostoses** are cartilage-capped bony protuberances that stop growing when the rest of the skeleton does. It is still arguable if osteochondromas are multiple polyostotic tumors or dysplasia affecting the growth of cartilages. They are most commonly seen in dogs and horses. Grossly, osteochondromas appear as multiple bony nodules near the growth plates.
- **Chondroma** (enchondroma and enchondroma) is a benign tumor arising from the cartilage. These tumors are most commonly seen in dogs, cats and sheep affecting flat bonea and ribs.

- **Osteosarcoma (Osteogenic Sarcoma)** is the most common skeletal neoplasm of dogs and cats (80% of all tumors). Most commonly found in large breeds with a mean age of 7.5 yr. These tumors arise from osteoid producing cells but some these cells may differentiate into cartilage or connective tissue (osteoblastic, fibroblastic, chondroblastic, or mixed type). Most osteosarcomas involve long bones (See Figure) and to a lesser extent other bones or extra-skeletal sites. Tumors can be osteolytic or osteosclerotic. Osteosarcomas frequently metastasize to other organs, particularly to the lung.

- **Chondrosarcomas** are rare tumors arising from malignant chondrocytes. Tumoral cells produce cartilaginous matrix but never produce osteoid. Chondrosarcomas are most frequently seen in dogs and sheep. The pelvis, nasal cavity, sternum and ribs are some of the most common sites. Microscopically, some neoplastic cells differentiate into chondrocytes.

- **Synovioma and Synovial Sarcoma:** These are rare tumors in domestic animals arising from synovial cells.

**Important:** Tumors of the bone and joints require histopathologic confirmation and decalcification of specimens and biopsies are often required.

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**Glossary (Bones and Joints)**

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<th>Term</th>
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<td>Angular deformity</td>
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<td><em>Arcanobacterium pyogenes</em></td>
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Amelia
Ankylosing spondylo-sis(-itis)
Ankylosis
Annulus fibrosus
Arthritis
Arthrogryposis
Arthropathy
Blastomyces dermatitides
Bone atrophy
Bone matrix
BVD
Calcitonin
Cancellous bone
Caprine arthritis-encephalitis
Cervical Vertebral Stenotic Myelopathy
Cervico-spinal arthropathy
Chondrodyplasia
Chondroma
Chondromalacia
Chondrosarcoma
Coccidioides immitis
Compact bone
Cortical bone
Craniomandibular osteopathy
Cryptococcus neoformans
Degenerative joint disease
Diaphysis
Dimorphic fungi
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End-stage joint
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Myelomalacia
Nucleus pulposus
Odontofluorosis
Onchocerca cervicalis
Ossification centres
Osseous metaphasia
Osteitis
Osteoarthropathy
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Osteochondrosis
Osteoclasts
Osteocytes
Osteodystrophy Fibrosa
Osteofluorosis
Osteogenesis
Osteogenic sarcoma
Osteoid
Osteolytic
Osteoma
Osteomalacia
Osteomyelitis
Osteon
Osteopenia
Osteopetrosis
Osteophytes
Osteoporosis
Osteosarcoma
Pannus
Panosteitis
Parathyroid hormone (PTH)
Periostitis
Peromelia
Phocomelia
Polydactyla
Poll evil
Polyarthritis
Polyserositis
Primary hyperparathyroidism
Primary spongiosa
Protrusion of intervertebral disk
Fibrillation
Fistulous Withers
Glasser's disease
Gout
Growth plate

_Histophilus somni_
_(Haemophilus somnus)_
*Haemophilus suis*
Haversian systems
Hemarthrosis
Hip (Acetabular) Dysplasia
Howship's lacunae
Hyperostosis
Hyperparathyroidism
Hypertrophic (pulmonary)
Hypervitaminosis A
Osteo(arthro)pathy

Intramembranous ossification
Involucrem

Joint effusion
Joint mice

Kyphoscoliosis
Kyphosis

Lamellar bone
Laminitis
Lion jaw
Lordosis
Lumpy jaw

Rheumatoid-like arthritis
Rickets
Ring-bone
_Rhodococcus equi_

Scoliosis
Secondary hyperparathyroidism
Secondary spongiosa
Sequestrum
Spavin
Spondylosis
Spondylosis deformans
_Streptococcus suis_
Syndactyia
Synovial hyperplasia
Synovial Sarcoma
Synovioma
Synovitis
Systemic Mycosis

Toxic Osteodystrophies
Villous hyperplasia (hypertrophy)
Wobbler syndrome
Woven bone

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