PART 3

It is All About the Foot:

Connective Tissue

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In this third installment of our educational refresher series re-acquainting you with the basic and advanced anatomy, and physiology of the foot, we will focus the next part of this series on what 'connects' the foot to the body.

The Foot Bone…is Connected to the…Connective Tissue

Thus far, we have covered the bones and articulations of the foot, along with bipedal motion in this series. These are the foundations of what make-ups the foot, but this is not enough. We need to ask now, what makes it come all together? It is time to connect all the previous parts we have discussed with connective tissues.

The human body is a very complex combination of systems that interact with each other to form a unified whole. Missing the use of a muscle or a nerve could easily make one unable to move or walk. Sometimes these deficits can be overcome or at least managed. It is always optimal that everything works together properly.

Engineers of suspension bridges and the design of the human foot have many similarities; taking basic building materials and putting them together in such a manner as to make them work.

Overcoming obstacles such as gravity, force, motion, stress and terrain are tasks any engineer or architect must perform to achieve a positive outcome. Unlike other areas of the body, the foot must accommodate great stresses, operate on various types of terrain, and ought to be both firm and flexible when the situation warrants it. It essentially operates in three planes at once, going up and down, side to side, and in and out simultaneously. Wow, what a job!

To accomplish all this, some would view this as a veritable 'LA rush hour' of perfectly timed maneuvers. With an assortment of muscle, tendon, ligament, and other associated connections present in the foot, everything must work together and simultaneously to perform any of the simple acts of movement that we take for granted in our daily lives, like standing.

Often times our patients complain about a surgeon causing some sort of problem during surgery. All the business we find in the structure and make-up of the foot makes one wonder why there are not more problems. With so many anatomical structures in such tight quarters, it does not allow a surgeon a large margin of error if he is performing foot surgery.

A Basic Overview of Terms and Basic Structures

A muscle contracts, elongates or remains stationary depending on the specific time period in the gait cycle. Muscle is what enables movement. Muscle is controlled by the central nervous system and is a smooth muscle for the most part. It is also a voluntary muscle, meaning that it is controlled by the individual as opposed to the heart which beats with or without our input.

Tendons connect muscle to bone and are elastic in nature. Ligaments are fibrous in nature and are inelastic. When a ligament is stretched beyond its normal capacity, it does not return to its regular size, it must be surgically repaired. This leaves the remaining structure, the connective tissues -- the retinaculae, bursas and hyaline cartilage.

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Retinaculae (pronounced *retinacula*), is a mild fibrous structure that holds tendons and muscles in place, much the same as a wire tie would hold groups of wires from moving about. Bursas are fluid filled sacs that provide cushion to the bundles of tendons over stress areas. **Bursas** are located on each malleolus and under major bundles of tendons. **Hyaline cartilage** encases the end surfaces of bones and are designed to move against each other for smooth movement in articulations. These articulations are encased in a joint capsule filled with **synovial fluid**.

Synovial fluid is viscous and lubricates the hyaline areas. In a person with osteoarthritis, the synovial capsule ruptures, allowing the fluid to escape. Over time, the now non-lubricated hyaline is subject to friction from movement and eventual breakdown into what is known as "bone on bone." One gets a different mental picture after having seen a joint with "bone on bone" involvement. The bone turns a shade of grey and is very porous--it looks like it is cinder block, not a human bone. It looks painful.

A myriad of ligaments join the individual bones together in non-moving articulations. Since ligaments are not elastic, the structure can be fairly rigid where it needs to be. Ligaments alone can hold the bones together into a recognizable, but non-functional foot.

For purposes of this discussion, we will begin with the tib/fib, then cover the foot's plantar, then medial then lateral areas. We start with the calcaneus and move counterclockwise on the foot. It would be most helpful to consult an anatomy atlas to visualize these descriptions.

Tib/Fib

The tibia and fibula with the talus form the ankle mortise. The long bones are held in alignment with **interosseus membranes**, which provide support for the rest of the muscles and various attachments to these bones. Many ligaments hold together the tib/fib to the calcaneus and talus. On the medial side, the **deltoid ligament** joins the tibia to the talus and the calcaneus. The **posterior talofibular** ligament joins the tibia to the fibula and the fibula to the calcaneus. This is located superior to the peroneal tendon.

Plantar Area Ligaments

The ligaments on the plantar exposure look a lot like a freeway ramp–moving from a single ligament and fanning out in several directions. The **long plantar ligament** ties the calcaneus to the four lesser digits. The **short plantar ligament** joins the calcaneus and cuboid and emanates from the long plantar ligament. The **spring ligament** joins the calcaneus to the navicular. Plantar **cuboidionavicular, cunieonavicular and tarsometatarsal** ligaments connect the cuneiforms to the metatarsals.

Medial Area Ligaments

Posteriorcalcaneal ligament joins the posterior superior tuberosity of the talus to the calcaneus. The Spring ligament joins the navicular to the **sustantaculum tali** (ST). **Medial talocalcaneal** joins the ST to the medial inferior posterior process of the talus. The Deltoid ligament has four parts:

1. Posterior tibialtalar--joins the tibia and talus at the posterior process of the talus.
2. Tibia and calcaneus.
3. Tibia and navicular.
4. Anterior tibia to talus.

Metatarsal area ligaments join the metatarsals to the cuneiforms and the cuneiforms to the navicular on both plantar and dorsal areas.

Lateral Ligaments and Tendons

Small ligaments bind the metatarsals together through the cuneiforms, navicular and cuboid. The **bifurcate ligament** joins the calcaneus and navicular in one extension, and the calcaneus and cuboid on the other. **Lateral collateral** ligaments are three in number. **Posterior talofibular**, **calcaneofibular** and **anterior talofibular ligaments**. The talofibular ligaments are anterior and posterior on the bones superior to the talus.

Mercifully, the tendons are fewer in number.

1. **Plantar Tendons:** Starting on the posterior aspect of the foot: the flexor hallucis longus, flexor digitorum longus and brevis, tibialis posterior and anterior, flexor hallucis brevis and longus, fibularis (peroneal) brevis and longus tendons pass. Recall that a longus tendon has its origin outside the foot, and the brevis tendons are completely within the foot (origin and insertion(s).

2. **Medial Tendons:** Tibialis anterior and posterior on the medial side.
3. **Lateral Tendons:** Peroneus longus and brevis, Achilles' tendon. (Actually on both medial and lateral to be precise).

Tendon sheaths provide the transition between the muscle and the insertion point on the bone itself. Retinaculae are discussed above. The ankle area is the chief location for the retinaculae as it is allowing the vertical leg bones to join the horizontal foot.

Muscles of the Foot

In gross anatomy, the student works from the outside of the body inward, not necessarily system by system as it is studied in lecture. We shall continue this outside inward mode here.

Dorsum: With the integument removed, there is little muscle tissue in the dorsal superficial examination of the foot. The tendon sheaths, tendons, and retinaculae take up the majority of the real estate. More muscle is visible once the tendons and retinaculae are removed. Muscles of the dorsum are: peroneus brevis, extensor digitorum brevis, extensor hallucis longus, tibialis anterior, extensor hallucis brevis, abductor digiti minimi and abductor hallucis.

Plantar: The superficial level includes the lateral medial plantar fascia (noted here because of its size and location of holding the muscle tissue in place) , the transverse metatarsal ligaments and the plantar aponeurosis. Many use the term plantar fascia to describe the plantar aponeurosis, where in reality there is more fascia than that.

The first layer of muscle contains the flexor digitorum brevis, abductor hallucis, flexor hallucis brevis, lumbricales, flexor digitorum minimi brevis and abductor digiti minimi. The second layer consists of the quadrates plantae. At this point, the plantar tendons are much more visible.

The third layer consists of the transverse and oblique heads of the adductor hallucis is prominent. The medial and lateral head of the flexor hallucis brevis. Interosseus muscle is located between the metatarsal shafts. They are four in number and are both dorsal and plantar manifestations.

Nomenclature (naming) of these connective structures seems more like a Latin language stew. Fortunately, bones, muscles, tendons, etc., are consistent with the bone or muscle nearest them. For example, the femur and femoral artery are similarly named as they are or are near to the femur. The tibialis posterior muscle ends with the tibialis posterior tendon.

Know one, and you can figure out the rest. Each of these systems must work together and perform their tasks flawlessly for normal ambulation. The toes, and for that matter, the fingers, are a veritable freeway interchange of connective tissues. It takes many connections to achieve motion in more than one plane at a time.