It is All About the Foot:
Basic Skeletal Structure

Part 1

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This year Current Pedorthics is presenting a refresher in foot anatomy and physiology. An entire series of articles spanning the next six to eight issues will re-acquaint you with the basic and advanced anatomy and physiology of the foot. The first area we will discuss is the basic skeletal structure of the foot.

The Foot Bone is connected to the ... Foot Bone

The human foot is a marvel of engineering. This single anatomical part alone is one of the most adaptable structures of the body, providing locomotion and adaptation to ground surfaces, all while operating in all of the three cardinal body planes simultaneously. Knowing what moves, and where it moves, is important to understanding the normal function of the foot.

First, it is good to remember that there are three cardinal planes to the foot: Sagittal, Transverse and Coronal (frontal). In each of these planes, there is also a position and an orientation. With the Sagittal plane, think of it as cutting a line through the middle of the body – front (anterior) to back (posterior). The motion in this plane is dorsiflexion or plantarflexion; the orientation is lateral to medial.

With the Coronal plane, the cutting line is through the body at a right angle to the Sagittal plane or from lateral to medial. Its orientation is anterior to posterior in the leg and dorsal to plantar in the foot. The motion in this plane is abduction and adduction. With these two cardinal planes alone, we are literally dividing the body in quadrants.

With the Transverse plane, it uniquely allows pronation or supination of the foot and the various mechanics of the foot, allowing for adjustment to any terrain it is presented with. The orientation in this plane cuts the body mediolaterally from top to bottom, with the motion in this plane being inversion or eversion. There are also other orientations of the foot that can also be superior to inferior; superior refers to the caudal (head) area and is proximal (the hip is proximal to the knee), while inferior refers to the area below the head and is known as distal (the ankle is distal to the knee).

What is unique with the foot is that it moves in all three cardinal planes at essentially the same time. Knowing when a foot is moving abnormally in a particular plane is key to managing it in as near normal condition as possible. To put it simply, the foot moves up and down, in and out, and side to side with each step. Pretty remarkable wouldn’t you say?

Distinct Regions with Distinct Tasks

The foot is divided into three distinct regions; the forefoot, the midfoot, and the rearfoot (also known as hindfoot). Each region has a specific task and takes on the abnormalities of the division and anatomy proximal to it. An example of this with the forefoot region is when the hip bone, connected to the leg bone, connects to the ankle bone, has something amiss somewhere in this ‘connection chair’. When there are abnormalities in the foot, it can be caused by issues much higher up in the connections associated with the anatomy in this area, than just the foot in general. Rest assured, the foot bone will pay for it somewhere along this line of connection.

Another marvel of this great human engineering is to consider that both human feet and hands contain literally half the bones in the human body, and this is because these four structures have the incredible abilities to move and adapt to terrain and dexterity. As in a machine, it takes a lot of pulleys and levers to bring in a ‘third dimension’ to life. Most orthopods work with bones in a single plane, while some may work in twos (the shoulder is one example), but still a majority work in a single plane.
A Plane is More Than for Travel

When talking about planes of the foot, the flat or level surface of them, you can actually use air travel as a good and logical analogy when breaking out the three divisions of the foot; the forefoot, the rearfoot and the midfoot. Picture the forefoot handles take-offs, the rearfoot (or also called the hindfoot, a term that can be used interchangeably) handles landings, while the midfoot ties these two divisions together to create one full fluid plane.

There are three more delineations: tarsus, metatarsus and phalanges.

The natural nomenclature of the tarsus consists of the calcaneus, talus, navicular, cuboid and the three cuneiforms. The tarsus acts much as the universal joint in a rear wheel drive automobile. It transfers power from the motor (moving in the vertical direction) to the wheels (moving in the horizontal direction.) The metatarsus consists of the five metatarsals. Sesamoids on the distal plantar surface of the first metatarsal head act as the "pulley" for the flexor hallucis longus tendon. The Phalanges are the two bones of the hallux (great toe) and the three bones of each of the four lesser digits.

The rearfoot is composed of the talus and calcaneus. These are the largest bones in size in the foot and are responsible for the marvelous motions that the foot performs. In the sagittal plane, the calcaneus allows heel strike whereas in the transverse plane, it locks and unlocks the talo-calcaneal articulation that allows shock absorption as the foot moves toward foot flat. The midfoot of the navicular, cuboid and cuneiforms. These work in concert with each other to allow pronation and supination with the cuneiforms being the bridge from the moving parts to the more stationary parts (metatarsals). The forefoot of the metatarsals and phalanges. This area provides both support, rigidity, flexibility and motion all at the same time.

Even the Foot Has Structural Arches

Just like any engineering marvel, support of a structure’s weight has to have unique arches built that work together to help with support and structural integrity. These arches help with the distribution of weight, and even the design of the foot possesses such arches to support the weight of the body standing and in motion. The foot contains three arches:

Medial Longitudinal Arch. This is the most commonly known and consists of the calcaneus, talus, navicular and three medial metatarsals. This is the “arch” that is most people think of when the word is used. Its height and structure has a great effect on a person’s ability to walk and form the basis for many of the pathologies that we treat.

Lateral Longitudinal Arch. This arch consists of the calcaneus, cuboid and two lateral metatarsals. This is the arch on the lateral side of the foot and is not intended for majority weight bearing, yet it is called upon for this task due to certain pathologies.

Transverse Arch. This third arch is comprised of the cuboid, cuneiforms and the adjacent parts of the metatarsals. At the level of the five metatarsal heads, the arch is no longer present. This is the widely unknown arch with little movement, yet it allows for the integrity of the entire structure of the foot. The foot needs all these bones to perform the myriad of functions of walking, and when they no longer function normally, we are called in to manage the problems.

At birth, there are only three to four ossified sections of bone in the foot. In utero, the tarsal bones ossify from the primary center: calcaneus in the third month, talus in the sixth, cuboid near or just after birth, lateral cuneiform at 1 year after birth, medial cuneiform at 2 years, intermediate cuneiform and navicular at 3 years. The calcaneus has a secondary center of a thin plate of bone on the posterior surface appearing at age 7 and fusing at puberty.

The metatarsal heads ossify at age 2-6 and fuse by age 18. It is for this reason why pediatric podiatry is such a controversial topic. Regardless of when the bones ossify, the structure of the foot is governed by genetics and heredity. With little exception, look at the parents and see the child. It is interesting to see a radiograph of a baby’s foot. The small areas of true bone are overwhelmed by the cartilage that eventually becomes bone. It is similar to looking at a ghost foot – future bones, with all the articulations, appearing in that opaque field.

The human foot is a marvel of engineering, and the more that is known about its structures and functions, the better pedorthists can help restore “normality” that nature may have not given or that is affected by injury or disease.

Eight Key Definitions of Foot Motion

Dorsiflexion: The bending back of a hand or foot; fingers or toes.

Plantarflexion: The bending back of the area relating to, affecting or occurring on the sole of the foot.

Abduction: To pull away from the midpoint or midline of the body or of a limb.

Adduction: To pull towards the centerline of the body (or toe or finger) towards the axis of a leg or arm.

Pronation: To rotate the bones of the foot so that the weight is borne mainly on the inside of the foot.

Supination: To turn the foot so that the sole is facing upward, so that the weight is borne mainly inward towards the body.

Inversion: The process of turning the foot or hand inward from its position.

Eversion: The process of turning the foot or hand outward from its position.