Tendons, Ligaments, Joints & the Skeletal System

By Claudia Deffenbaugh

**Tendons - connect Muscle to Bone**

**Tendons** are fibrous cords of connective tissue attaching muscle to bone, cartilage or other muscle. Tendons insert into bone or cartilage by means of small spikes known as ‘Sharpey’s fibres’

There are 2 main types of tendons:

1. Flexor tendons- flex or bend with the leg when leaving the ground
2. Extensor tendons – straighten the leg in mid air to allow or prepare the leg for the next stride.
   - Once the leg is in motion, the tendons slide up and down when the proper Muscles are put in motion by the various nerves.

**Ligaments– connect Bone to Bone**

**Ligaments** help to limit the movement of joints according to their functions; e.g. the fetlock, pastern and coffin joints all have ligaments that allow the joint to move forward and backward only. They are poorly supplied with blood and are very slow to heal after injury and do not withstand prolonged stretching.

They are also rich in nerve endings making injuries here painful for the horse. They are made of bands of white and yellow fibrous tissue, the white being inelastic, and the yellow elastic. There are four different types of ligament:

- **Supporting or suspending** - the Suspensory ligament.
- **Annular** - a broad band of ligament, which directs the pull on a tendon.
- **Inter-osseous** - ties bone together, e.g. the pedal and navicular, canon and splint
- **Funicular** (or cord like) - holds bones together.

3. The main ligament of interest is the suspensory ligament – it acts as a support bandage or brace – preventing the entire fetlock joint from coming to close to the ground. The suspensory ligament is different than other ligaments in that it contains some muscle fiber allowing it to have more “give” at the fetlock joint.

4. The interosseous ligament – joins the splint bones to the canon bones – this is the ligament that becomes ossified (calcified or turns to bone) and appears as a splint

5. Sesmoidean ligaments attach sesmoid bones to long pastern bone

6. Other ligaments of interest Inferior and superior check ligaments and annular ligaments. Check ligaments are linked from bone to tendon and try to prevent the tendon from being overstretched. They “check” the stretch and movement. The annular ligament wraps around the sesmoid bones providing support and protection.
### Tendons and ligaments of the lower leg

<table>
<thead>
<tr>
<th>Tendon or ligament</th>
<th>Origin / where it starts</th>
<th>Insertion point; where it finishes</th>
<th>Action</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Digital Extensor Tendon (CDET)</td>
<td>Common digital extensor muscle</td>
<td>Front of the short pastern bone and the centre of the pedal bone</td>
<td>Lifts the toe, extends bones of the foot.</td>
<td></td>
</tr>
<tr>
<td>Lateral Digital Extensor Tendon (LDET)</td>
<td>Lateral digital extensor muscle</td>
<td>Outside of the long pastern bone</td>
<td>Helps the CDET lift the toe and extend the bones of the foot.</td>
<td></td>
</tr>
<tr>
<td>Deep Digital Flexor Tendon (DDFT)</td>
<td>Deep digital flexor muscle starts at the ulna</td>
<td>Underneath the pedal bone</td>
<td>Flexes the joints of the lower leg, prevents the fetlock from over extending, together with the check ligaments helps with weight bearing.</td>
<td>Passes over the back of the knee, held in place by the check ligament, passes over the sesamoid bones and fans out over the navicular bone.</td>
</tr>
<tr>
<td>Superficial Digital Flexor Tendon (SDFT)</td>
<td>Superficial digital flexor muscle</td>
<td>Back of long and short pastern bones</td>
<td>Flexes the joints of the lower leg, prevents fetlock from over extending &amp; helps with weight bearing.</td>
<td>Passes down the back of the cannon bone covering the DDFT, enclosing it at the fetlock joint forming Annular ligament.</td>
</tr>
</tbody>
</table>
### Tendons and ligaments of the lower leg

<table>
<thead>
<tr>
<th>Ligament</th>
<th>Bottom row of knee bones between splint bones</th>
<th>Divides in two above the fetlock, each branch joins to a sesamoid bone and blends with CDET</th>
<th>Supports and prevents over extension of fetlock joint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspensory Ligament</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inferior Check Ligament</strong></td>
<td>Back of the knee joint</td>
<td>Deep flexor tendon</td>
<td>Prevents strain to flexor tendons, supports the horse whilst sleeping standing up.</td>
</tr>
<tr>
<td><strong>Superior Check Ligament</strong></td>
<td>Above the knee</td>
<td>Superficial flexor tendon</td>
<td>Supports superficial flexor tendon above the knee.</td>
</tr>
<tr>
<td><strong>(Carpal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(Radial)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Equine Stay Apparatus

Equids (horses, asses, and zebras) are the only animals that sleep standing up. According to the Department of Natural Sciences at the Florida Museum of Natural History, the ability to sleep on the hoof evolved as a way to remain ever alert for predators. Being prey animals, equids could flee faster if they napped on their feet rather than on the ground--it took much longer to wake up, get up, and run rather than to just wake up and run. That head start meant the difference between staying alive and becoming a tasty meal. There are two other theories as well: The longer an animal could stand, the more grass he could eat, and lying down to snooze was too difficult for his ever-increasing body size.

- Three features of equine leg anatomy allow horses this advantage. They are the stay apparatus, the reciprocal mechanism, and the locking mechanism of the stifle joint.
- The stay apparatus consists of ligaments and tendons that stabilize all the joints of the forelimb and the lower joints (the fetlock and pastern) of the hind limb. Minimal muscular activity is needed to hold tension on these ligaments and tendons, which in turn prevent flexion of the joints and collapsing of the leg. This allows the horse to balance its weight on its legs almost as if they were legs of a chair.
- The locking mechanism of the stifle (equivalent to the knee) and the reciprocal mechanism together allow the horse to put weight on one hind limb at a time while it rests the other. A horse can lock the stifle joint by lifting and rotating the patella (knee cap) and then releasing it with one patellar ligament hooked over a protuberance of the femur. The patella is thus firmly secured and the joint is locked in an extended or open position. It can be unlocked quickly by reversing the motions that locked it.
- The reciprocal mechanism forces the stifle and hock (the joint below the stifle) to move in unison so that the hock must be extended or flexed when the stifle joint is extended or flexed. Therefore, when the stifle joint is locked by the locking mechanism, the hock is also locked by the reciprocal mechanism.
- The stifle and hock are fully locked only when the horse puts most of its weight on that limb. The other leg rests on the tip of the hoof. This posture can be recognized because the resting hip sags lower than the supporting one, just as a person's relaxed hip sags when all the body weight is put on the one leg. This does take some minimal muscular effort and every few minutes a horse will shift its weight from one leg to the other, alternately resting the other leg.
- So, next time you see a horse standing with its head hanging low, its bottom lip drooping, and one hip sagging and you think it looks like it is napping, it may well be. But give it just a slight provocation and it will be off in a flash.
- The stay apparatus' job is to brace the entire joint system of the forelegs and the pastern and fetlock joints in the hind legs. These fibrous bands take over the muscles' job of straightening the various
joints. They act as drawstrings uniting all the joints together. Their task is passive and no rest is required, unlike muscles, whose tasks are usually active and therefore require rest.

- Modern-day horses possess a biceps tendon that travels from the top of the upper foreleg bone and attaches to the shoulder blade. The tendon is dimpled, which means it can fit over a structure called the intertubercular crest, or INT, in the center of the shoulder blade. This structure, along with the tension exerted by the triceps brachii muscle associated with the elbow, prevents flexion and collapse of the forelimb. The Suspensory ligament supporting the carpus (knee), and the distal sesamoidean ligaments supporting the pastern, prevents overextension of the leg.

- Through studying fossils, researchers were able to pinpoint the time when the stay apparatus evolved. They found that the INT was not present during much of the horse's evolution. Dinohippus (5 million years ago) was the first to show the INT. Two million years later during the Pliocene period, the time of spreading grasslands and development of long-legged grazers, the INT was fully apparent.

- The haunches work a little differently. When the horse puts most of his weight on one leg, the locking mechanism (a function of the stifle) and the reciprocal mechanism team up to allow one hind leg to lock into place, allowing the other leg to rest.

- In the horse, the patella (knee cap) ligament has three parts, not just one like in humans. The quadriceps lifts the patellar ligaments and hooks it onto a big knob on the femur. When the stifle (knee) locks, the reciprocal mechanism, which makes the stifle and the hock move together, causes the hock to lock as well and the entire leg is braced. The other leg can then rest on the tip of the hoof. Although these mechanisms help reduce the amount of energy need for standing, the muscles are still in play, therefore the horse will swap legs every few minutes or so to reduce fatigue.

- The horse's neck lowers during sleep and is supported by the suspensory ligament of the neck (nuchal ligament). This mechanism makes it possible for the horse to sleep while standing.

- The structures involved are:
  - biceps brachii tendons (both origin and insertion)
  - lacertus fibrosis tendon
  - radial carpal extensor tendon
  - common digital extensor tendon
  - serratus ventralis muscle (thoracic portion)
  - triceps muscle (long head)
  - SDFT and superior check ligament
  - DDFT and inferior check ligament
  - suspensory ligament and its branches
  - distal sesamoidean ligaments
SHOULDER:

The biceps brachii tendon originates on the end of the scapula and travels over the intertuberal groove of the humerus. The biceps muscle attaches inside the elbow, but also has a long tendon that joins the extensor carpi radialis muscle, which attaches all the way down to just below the knee. This combination allows the shoulder, elbow, and knee to be “fixed” while standing.

FRONT LEG:

The biceps tendon travels from the top of the upper foreleg bone and attaches to the shoulder blade. The tendon is dimpled to fit over a structure called the intertubercular crest in the center of the shoulder blade. This structure, along with the tension exerted by the triceps brachii muscle, prevents flexion and collapse of the forelimb. The suspensory ligament supporting fetlock and the distal sesamoidean ligaments supporting the pastern prevent overextension of the leg.
HIND LEG:

In the horse the patella (knee cap) ligament has three parts. These ligament parts lift the patella and hook it onto a big knob on the femur. When the stifle (knee) locks, the reciprocal mechanism, which makes the stifle and the hock move together, causes the hock to lock as well and the entire leg is braced.

DR. ROBIN PETERSON ILLUSTRATIONS

Horse Skeleton:
Horse Skeleton:

The skeleton of a horse contains 205 bones.
These bones provide:
- Support or framework of the body
- Levers for the skeletal muscles to attach to
- Protection for delicate organs
- Store for minerals such as Calcium, phosphorus, magnesium
- Production of red and white blood cells in the bone marrow

Bone consists of 30% collagen and 70% bone salts – the combination makes for a structure strong enough to support the horses body, yet flexible enough not to shatter during movement.

The bones:
- Skull – 34 bones
- Vertebral column – 54 bones
  - Cervical – 7 bones (atlas C-1, Axis C-2)
  - Thoracic – 18 bones
  - Lumbar – 5-6 bones
  - Sacrum – 5 bones (fused)
  - Coccygeal (tail) – 18 bones
- Ribs – 36 bones
  - 18 pairs (8 true, 10 false)
- Sternum – 1 bone
- Thoracic limbs (front) 40 (20 each)
  - Scapular cartilage
  - Scapula
  - Humerus
  - Radius
- Ulna
- Carpal bones (7-8) Top: Radial Carpal bone (RC), Intermediate carpal bone (IC), Ulnar Carpal bone (UC), Accessory Carpal bone (AC); bottom: First carpal bone (1C) may be absent, 2\textsuperscript{nd} carpal bone (2C), third carpal bone (3C), fourth carpal bone (4C)

- Metacarpal bones (3) 2 splint bones (2\textsuperscript{nd} and 4\textsuperscript{th} metacarpal) and the canon (3\textsuperscript{rd} metacarpal)
- Proximal sesmoid bones (2)
- Proximal phalanx (P-1, long pastern bone)
- Middle Phalanx (P-2, short pastern bone)
- Distal sesmoid bone (navicular bone)
- Distal phalanx (P-3, pedal bone or coffin bone)

- Pelvic limbs (hind) 40 (20 each)
  - Ilium
  - Pubis \{ Fused to form the hip bone (Os Coxae) \}
  - Ischium
  - Femur
  - Patella
  - Tibia
  - Fibula
Tarsal bones (6) Top to bottom: Calcaneus (C), Talus (T), Central tarsal bone (CT), First and second tarsal bones (fused) (1st and 2nd T), third tarsal bone (3T), fourth tarsal bone (4T)

Metatarsal bones (3) 2 splint bones (2nd and 4th metatarsal) and the canon (3rd metatarsal)

Proximal sesmoid bones (2)

Proximal phalanx (P-1, long pastern bone)

Middle Phalanx (P-2, short pastern bone)

Distal sesmoid bone (navicular bone)

Distal phalanx (P-3, pedal bone or coffin bone)

Axial skeleton = spine, ribs and skull

Appendicular skeleton = limbs

Bones are: Long, Short, Flat or Irregular
- Long: levers for the muscles, support horse when moving, dense, compact, contain bone marrow e.g.: humerus, tibia, femur
- Short: Shock absorbers, less dense and spongy, contain bone marrow eg.: small bones of knee and hock
- Flat: sheets of bone – protect vital organs and enclose cavities eg.: skull, ribs
- Irregular: bones of the vertebral column – protect spinal cord eg: vertebrae

All bones covered by membrane called the periosteum which contains the cells that make and remodel bone according to stresses placed on it.

Cartilage: smooth tough rubber like substance found between moving bones including the vertebrae. Main function is to withstand and spread the forces to which a horse’s bones are subjected over a wide area and to provide relatively frictionless movement between opposing joint surfaces. There are 3 types:
- Hyaline (articular cartilage): compressible, elastic found at the ends of articulating bones e.g.: the end of humerus and radius
- White fibrous cartilage: Strong and tensile found between the vertebrae
- Yellow elastic cartilage: very flexible – epiglottis

*Note: cartilage has no blood supply, lymphatic channels or nerves and is the least dense containing fewer cells than any other structure in the body. So if it damages itself, it is the least able to repair itself and articular cartilage especially tends to scar and form arthritis in response to injury.
Joints: formed when 2 or more bones meet. Vital for the movement of the horse and depend on muscle contraction. 2 categories of joints:

- Moveable (diarthroidal joint) more complex and named by movement they allow; every movable joint has 2 bones which meet to form a junction; each bone end has a layer of articular cartilage to protect against wear; each is enclosed by an inner synovial membrane which secretes synovial fluid (joint oil); and is covered by a sheath of fibrous tissue called the joint capsule which supports the joints, holds the bones in place aided by straps of ligaments.
  - Ball and Socket- wide ranging multidirectional movement – shoulder and hip
  - Hinge – folding movement – elbow, fetlock, pastern, stifle, hock
  - Plane – gliding movement (hinge and plane – Knee)

- Fixed (synarthroidal joint) found in areas that do not need to move eg: the bones of the skull
  - Fibrous – allows almost no movement – the joints of the skull
  - Synchondrosis joint – between the shafts and the ends of the long bones in the skeleton
  - Symphysis or cartilaginous joint- allows some movement and cushioned by a disc of cartilage e.g.: both sides of the pelvis