EC PAEDIATRICS
Review Article

Overview of Congenital Deformities of Foot in Children

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Abstract

Foot deformities should be carefully examined as an essential part of the child's evaluation. A thorough examination should include vascular, dermatologic, and neurologic evaluation of the lower extremities, as well as inspection, palpation, and assessment of the range of motion of the joints in both feet. Common foot abnormalities include adductor hallux valgus, clubfoot, valgus flatfoot (flexible flatfoot), postural flatfoot (rigid flatfoot), adductus varus, and many others. Most treatments include conservative measures and surgery. However, if these conditions do not improve or become worse, it is important to seek medical attention. Cases requiring surgical correction should be referred to a specialist with expertise in the correction of foot and leg deformities in children. Treatment should be initiated early, even at birth, for clubfoot according to Ponseti, or clubfoot with fibula graft according to Hung NN. Until recently, children with this deformity could be diagnosed in utero and planning could be done from birth. Currently, the conditions for treating congenital deformities allow for treatment while the child is still in the womb, as with other deformities. With some exceptions, surgical techniques are recommended if conservative correction of the foot within 3 to 6 months is not completely satisfactory. Cases requiring surgical correction should be referred to a specialist with expertise in the correction of foot and leg deformities in children.

Keywords: *Clubfoot; Flatfoot; Adductus Varus; Congenital Foot Deformities; Osteotomy Bone; Artery Supply Foot*

Introduction

The foot is a complex anatomical structure consisting of many bones, joints, ligaments, muscles and tendons responsible for the complex coordinated movements of our gait and ability to stand upright. By definition, the foot is the lower limb distal to the ankle joint. The ankle joint (sometimes called the tibiotalar joint) is the result of the assembly of the tarsal bones and the socket formed by the tibia and fibula distal to the tarsus [1]. The foot has 26 bones (tarsals, metatarsals and phalanges) divided into groups called the hindfoot, midfoot and forefoot. The articular surfaces of the bones are covered by articular cartilage. The joints or joints are covered by joint capsules and ligaments, which provide stability to the joints. In addition, there are 29 muscles responsible for the movement of the bony structures of the foot and ankle [2]. The muscles are attached to the bony structures via tendons. The innervation and vascularity are equally complex. The major arterial structures include the anterior tibial artery, posterior tibial artery, and peroneal or fibular artery. Each of these major arteries has multiple branches, which will be discussed further below. The major nerves that innervate the foot and ankle include the tibial, deep peroneal, and sural nerves, each with multiple branches [3]. Finally, subcutaneous fat, fascia, and skin complete the anatomical components of the foot and ankle. It is no surprise that acute injuries, chronic repetitive trauma, and degenerative or inflammatory conditions are common reasons for patients to visit the emergency department or primary care physician. If not treated properly, these conditions can lead to chronic disability.

Foot anatomy

The foot contains 26 bones, 33 joints, and more than 100 tendons, muscles, and ligaments. It may seem like a lot for a flat structure that supports your weight, but you may not realize how much work your feet have to do [4].

The foot functions to balance the weight of the body on two legs, a feat that modern roboticists are still trying to replicate. This requires strong, delicate muscles that can keep the foot stable even as we move our body weight in different positions and angles.

Many bones work together to create this delicate and subtle movement by shifting subtly inside the foot. They also allow us to perform complex actions such as standing, climbing, and "gripping" the ground with our feet on moving or uneven surfaces.

Here, we will discuss the most important parts of foot anatomy and some of the injuries and disorders that can occur when these parts are damaged.

Please note that we are making general statements about how a doctor may treat various foot injuries and disorders. This is not a substitute for medical advice.

See your doctor about any suspected foot injury or disorder, as prompt diagnosis and treatment can lead to a faster, easier recovery, while improper treatment can lead to long-term damage.

Bones of the foot

The foot has 26 bones (Figure 1). Includes:

- The phalanges, which are the bones in your toes.
- The metatarsals, which run across the flat part of your foot.
- The cuneiform, scaphoid, and cuboid bones, all of which give your foot a firm but somewhat flexible foundation.
- The calcaneus, which is the bone in your heel.
- The talus, which is the bone in your ankle.
- The talus connects to the tibia, which is the main bone in your lower leg.

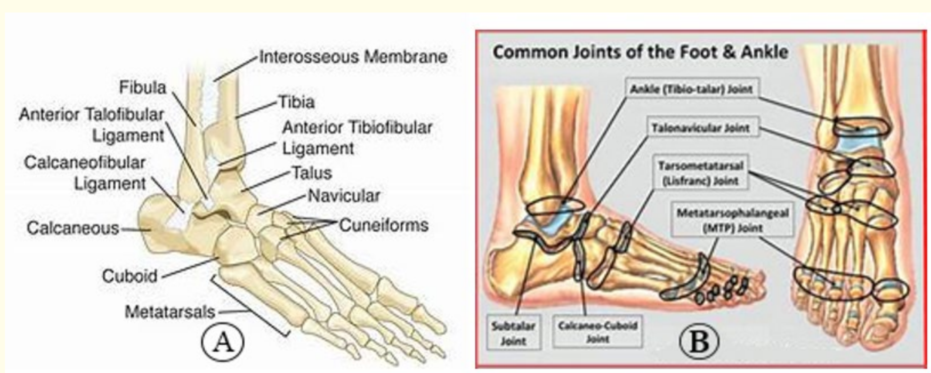


Figure 1A and 1B: *A: Bone of Foot; B: Joint of the foot and ankle.*

The most common type of foot fracture is a toe fracture, which can occur after hitting a toe on a hard or sharp surface while walking, running, swimming, or playing sports.

Foot fractures usually require rest, ice, compression, and elevation to reduce swelling. It is helpful to remember the acronym “RICE”, which stands for Rest, Ice, Compression, and Elevation [5]. This combination of home treatments is an effective first-line treatment for many foot and leg injuries (Figure 1).

Supportive bandages or splints may be used to relieve pain and keep the bones aligned. Sometimes, crutches or other measures may be prescribed to take weight off the foot. In rare cases where a bone breaks into two or more pieces and the pieces are out of place, surgery may be needed to put the pieces back in place so they can heal.

Another problem that can occur with the bones in your feet is a bone spur or metatarsal cyst. A bone spur occurs when an extra bone grows, usually near the end or joint of a bone. This can be caused by chronic irritation of the joint, such as rubbing against another bone or joint. The most common types of bone spurs on the foot occur in the big toe and are called “bunions”.

Bunions and bone spurs can cause significant pain. Internally, they can rub against other bones, muscles, and nerves under the skin. Externally, they can change the shape of the foot, causing pain and discomfort when wearing regular shoes.

Ligaments of the foot

Ligaments are very strong, flexible bands of tissue that perform the important job of connecting bones together. Ligaments are very strong and difficult to injure, but ligament injuries can be very serious when they do occur. This is because ligaments don’t get as much blood flow as bones and muscles, so they’re slow to repair themselves (Figure 2).

There are a lot of bones in the foot, so you might guess that there are a lot of ligaments. In fact, there are so many that we need three different diagrams to show you all of them! This diagram shows the sole of the foot [6]. You can see the toes at the top and the heel at the bottom, while the arch and sole are made up of a thick network of ligaments that hold the bones together.

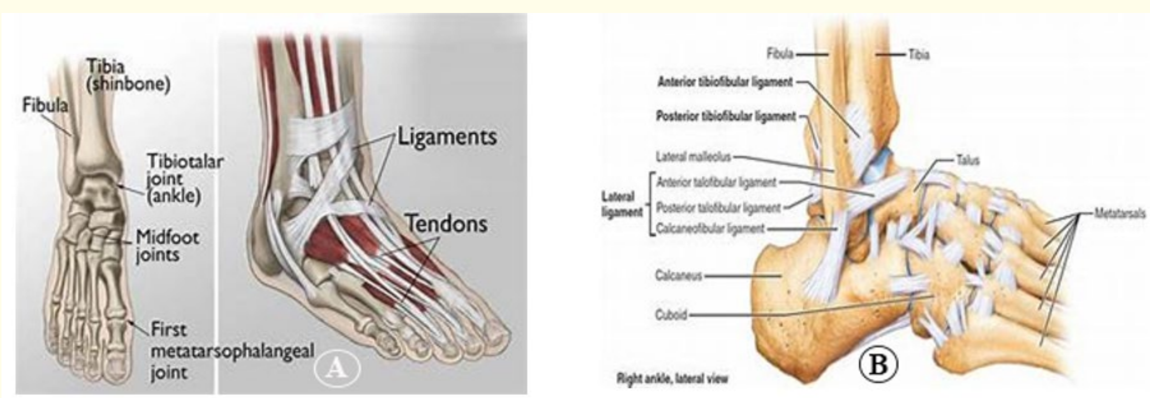


Figure 2A and 2B: *A: Bone and ligament; B: Ligaments of foot.*

This diagram shows the "medial side" of the foot. The term comes from the terms "medial side", meaning "center" or "in the middle", and "side", meaning "face". In other words, this is the "side" that the foot faces toward the center of the body. It is the side of the foot that faces inward.

Finally, this diagram shows the "lateral side" of the foot, with "lateral" meaning "to the side". This is a view of the foot from the side of the body; a view of the part of the foot that faces outward.

On the left side of the image, above the heel, you can see a delicate leg bone called the fibula. The fibula is smaller than the tibia and runs alongside the tibia. Having two separate bones instead of one connecting the foot to the leg makes the foot and leg more balanced and easier to control.

Physical therapy can be particularly helpful in the case of sprains, where it can ensure that the injured ligament is gradually strengthened and properly supported by the surrounding muscles.

A torn ligament occurs when the foot is pulled or twisted so hard that the ligament actually tears. This can be serious because a completely torn ligament may not heal on its own like a bone or muscle.

A torn ligament can sometimes be treated in the same way as a strain, but surgery may be needed if the tear is severe or if the function of the foot is permanently impaired. Surgery can be used to fuse the two ends of the damaged ligament together or replace the damaged ligament with a healthy ligament from another part of the body.

Foot muscles

The muscles that act on the foot can be classified as extrinsic and intrinsic (29 in total; 10 extrinsic and 19 intrinsic) [7]. The extrinsic muscles originate outside the foot but support the foot, while the intrinsic muscles originate inside and lie entirely within the foot, providing fine motor movement.

The extrinsic muscles can be arranged compartmentally. The anterior dorsiflexors include the tibialis anterior, the extensor digitorum longus, and the extensor pollicis longus. In the posterior compartment of the ankle, the extensor pollicis longus and extensor pollicis brevis are involved in plantar flexion. In the posteromedial compartment of the ankle, deep to the plantar flexor tendon, lie the tibialis posterior, flexor hallucis longus, and flexor hallucis longus, which also participate in plantar flexion. Finally, in the posterior ankle and hindfoot, superficial to the plantar flexor muscle lies the soleus muscle with the tendon of the gastrocnemius muscle forming the Achilles tendon. The plantar flexor lies lateral to the Achilles tendon, both of which attach to the posterior calcaneus and participate in plantar flexion [7].

The intrinsic muscles can be arranged according to the digits they innervate: first, third, and fifth.

The muscles of the great toe include the abductor hallucis longus, flexor hallucis longus, and adductor hallucis longus [8]. The abductor hallucis longus originates on the calcaneal tuberosity and attaches to the proximal phalanx of the first toe. It originates on the great toe to help maintain the arch of the foot. The flexor hallucis longus, which is involved in flexion of the first toe, originates on the cuneiform and cuboid lateral surfaces and also attaches to the proximal phalanx of the first toe. The adductor hallucis has two heads. One head originates diagonally across the middle of the midfoot at two to four proximal metatarsals, and the other head originates across the metatarsal ligaments of the great toe three to five. They attach to the first proximal phalanx. This muscle adducts the big toe [7].

The muscles of the middle toe include the four lumbrical muscles, the quadratus plantaris, the flexor hallucis brevis, the dorsiflexor hallucis, and the plantar interosseous muscles. The lumbrical muscles originate from the flexor hallucis longus tendon and attach to the extensor hallucis longus tendon. They extend the interphalangeal joints and flex the big toe joints. The quadratus plantaris originates on the calcaneus and attaches to the flexor hallucis longus tendon, thereby flexing the distal phalanx. The flexor digitorum brevis originates on the calcaneal tuberosity and attaches to the middle three phalanges of the little toe and assists in flexing the second through fifth toes. The adductor interosseous muscles originate on the third through fifth metatarsals and also attach to the middle three phalanges [7].

The muscles of the little toe include the abductor digitorum, flexor digitorum, and antipodals. The abductor digitorum originates on the calcaneal tuberosity and attaches to the base of the fifth metatarsal. The flexor digitorum originates on the base of the fifth metatarsal and attaches to the proximal phalanx of the little toe [7].

Foot tendons

Tendons are thick bands of tissue that connect muscles to bones. By connecting strong bones to strong muscles, tendons allow us to move. Movement occurs when muscles pull on bones, moving them (Figure 3).

The following diagram shows tendons on the lateral side of the foot—that is, the side facing outward, away from your body.

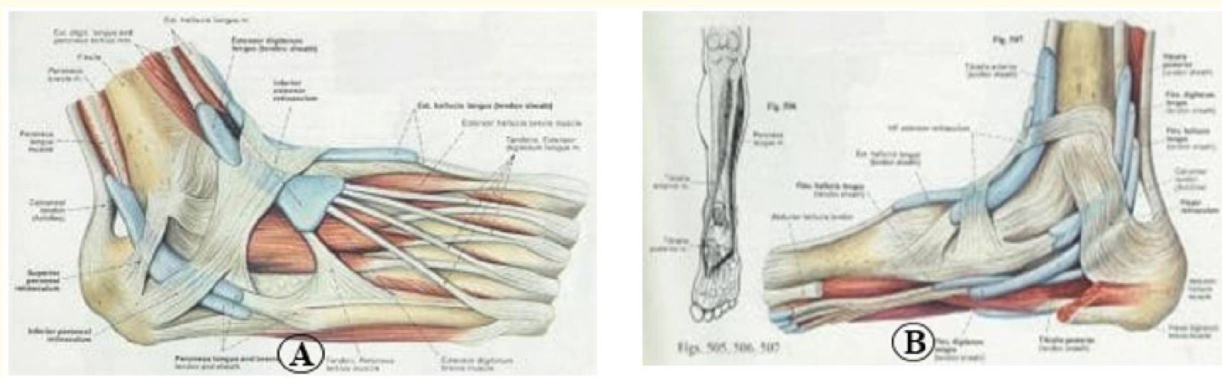


Figure 3A and 3B: *A: Tendons of extension toes; B: Tendons of post-anterior tibia.*

Here you can see the tendons that run down the top of the foot towards the toes, allowing you to curl your toes up if needed. You can also see arguably the most important tendon in the foot - the Achilles tendon, or heel tendon, which allows the muscles in the calf to control the movement of the foot.

The achilles tendon gets its name from the Greek mythological hero achilles, who was invulnerable except for his ankles. An injury to his ankles - possibly the achilles tendon - left him unable to stand and fight.

This image of the medial aspect of the foot shows the tendons that run along the sole of the foot. It is these tendons that allow you to curl your toes and grip surfaces with your foot, by allowing the muscles in the sole of the foot to stretch [6]. Injuries can occur to any of the tendons in the foot, and these injuries can cause pain or loss of balance. An Achilles tendon injury is one of the most common tendon injuries that can occur, as the body relies on the Achilles tendon to support its weight.

Tendonitis occurs when the tendon - a fibrous connective tissue that attaches muscles to bones - becomes irritated over time. This can happen through overuse or misuse if a person moves in a way that puts stress on the tendon. Tendonitis often comes on slowly, presenting as a sharp pain when a person performs a certain movement. People with tendonitis in the foot may experience pain when putting weight on the foot, even if there is no obvious injury such as an injury or strain. Tendonitis can be treated with RICE and over-the-counter anti-inflammatory medications. Physical therapy can also be extremely beneficial, as this can involve gentle exercise and stretching of the tendon, as well as correcting any movement habits that may be causing the irritation.

Foot arches

Normally, tendons in the foot pull the bones of the foot together, forming special arches between the heel and the toes, and between the inner and outer toes [9]. These arches are important for ensuring that weight is distributed properly between the strongest muscles of the leg and foot, and for ensuring that we can shift our weight when needed for balance or rapid movement (Figure 4).

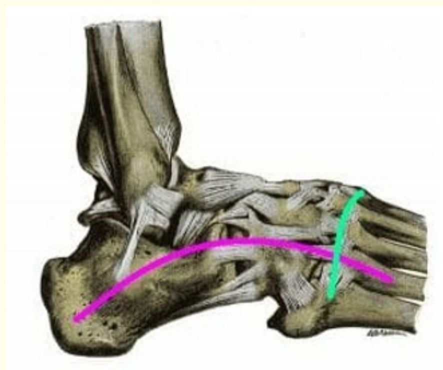


Figure 4: *Foot aches.*

Collapsed arches, or "flat feet", can occur when the tendons in the foot do not pull the bones of the foot together with the normal force. This causes the foot to become "flat", which can lead to pain, loss of balance, and fatigue in the foot or leg.

Flat feet can occur due to injury, or in some people, the tendons never pull together properly. Rarely, other health problems such as arthritis or problems with the nerves that go to the feet can cause flat feet [10].

Flat feet can be painful and tire easily. Back pain and foot pain can also occur because the muscles in the back and legs may work too hard to compensate for the normal balancing functions of the arch.

Treatment for flat feet can depend on the cause. If you think you have flat feet, see your doctor to find the best treatment for you!

Nerves of the foot

The nerves of the foot and ankle include the saphenous, superficial peroneal, deep peroneal, medial plantar, lateral plantar, sural, and calcaneal branches (Figure 5).

The saphenous nerve originates from the femoral nerve and supplies the skin of the medial ankle and foot down to the first metatarsal.

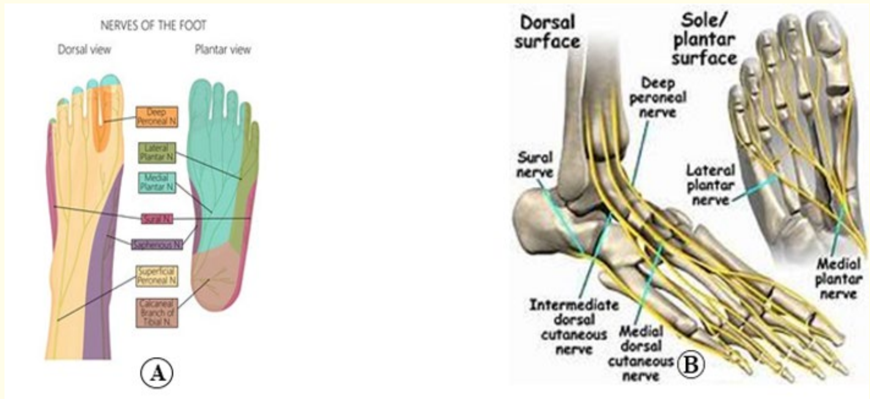


Figure 5A and 5B: *A: Foot sensory area; B: Nerves of dorsal surface and plantar of foot.*

The superficial and deep peroneal nerves originate from the common peroneal nerve. The superficial peroneal nerve innervates the dorsal skin and lateral digits of the first dorsal toe, second dorsal toe, and lateral fifth toe. The deep peroneal nerve innervates the extensor digitorum brevis and the skin of the first dorsal toe and second dorsal toe [11,12].

Peroneal nerve

The medial and lateral plantar nerves originate from the tibial nerve. The division occurs at the level of the ankle in the metatarsal tunnel. The medial plantar nerve travels deep to the abductor hallucis longus. It then branches into the common plantar and plantar nerves of the first to fourth toes. The medial plantar nerve and its terminal branches innervate the flexor hallucis longus, iliopsoas major, abductor hallucis longus, and flexor hallucis longus. In addition, it provides sensory innervation to the skin of the plantar surfaces of the first three toes, the middle fourth toe, and the midfoot. The lateral plantar nerve lies obliquely along the lateral aspect of the plantar foot between the flexor hallucis longus and quadratus plantaris. It innervates the flexor hallucis longus, abductor hallucis longus, quadratus plantaris, adductor magnus, lateral triceps, and the plantar interosseus/plantar interosseus muscles. The lateral plantar nerve is also responsible for sensory innervation to the skin of the lateral plantar surfaces of the lateral fifth and fourth toes and the lateral foot [11].

The sural nerve originates from branches of both the common peroneal nerve and the tibial nerve. It innervates the posterolateral and midfoot. The calcaneal branches originate from the tibial and sural nerves and innervate the skin of the heel [12]:

- Tibial: The Tibial nerve originates at the L5, S1, and S2 levels along with the common peroneal nerve (fibular).
- Motor fibers: Gastrocnemius, soleus, tibialis laterior, flexor digitorum longus, and flexor hallucis longus.
- Common fibular (peroneal):
- Deep fibular
- Superficial
- Sural.

Plantar nerve

The plantar nerve originates from the tibial nerve at the medial malleolus. The nerve divides into two branches: the medial and lateral branches. It provides motor and sensory innervation to the muscles of the foot:

- Medial plantar nerve
- Lateral plantar nerve
- Common peroneal nerve
- Superficial
- Deep: sometimes purely sensory.

Foot arteries

The arterial blood supply of the foot is provided by branches of the posterior tibial artery together with the dorsalis pedis artery (also called the dorsalis pedis artery) [13,14].

The posterior tibial artery passes towards the sole of the foot and divides into the lateral and medial plantar arteries. The lateral plantar artery joins the head of the dorsalis pedis artery (deep plantar artery) to form the deep plantar arch. The blood supply to the toes is provided by branches from this arch (Figure 6).

The dorsalis pedis artery is an extension of the anterior tibial artery, which runs across the dorsum of the foot and descends to enter the sole of the foot as the deep plantar artery, between metatarsals I and II (Figure 6).

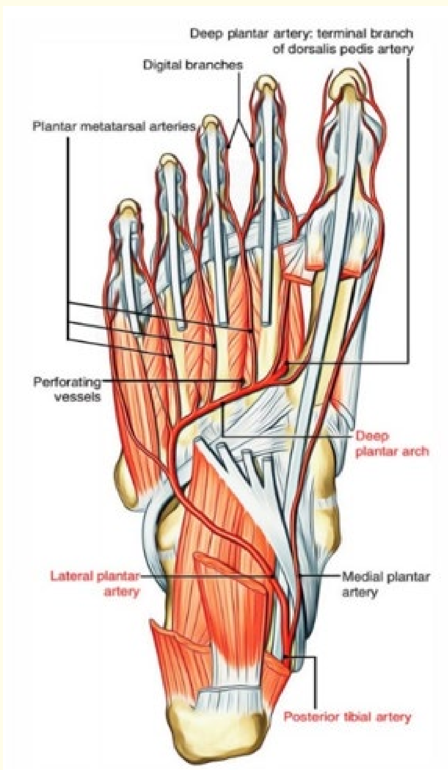


Figure 6: *Arteries of foot: medial plantar artery.*

Posterior tibial and plantar arches

- Medially at the ankle and posteriorly towards the medial malleolus, the posterior tibial artery enters the foot via the tarsal tunnel.
- At this point, the posterior tibial artery divides into a small medial plantar artery and a significantly larger lateral plantar artery [14,15].

Lateral plantar artery

Towards the lateral side, the lateral plantar artery runs on the sole of the foot, first deep to the proximal head of the abductor hallucis longus and then medially to the quadratus plantar and flexor hallucis brevis.

Deep plantar arch

The lateral plantar artery turns medially to form the deep plantar arch, which traverses the deep plane of the sole of the foot through the metatarsal base and the interosseous muscle.

The deep plantar arch joins the deep plantar artery (terminal branch) of the dorsalis pedis artery, which enters the sole of the foot from the dorsum of the foot, between the bases of metatarsals I and II [15-17].

The main branches of the deep plantar arch include:

- One digital branch: Runs towards the lateral aspect of the little toe.
- Four plantar arteries: Give rise to great toe branches towards the adjacent sides of the great toes from I to V and the medial aspect of the great toe.
- Three perforating arteries: Run between the bases of metatarsals II to V to communicate with the dorsum of the foot.

Medial plantar artery

By going deep to the proximal end of the abductor hallucis muscle, the medial plantar artery runs inside the sole of the foot. To the adjacent muscles, it gives off a deep branch and then runs forward in the medial recess of the abductor hallucis muscle together with the flexor hallucis brevis muscles.

It ends by anastomosing with the great toe branch (great toe artery) of the deep plantar arch, circulating the medial aspect of the great toe [16,18]. Near the base of the first metatarsal, the medial plantar artery gives off a superficial branch, which divides into three vessels that run superficially toward the flexor hallucis brevis muscle to anastomose the plantar arteries with the deep plantar arch.

Plantar arteries of the big toe

All plantar arteries of the big toe divide into a common pair of great toe arteries, which then divide on each side of the toe into two main great toe arteries that circulate on both sides of the adjacent great toe [17,19,20].

Dorsalis pedis

The dorsalis pedis is an extension of the anterior tibial artery and begins where the anterior tibial artery passes through the ankle joint (Figure 7).

The branches of the dorsalis pedis artery include the lateral and medial tarsal branches, an arch artery, and a first dorsalis pedis artery [21].

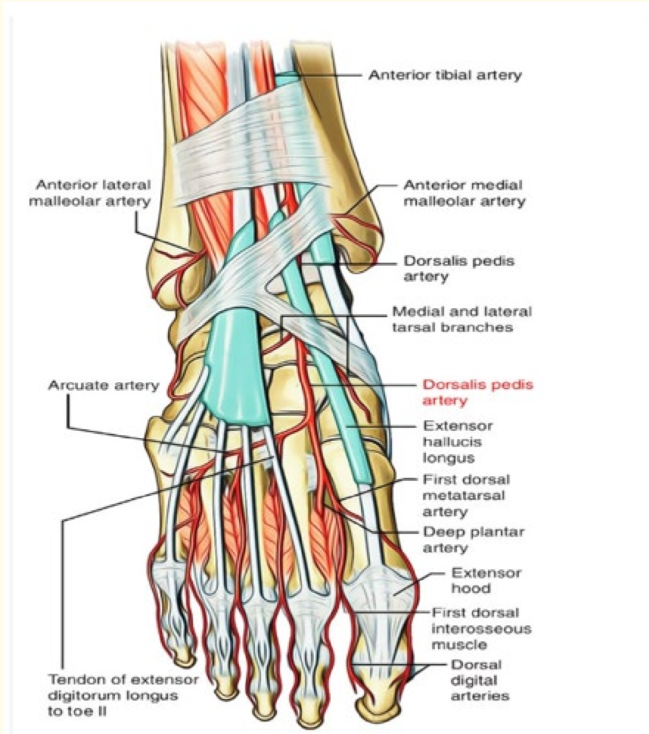


Figure 7: *Arteries of foot: dorsalis pedis artery.*

Foot imaging diagnosis

Foot and ankle imaging has made significant advances over the past 50 years, allowing rapid, noninvasive, high-resolution visualization of anatomy and pathology (Figure 8). Technical advances in magnetic resonance imaging (MRI), including faster gradients, higher-field magnets, and better coils; in computed tomography, including the advent of helical acquisition and multiple probe capabilities; and in ultrasonography, including higher-frequency probes, have allowed for a better understanding of foot and ankle pathology and associated findings [22]. For example, high-frequency ultrasonography is well suited to examining common surface structures in the musculoskeletal system (such as peripheral nerves, tendons, and ligaments), and visualization of these structures during real-time scanning can be used to provide physiological or biomechanical information such as the detection of abnormal tendon dislocations or ligamentous failure during dynamic or stress events [23]. Furthermore, patient positioning and imaging planes may not be standardized across institutions, which may result in differences in the shape and orientation of structures.

Finally, ultrasound in particular is highly dependent on probe placement and often relies on a smaller field of view than other imaging modalities. This makes ultrasound images difficult to reproduce and may not allow the interpreter to place suspected pathology in the complete anatomic context.

However, with the increasing use of diagnostic imaging of the foot and ankle, radiologists and clinicians are becoming more aware of these considerations [24] (Figure 9). This should help to minimize the impact these issues may have and further improve the diagnostic capabilities of noninvasive imaging.

Radiography

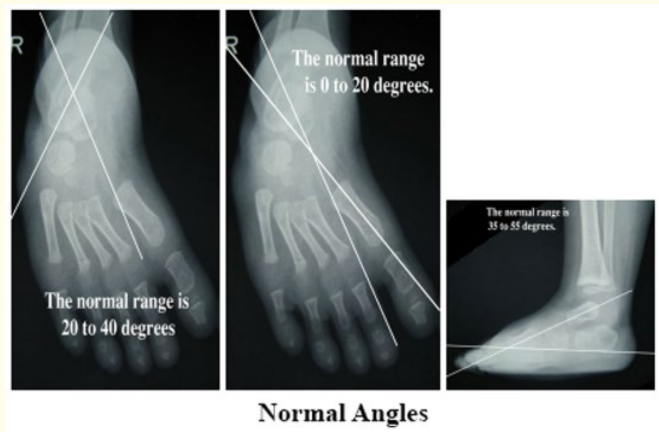
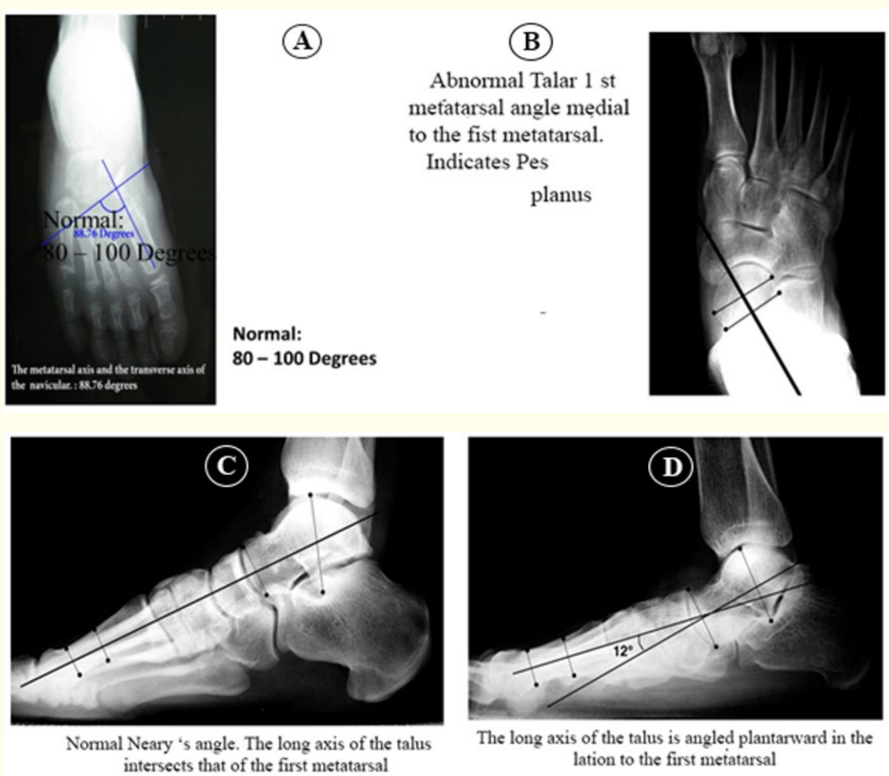
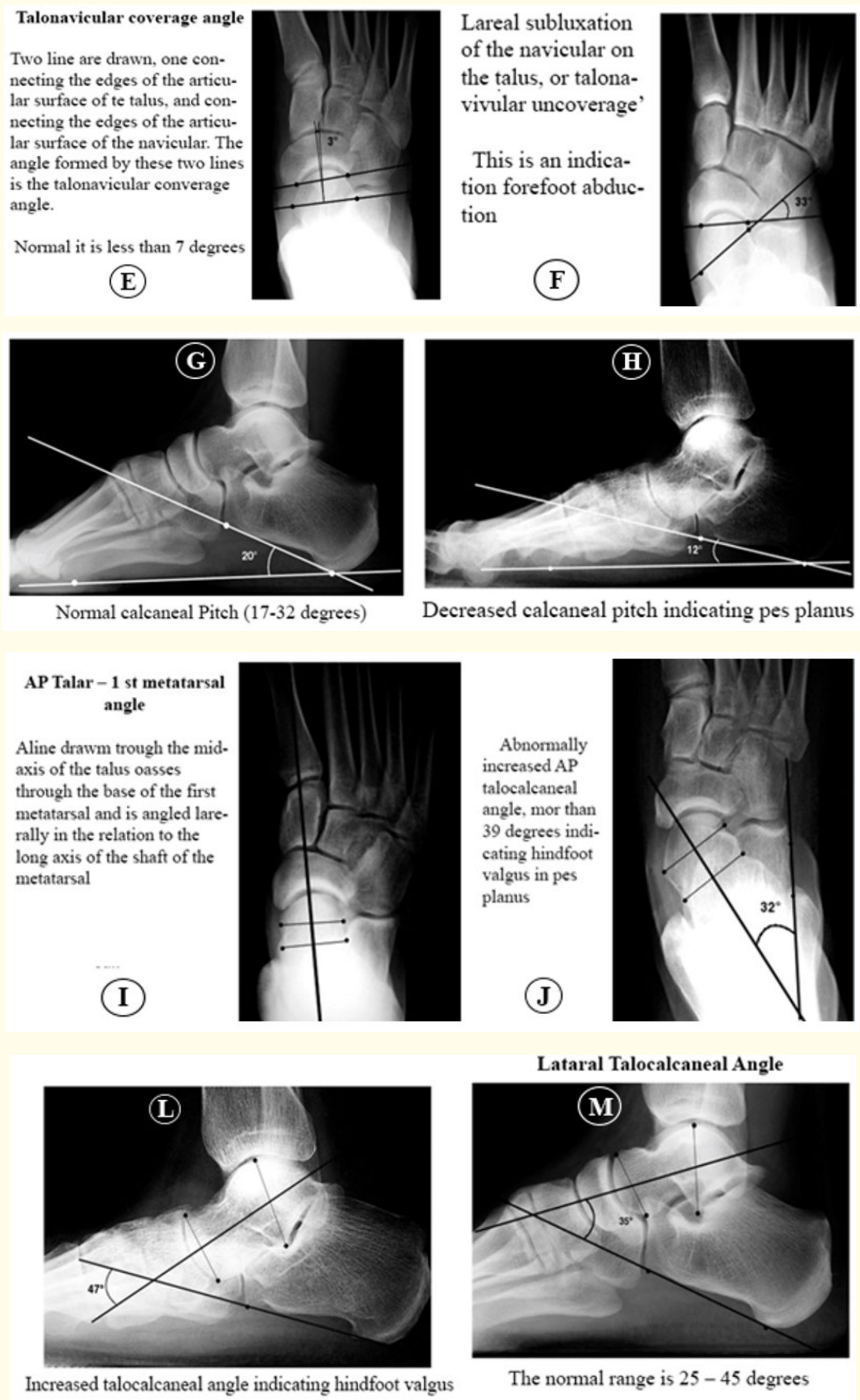


Figure 8: *Normal angle food.*




Talonavicular coverage angle
Two line are drawn, one connecting the edges of the articular surface of te talus, and connecting the edges of the articular surface of the navicular. The angle formed by these two lines is the talonavicular converage angle.
Normal it is less than 7 degrees
E
3°
Lareal subluxation of the navicular on the talus, or talonavivular uncoverage'
This is an indication forefoot abduction
F
33°
G
20°
Normal calcaneal Pitch (17-32 degrees)
H
12°
Decreased calcaneal pitch indicating pes planus
AP Talar – 1 st metatarsal angle
Aline drawm trough the mid-axis of the talus oasses through the base of the first metatarsal and is angled larerally in the relation to the long axis of the shaft of the metatarsal
I
Abnormally increased AP talocalcaneal angle, mor than 39 degrees indicating hindfoot valgus in pes planus
J
32°
L
47°
Increased talocalcaneal angle indicating hindfoot valgus
Lataral Talocalcaneal Angle
M
35°
The normal range is 25 – 45 degrees

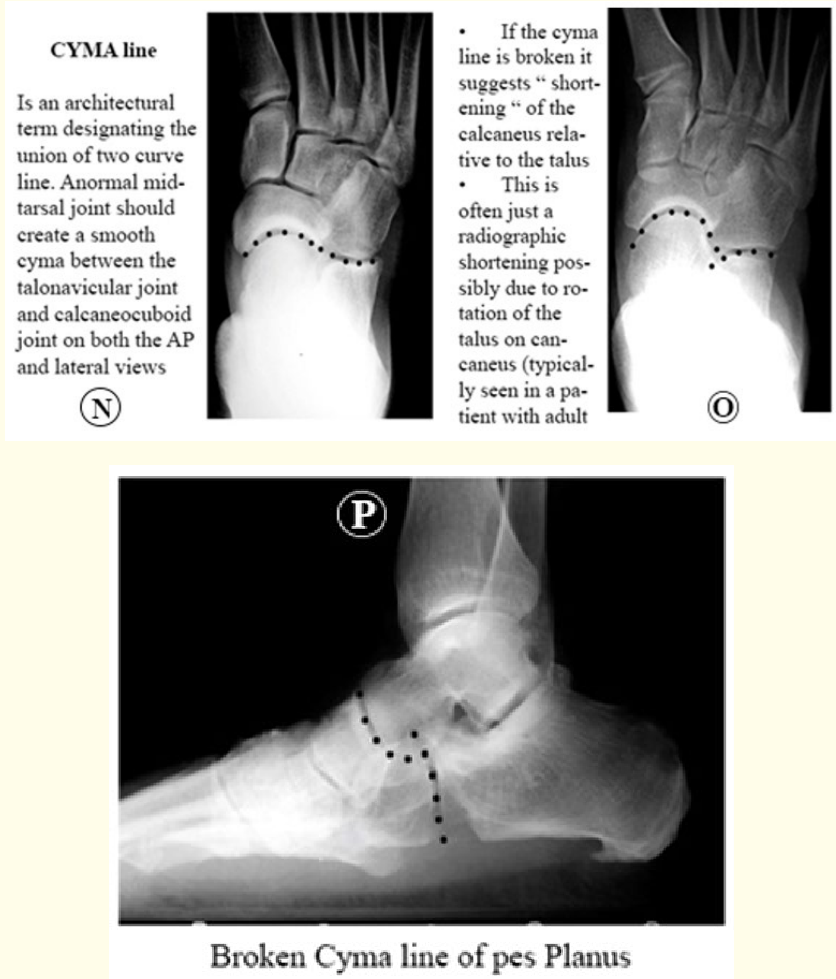


Figure 9A-9P: *Lines and angles in foot.*

Magnetic resonance imaging of the ankle and foot

Magnetic resonance imaging (MRI) has become a routine imaging tool in the diagnosis of ankle and foot disorders [25]. Although radiographic evaluation remains an essential first step, MRI allows for a deeper understanding of pathological conditions of articular cartilage and bone, and detailed assessment of problematic soft structures. Compared to other anatomic regions in musculoskeletal imaging (Figure 10), MRI of the ankle and foot poses an additional challenge for interpretation, due to its relatively complex anatomy and wide spectrum of normal variations and pathological conditions [26,27]. This review will focus on the MRI diagnosis of common clinical conditions affecting the ankle and foot along with a brief review of relevant normal MRI anatomy.

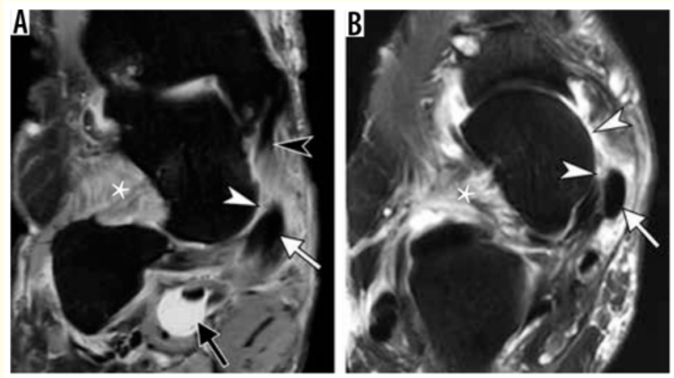


Figure 10A and 10B: *Flat foot deformity. Coronal fat-suppressed proton-density-weighted (A) and axial T2-weighted (B) magnetic resonance images of the ankle demonstrate mildly enlarged posterior tibialis tendon (PTT) (arrow).*

Congenital deformities of the foot

Clubfoot

Figure 11A and 11B: *Clinical clubfoot.*

Idiopathic congenital clubfoot (Figure 11) is a common complex deformity occurring in approximately one or two newborns in every 1000 [28]. The entire population of New Zealand is 4 million, of whom 750,000 were reported to be Polynesian according to the 2001 census. With an estimated incidence of 6.8 clubfeet per 1000 in the Polynesian population, compared to one per 1000 in the Caucasian European population, New Zealand paediatric orthopaedic surgeons treat a large number of clubfeet.

Treatment of clubfoot remains controversial as the initial deformity can be corrected with both surgical and non-surgical methods. The long-term goal of treatment is a functional, pain-free, ambulatory foot with good mobility, free of calluses, and no need for modified footwear.

Several investigators have reported short-term success in correcting clubfoot using the Ponseti method with sequential manipulation and casting. In addition, good foot function has been reported more than twenty-five years after Ponseti treatment of clubfoot [29]. As a result of these reports, the number of children undergoing long-term soft tissue release surgery has decreased. However, long-term soft tissue release is usually performed when the results of the Ponseti method are inadequate, in children with refractory clubfoot, or because of relapse due to poor adherence to splinting. Long-term soft tissue releases often provide definitive correction [30], but they can cause short-term complications, and up to 47% of patients require additional surgery. With some exceptions, surgical techniques are recommended if conservative correction of the foot within 3 to 6 months is not completely satisfactory. Early surgical approaches range from posterior release [31] to posteromedial or posterolateral release and finally extended periglenoid release.

Clinical examination

Information collected from the medical record includes demographic data (including patient sex), side of the clubfoot, baseline age, duration of preoperative cast treatment, age at surgery, duration of postoperative cast treatment and details of the surgical procedures. The clinical examination includes assessment of patient height and weight, limb length (measured from the anterior superior iliac spine to the medial malleolus), calf circumference (in cm), and foot length and width (in cm). The foot should be inspected for calluses and palpated for tenderness. Clubfoot should be examined before and after each treatment with manipulation and casting. A reference point, usually the knee flexed at 90˚, should be selected to examine the foot. The alignment of torsion, varus, and valgus should be assessed, as should the overall size and shape of the leg, ankle, and foot [32]. Torsion is difficult to assess clinically in patients with clubfoot because the medial malleolus is obscured by the scaphoid bone and atrophy of the calf muscles is an expected component of clubfoot.

Note eversion of the forefoot. All deformities involving the next most proximal segment should be assessed, i.e. the forefoot at the midfoot, the midfoot at the back of the foot, and the hindfoot at the ankle. If the hindfoot forms a 30˚ angle with the tibia and the forefoot (the line of the toes) forms a 30˚ angle with the tibia, the deformity is posteriorly inclined and there is no eversion of the forefoot. Errors in this assessment can lead to overcorrection of the forefoot in casting or surgical eversion [31]. Palpation of the lateral column with the foot in dorsiflexion may demonstrate overcorrection of the midfoot (pathological eversion).

A limp was observed. A hand-held goniometer was used to measure passive dorsiflexion and plantarflexion of the ankle with the knee straight, as well as supination and pronation of the forefoot and varus-valgus movement of the heel. Clinical assessment and grading of all patients according to Diméglio., *et al.* [30] (Figure 12). The system of Diméglio., *et al.* was derived from a detailed scoring system based on the measurement of four parameters: 1) equinus in the vertical plane; 2) varus deviation in the frontal plane; 3) 'rotation' of the anterior calcaneus around the tarsus; and 4) adduction of the forefoot into the hindfoot in the horizontal plane. The scale includes four additional points for the presence of medial creases, posterior creases, arches, and poor calf muscle tone. From a maximum score of 20 points, the deformity can be classified as benign, moderate, severe, or very severe (Table 1).

Table 1. The system of Diméglio *et al.* [23] for the classification of congenital talipes equinovarus.

Classification Grade	Type	Score	Reducibility
I	Benigin	<5	< 90%, soft-soft, resolving
II	Moderate	5 to <10	>50%, reducible, partly resistant
III	Severe	10 to <15	<50%, resistant, partly reducible
IV	Very severe	15 to <20	<10%, resistant

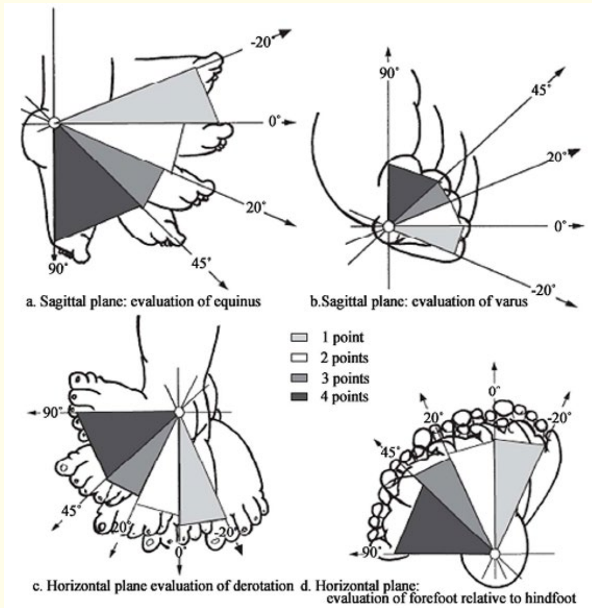


Figure 12: *Classification for all patient according to Diméglio [30].*

Radiographic evaluation

Radiographs are not necessary in the initial evaluation of isolated clubfoot in the neonatal period. It is difficult to assess the extent of the deformity in infants and young children because the ossification centers of the calcaneus, talus, and cuboid are small and long. In addition, the scaphoid, the most displaced component of clubfoot, does not ossify until 3 or 4 years of age. Furthermore, Cooper., *et al*. [33] reported, with a mean follow-up of 30 years, that residual deformity on foot radiographs did not predict success or failure of treatment. The potential danger of focusing on achieving “good” radiographic correction is that it often leads the treating physician to perform more extensive surgical correction, which may result in a foot that looks good on radiographs but does not function well clinically due to stiffness and the development of arthritis in the foot and ankle. Instead, radiographs are reserved for the evaluation of recurrent or neglected clubfoot or in cases where the foot may not respond to conservative treatment and more extensive surgical treatment is being considered. In non-ambulatory children, standard radiographs include anteroposterior (AP) and lateral views of both feet. AP and lateral standing radiographs are desirable when available. Important angles to consider when evaluating clubfoot are the talocalcaneal angle on AP radiographs, the talocalcaneal and tibiocalcaneal angles on lateral radiographs, and the talometatarsal angle (Figure 13).

The use of computed tomography (CT) and magnetic resonance imaging (MRI) to better delineate clubfoot deformity has been described, but these costly procedures often provide little clinically useful information and are not routinely used. Several authors have reported the use of ultrasound as a screening tool in neonates, to monitor the success of conservative treatment, to guide surgical correction, and to assess reduction during surgery. Proponents cite the advantages of ultrasound being quick and simple, well tolerated by children, and able to be repeated frequently to monitor response to treatment.

Figure 13A-13D: *Radiographic evaluation of clubfoot. A: Decreased talocalcaneal angle and negative talus-first metatarsal angle on anteroposterior view of right clubfoot. B: Talocalcaneal angle of normal left foot. C: Talocalcaneal angle of zero and negative tibiocalcaneal angle on dorsiflexion lateral view of right clubfoot. D: Same angles in normal left foot.*

Treatment

Conservative treatment

The goal of minimally invasive surgical treatment of clubfoot is to provide functional correction with the advantages of producing less scar tissue and thus a more flexible foot than those treated with more extensive surgery. The two most commonly used methods are the French method and the Ponseti method. The French method, which relies on intensive physical therapy and bracing, often results in incomplete correction of hindfoot contractures, requiring posterior soft tissue release surgery for complete correction. The Ponseti method, which involves sequential casting, Achilles tenotomy, and lateral plantar fasciectomy, has become the gold standard for clubfoot treatment in North America and many other parts of the world because it provides excellent long-term treatment without the risks associated with more extensive release surgery, including stiffness, pain, arthritis, and the need for additional surgical procedures. Globally, the Ponseti method has created opportunities for the treatment of pediatric clubfoot in developing countries where surgical intervention is inadequate or unavailable. Because of the high success rate of the Ponseti method in treating infants with isolated clubfoot, many have expanded the age range and successfully used it to treat children with clubfoot aged 1 to 9 years with previously untreated or neglected clubfoot,116 with one report of success in a previously untreated 19-year-old male with unilateral clubfoot (personal communication).

The Ponseti method [30] has also been used successfully to restore correction in patients with relapse after extensive soft tissue release surgery. In fact, it could be argued that the Ponseti method should be the first-line treatment for any clubfoot, regardless of age at presentation, associated diagnosis, or previous treatment history [35]. If full correction is not possible in more difficult cases, partial correction still reduces the amount of surgery required, essentially making the procedure an "optional" approach [36].

Ponseti method

The Ponseti method is the most common and effective treatment for clubfoot. This treatment uses a series of splints and braces to rotate the child's foot into the corrected position. The foot is rotated outward until it is rotated 60-70 degrees. Treatment usually begins sometime between birth and 4 weeks of age and consists of two phases: treatment and splinting.

Treatment phase

During the treatment phase, your child's doctor will slowly reposition your child's foot using a series of splints. This phase includes two to three months of stretching and repositioning the foot.

The doctor will stretch and reposition your child's foot, then apply a cast to the foot, ankle, and leg to hold the foot in the new position (Figure 14):

- After about a week, the doctor will remove the cast and reposition your child's foot again. A new cast will hold the foot in the new position.
- This process will be repeated weekly until your child's foot is moved from the incorrect inward position to the correct outward position. Typically, five to eight adjustments and cast changes are needed to get the foot into the correct position.
- Once the outward position of the foot improves, most children need a minor surgery (tenotomy) to lengthen the Achilles tendon. This is the ligament that connects the calf muscle to the heel. About 95 percent of babies need this surgery, which is usually done under local anesthesia

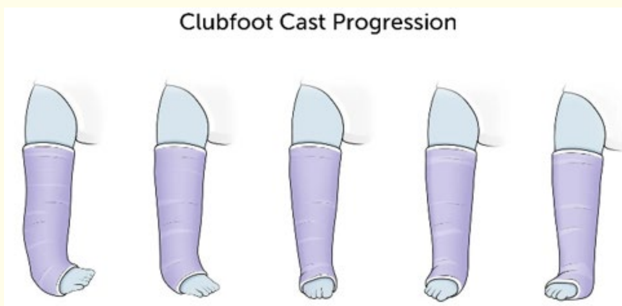


Figure 14: *Club foot cast progression.*

Clubfoot bracing stage

Clubfoot bracing lasts for several years and is crucially important to your child's long-term mobility. The brace maintains your child's foot in a corrected position (Figure 15).

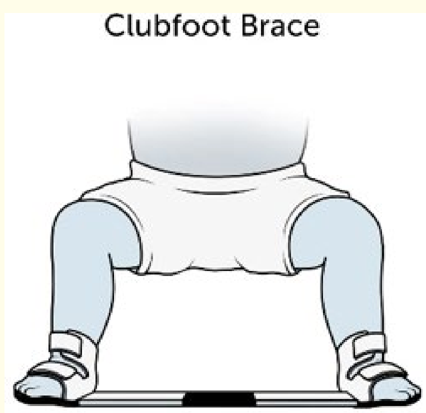


Figure 15: *Clubfoot Brace.*

- From the end of treatment until your child is 3 to 6 months old, your child will wear the brace about 22 hours a day.
- After this initial period, your child's doctor will probably say that your child can wear the brace at night and during naps, about 15 or 16 hours a day.
- When your child is ready to learn to crawl, then walk, run, and play, he or she can do so without the brace.
- You will need to strictly follow the brace program until your child is 4 years old. Although it is inconvenient, this is the best way to prevent your child's foot from turning inward again and requiring further medical intervention.

Surgical treatment

The indication for extensive soft tissue release for clubfoot is decreasing as orthopedic surgeons gain experience with the expanded indications for using the Ponseti method. Surgical correction of clubfoot should be reserved for the rare patient whose clubfoot cannot be adequately corrected by more conservative measures and for those cases of recurrent clubfoot in which, despite casting, some deformity remains to be addressed (Figure 16). In all cases, surgical correction of residual clubfoot should be performed using a less-is-more philosophy [37].

French method: Another nonsurgical method for correcting clubfoot is stretching, mobilization, and taping. The French method—also known as physical or functional therapy—is typically administered by a trained and experienced physical therapist.

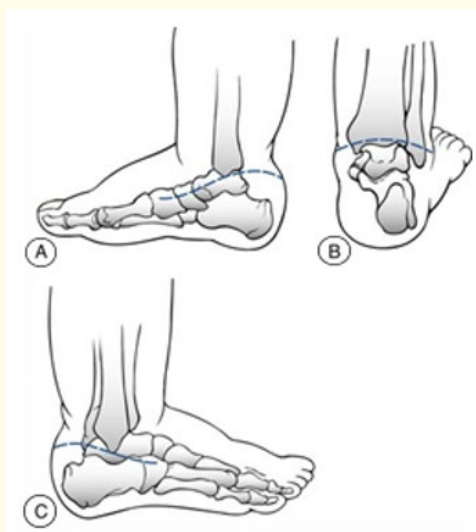


Figure 16: *Transverse circumferential (Cincinnati) incision. A: Medial view. B: Posterior view. C: Lateral view. (Modified from Crawford AH, Marxen JL, Osterfeld DL: The Cincinnati incision: a comprehensive approach for surgical procedures of the foot and ankle in childhood. J Bone Joint Surg Am 64:1355-1358.*

Like the Ponseti method, the French method begins immediately after birth and requires family involvement. Each day, the baby's foot is stretched and massaged, then bandaged to maintain the range of motion achieved after the massage. After the bandage is applied, a plastic splint is placed over the bandage to maintain the improved range of motion.

This method requires about three visits to a physical therapist per week. Since it is a daily regimen, the therapist will instruct parents on how to do it properly at home.

Infants requiring clubfoot surgery are usually treated between the ages of 6 months and a year. Unlike a gradual cast, the doctor will correct everything in one procedure [38]. They may lengthen the tendons or take other steps to rotate and shape the foot into a more normal position.

After surgery, your baby will need a cast to keep the foot at the correct angle. After that, your child will need braces or special shoes for about a year to keep the foot from returning to its original position.

French method

Another nonsurgical method for treating clubfoot is stretching, mobilizing, and bandaging. The French method also known as physical or occupational therapy - is usually taught by a trained and experienced physical therapist.

Like the Ponseti method, the French method is started soon after birth and requires family involvement. Each day, the child's foot is stretched and massaged, then bandaged to maintain the range of motion achieved after the massage. After the bandage is applied, a plastic splint is placed over the bandage to maintain the improved range of motion.

This method requires about three visits to the physical therapist per week. Since this is a daily regimen, the physical therapist will instruct parents on how to do it properly at home.

By 3 months, most infants have significantly improved foot position and require fewer visits to the physical therapist. Like children treated with the Ponseti method, infants treated with the French method often require Achilles tenotomy to improve dorsiflexion (dorsiflexion is the backward bending and flexion of the foot, such as when you bend the toes toward the shin).

To prevent recurrence of clubfoot, the family must continue a daily regimen of stretching, bandaging, and splinting until the child is 2 to 3 years of age.

A surgical procedure to completely release the soft tissue through a circumferential transverse incision, modified from the procedure described by McKay [39], has been described, but the authors' current approach to residual clubfoot deformity is "optional," in that it only releases tight structures and does not perform complete release in many patients. The procedure described by McKay [39] takes into account the three-dimensional deformity of the subcalcaneal joint and allows correction of the internal rotational deformity of the calcaneus and release of contractures in the posterolateral and posteromedial hindfoot.

Tuncay., *et al.* [40] found a high rate (70%) of myopathic changes in 17 infants after clubfoot surgery; they used light general anesthesia combined with regional anesthesia (caudal or spinal) without complications and recommend regional anesthesia and careful monitoring to prevent malignant hyperthermia, cardiovascular or neurological complications that may occur in children undergoing clubfoot surgery.

The circumferential (Cincinnati) incision [41] provides excellent exposure to the subcalcaneal joint and is useful in patients with severe internal rotational deformity of the calcaneus.

The problem with this incision is the tension in the sutures when the surgeon tries to place the foot in a dorsiflexed position for the cast after surgery. To avoid this, the foot can be placed in a dorsiflexed position in the cast immediately after surgery and then dorsiflexed back to the corrected position during the first cast change when the wound has healed 2 weeks after surgery. This cast change usually requires sedation or general anesthesia on an outpatient basis.

Complications

Clubfoot usually doesn't cause any problems until the child begins to stand and walk. Treatment can put the foot in the correct position and help the child walk well. But the child may still have some problems with:

- Mobility: The foot may be a little stiff and not bend easily.
- Leg length: The leg with clubfoot may be slightly shorter, but this usually doesn't prevent the child from learning to walk.
- Shoe size: The foot may be up to 1 1/2 shoe sizes smaller than the other foot.
- Calf size: The calf muscles on the side with clubfoot may always be smaller than those on the other side.
- Foot shape: The foot is often bean-shaped and has a small point that points inward, even after treatment.

Summary

Clubfoot is a common deformity that occurs in about 1 in every 1,000 births. It is treatable, and in the United States, treatment usually begins a week or two after a baby is born. Nonsurgical treatments are effective in about 90% of people with clubfoot. However, children with severe, recurrent clubfoot, or other health problems may need surgery to correct the condition.

Although the prognosis is good, your child may experience some long-term complications. This includes having slightly smaller feet or having leg muscles that tend to tire more quickly than children of the same age.

Flat foot (also called pes planus or fallen arches)

The arch is formed by the metatarsal bones and metatarsals, passively supported and actively stabilized by ligaments and tendons, allowing the foot to support the weight of the body in a standing position and to fully distribute the forces generated by contact with the ground during walking. All children are born with flat feet, and a normal arch may not develop until they reach the age of 7 to 10 years Pfeiffer [42]. The arch develops during childhood as part of normal growth and strengthening of bones, ligaments, muscles, and tendons. When imbalance occurs, the bones become deformed, or the tendons or ligaments weaken, the foot may become deformed. Flatfoot is a pathological condition in which the entire sole of the foot is in complete or almost complete contact with the ground (Figure 17). Although the most common form is physiological flatfoot, progression to more severe deformities can lead to the development of symptomatic flatfoot, causing subjective complaints and affecting function Haendlmayer and Harris [43]. However, the true significance of clinical findings is often underestimated. In decision making, it is essential to distinguish between different types of flatfoot deformities: infantile or adult, congenital or acquired, flexible or rigid. It is also important to recognize the factors involved in the formation and maintenance of the arch, and to properly assess foot posture to identify flatfoot deformities and differentiate between cases requiring treatment and those requiring only reassurance.

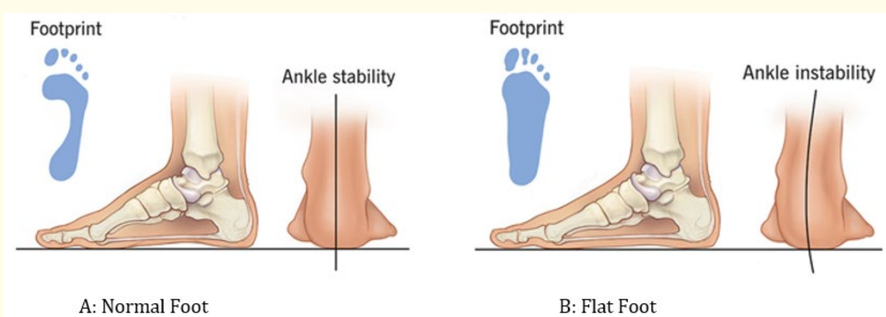


Figure 17A and 17B: *A: Normal foot; B: Flat foot.*

Types of flat foot

Flat feet are classified based on two aspects:

- Arch height: The best parameter to describe the mid-arch structure is the ratio of the height of the scaphoid bone to the length of the foot. It is accepted that the flatness of a normal child's foot is inversely proportional to the child's age.
- Heel tilt: Heel tilt or curvature of the hindfoot is generally accepted as a normal finding in infants and toddlers and is expected to decrease with age. Heel tilt has been used many times to determine foot posture in children. The resting calcaneal posture is a newer method. It has guided clinicians to assess the child's foot posture and recommends decreasing the calcaneal tilt by one degree every 12 months to an upright position by age 7. An upright calcaneal position is optimal for foot function. The average hindfoot angle in children aged 6 to 16 years is 4° (range 0 to 9° valgus) [44].

Rigid or soft flatfoot configuration

1. Flexible flatfoot (flexible FF): The longitudinal arches of the foot are present in a heel-raising (toe-off) and non-weightbearing position but disappear when the foot is fully weightbearing.

- FF is called developmental FF when observed in infants and toddlers and is part of normal development. However, by the age of 8 to 10 years, clinicians may consider it a true FF.

2. Rigid flat feet: The longitudinal arch of the foot is absent in both the heel-raising (toe-stand) and weight-bearing positions. This is often associated with underlying pathology.

Recently proposed guidelines by Harris., *et al*. 2004 [45] and Rao., *et al*. 1992 [46] may contribute to standardizing the management of flat feet, but decision-making should be individualized on a case-by-case basis.

Clinical measurements

Footprints are taken using carbon paper and the length of the foot (excluding the toes) is divided into three equal parts. The arch index (AI) is calculated as the ratio of the area of the middle third of the footprint to the entire footprint area (Figure 18). Normal feet are characterized by an AI of 0.20 to 0.28, while a ratio higher than 0.32 indicates a flat-arched foot [47].

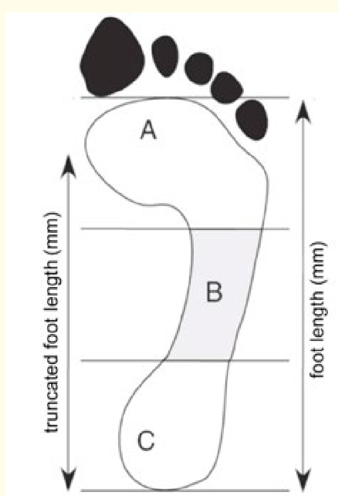


Figure 18: *Clinical measurement of arch index (AI=B/A+B+C). Modified from Murley., et al. (2009).*

Although it is conceivable that AI may be confounded by changes in soft tissue composition, ultrasound examinations have shown no significant differences in plantar fat pad thickness between overweight/obese and non-overweight preschoolers [48]. Therefore, the finding of higher AI in overweight/obese children suggests a true lowering of the mid-arch according to the Jack Test (Figure 19).

Figure 19: *Jack Test. Jack Test demonstrates hindfoot/subtalar flexibility in a flexible flatfoot and is based on principle of "windclass" action of the plantar fascia.*

Jack test and Feiss angle (related) [49]: Perform the Jack test (Figure 19). Manually flex the foot while the child is standing. If the medial longitudinal arch is raised by dorsiflexion, the foot is considered a flexible flatfoot. If the medial longitudinal arch is unchanged, the test indicates a rigid flatfoot. The purpose of this test is to test the flexibility of the foot and the initiation of the hoisting mechanism by stretching the plantar fascia over the extensor portion of the first big toe joint. The Feiss line is the line connecting the medial malleolus, the scaphoid bone, and the head of the first big toe bone. The inclination of this line relative to the ground increases when the first big toe joint is dorsiflexed (Jack test). This dorsiflexion triggers forefoot supination and arch height elevation (140° ± 6°) [49].

Normalized scaphoid height: Normalized (truncated) scaphoid height (NNHt) is the ratio of scaphoid height (measured as the distance from the most prominent middle scaphoid bone to the supporting surface) to the truncated length of the foot (from the first metatarsal joint to the last metatarsal joint of the Gothic foot. Values less than 0.21 indicate a bow-foot [50].

In young adults, NNHt provides the strongest correlation with radiographic measurements. Both clinical measurements (AI and NNHt) can be used successfully to screen for flatfoot posture, avoiding unnecessary referrals for radiographic assessment, and are recommended for recruiting participants to foot posture studies [50].

Radiographic measurements

Radiographic examination of foot shape is useful for assessing expectations and documenting change; it is necessary to establish plan ahead and evaluate the value of the results (Figure 20). For flat feet, this method focuses on the relationship between the metatarsal and plantar bones, which can be assessed on the longitudinal product in the lateral view and on the transverse product on anteroposterior (A-P) radiograph while the subject is at a comfortable force in a relaxed bipedal position [50].

Talocalcaneal angle

The talocalcaneal angle (Kite angle) is formed by the intersection of two lines parallel to the longitudinal axis of the calcaneus and the calcaneus in the horizontal plane. When the talocalcaneal angle increases significantly, both on anteroposterior and lateral radiographs, hindfoot eversion occurs. Calcaneal inclination angle This is the angle between the inferior surface of the calcaneus and the supporting surface, assessed on a lateral radiograph (Figure 18). A lower calcaneal inclination angle indicates a flatter foot, however the suggested normal values refer only to the adult population (range 17.9-25.4° for men and 17.2-23.3° for women).

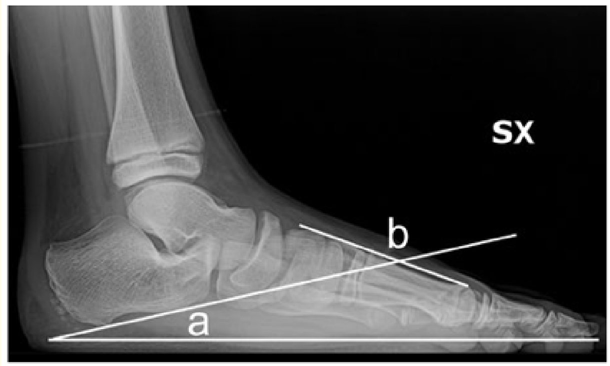


Figure 20: *Flatfoot on the lateral view radiography, in a relaxed, bipedal, weight-bearing stance position. Low calcaneal inclination angle (a) with increased value of calcaneal-first metatarsal angle (b).*

Calcaneal-first metatarsal angle

This is the angle formed on a lateral radiograph by extending a line parallel to the inferior surface of the calcaneus through the dorsum of the foot and the first metatarsal. A larger value indicates a flatter foot, and the suggested normal range is 128.1-136.1° for men and 129.3-137.4° for women.

Talo-scaphoid angle: This angle is formed by a line drawn on the anteroposterior radiograph connecting the anteromedial and anterolateral poles of the head of the talus and a line drawn along the proximal articular surface of the scaphoid. In flat feet, the head of the talus is no longer covered by its articulation with the scaphoid, and the talo-scaphoid angle increases (it may exceed 19.3° in men and 21.7° in women with dorsiflexion).

Flat feet in children

A recent study of 11- to 15-year-olds found no association between the degree of flat feet (as assessed by the arch index) and motor skills or athletic performance [51]. In contrast, the presence of supination rather than pronation (as assessed by the FPI-6) was found to be associated with an increased risk of overuse injuries in adult triathletes and adolescent indoor soccer players. However, undetected and progressive flat feet can lead to structural abnormalities and stress in the feet, as well as the legs and lower back, impairing lower extremity function. Appropriately, concerns about foot posture in children are a common reason for frequent consultation with many health care professionals; Among them, sports medicine specialists are often the first to recognize and advise on foot pathology.

The American Academy of Foot and Ankle Surgeons has developed clinical practice guidelines for the diagnosis and treatment of flat feet in children [52], which were adapted by Evans., *et al*. (2009) [53] in their clinical care pathway for flat feet in children (pediatric flatfoot, p-FFP). Diagnosis should be directed toward determining the type of flat foot.

Symptomatic or asymptomatic:

- Flexible (normal arch visible in non-weight-bearing feet and when standing on tiptoes), which may be physiologic, developmental, i.e. improving over time, or non-physiologic, non-developmental, i.e. progressing with age to a more severe structural deformity;
- Rigid (flat arch in both weight-bearing and non-weight-bearing feet).

Diagnosis can be made through careful history taking, clinical examination, and appropriate imaging. A family history of flat feet suggests that children may have similar problems. The presence of associated conditions known to influence the natural history and severity of flatfoot in children, such as obesity, neurological (cerebral palsy or low muscle tone) or connective tissue disorders (ligamentous laxity, Ehlers-Danlos syndrome), muscular dystrophy, and structural abnormalities above the ankle (e.g. rotational deformity, length discrepancy, tibial vara, genu valgum) should be considered. Subjective symptoms may include postural deformity and pain (usually after bouts of activity), occurring in the foot (usually along the medial aspect of the foot), leg, and knee, leading to decreased strength and cessation of voluntary physical activity. The age of symptom onset is also important (rigid flatfoot with calcaneo-scaphoid fusion becomes symptomatic in children aged 8-12 years, whereas calcaneo-tibial fusion may manifest as early as 12-14 years) [54]. Previous trauma may have exposed the flatfoot, manifesting as clumsiness and frequent falls, or may have been the cause of the deformity (posttraumatic rigid flatfoot). Diagnostic observations focus on mid-arch height, heel (and toe) pronation, and tibia and knee position; observation of other foot characteristics included in the FFI-6 may be a useful tool during repeat assessments over time or during follow-up after treatment. Measurements should include NNHt and RCSP [53]. Evaluation of diagnosed flatfoot should also include assessment of the angle of gait (AOG, deviation of the vertical plane of the foot from the line of progression) and origin of gait (distance between the feet perpendicular to the line of progression) and identification of areas of pain. The differential diagnosis of rigid flatfoot should be supported by imaging to determine the underlying cause [52]:

- Metatarsal fusion, i.e. congenital fusion of bone, cartilage or fibre between bones of the foot, most commonly the calcaneo-caudal or calcaneo-tibial bars; findings include the presence of a fixed valgus hindfoot, pain and loss of motion below the ankle;
- Congenital longitudinal tarsi (metatarsal condyles), due to abnormal ankle dorsiflexion (dorsiflexion); this condition should be detected early after birth as it may be associated with genetic syndromes;
- Flatfoot with peroneal contracture: a painful foot deformity associated with a variety of conditions (e.g. juvenile rheumatoid arthritis, osteochondritis dissecans of the hindfoot) or idiopathic (hence, diagnosis by exclusion), in which spasm of the extrinsic muscles restricts movement below the ankle and below the ankle, causing the foot to splay outward and be painful on activity;
- Iatrogenic or post-traumatic deformities, resulting from under- or over-correction of primary foot deformities and manipulation or casting of the feet of infants.

Treatment options

Conservative care

Most patients find that they can control their symptoms using non-surgical treatments. Footwear is key. The right shoe size, width and depth are key with adequate support to keep the foot in the correct position (lacing). You will be advised on the best shoe for your problem. Flexible footwear should be avoided. If the shoe does not fit properly, the remaining non-surgical treatments are unlikely to be effective in the long term. A combination of the following options is often used:

- When active, use a stiff, firmly laced shoe with a cushioned insole. Examples: hiking boots or MBT-style shoes
- Special shoe inserts called orthotics
- Ice packs
- Anti-inflammatory and pain medications
- Cortisone injections combined with the above treatments
- Physical therapy/Stretching exercises for the calf and hamstring muscles
- Swede-O Ankle Lok braces with straps (see image below) can be very effective in supporting the foot in an improved position. These are usually easy to put on the shoe and can be purchased online.

Surgical management

Surgery to correct flat feet can be complicated and is not necessary in most cases. Surgery is only considered when a person has severe pain that does not improve with conservative care and sometimes in children when the deformity is severe. Cases where the foot position is severely affected or the joint is very mobile (hypermobile) may require surgery to correct it.

Often, a combination of techniques and procedures is needed to restore good foot alignment. Different types of surgery include osteotomies (cutting the bone to realign), joint fixation, tendon lengthening and tendon transfers, and implanted devices to help maintain the correction. The combination that is needed for you will be determined by your podiatrist and will be discussed with you if you decide to have surgery.

Most patients who undergo surgery to correct flat feet will have a long and challenging post-operative regimen.

Overall, 95% of patients are satisfied with this type of surgery, although it can take up to a year to fully recover.

All surgeries have some risks. These include the general risks of surgery and anesthesia, including deep vein thrombosis, pulmonary embolism (blood clot in the lungs) which can sometimes be fatal, problems with anesthesia, infection, and problems with wound healing.

Complications specific to this type of surgery include:

- Pain that does not improve or becomes worse.
- Recurrence of flat feet due to re-rupture of the reconstructed tendon.
- Stiffness of the ankle and foot.
- Persistent swelling.
- Nerve and blood vessel damage
- Requires a second minor surgery to remove the screw or metal plate.
- The bone does not fuse together, requiring additional surgery.

Summary

Flat feet occur when a person has little or no arch in their foot, which often causes problems when walking and sometimes pain. There are many different causes of flat feet, and not all of them cause discomfort and symptoms.

When this condition develops in children, it usually disappears as the child gets older. Treatment may be needed if it is painful or affects a person's early life. This usually involves foot orthotics and anti-inflammatory medications. In rare cases, a person may need surgery.

Congenital adductus varus

Metatarsus adductus (MTA) was first described by Henke in 1863 but was rarely reported in the literature until 1940 (Tax 1985, p. 356) [55] (Figure 21). MTA is a relatively common congenital foot anomaly, reported to occur in 1:1000 live births and has an increased incidence in later-generation siblings of 1:10 ([56], p. 2612) (Figure 19). An average of 55 new cases of MTA are referred to the Adelaide Women's and Children's Hospital each year. Trott (1982) [57] believes that some degree of MTA is present in 70 percent.

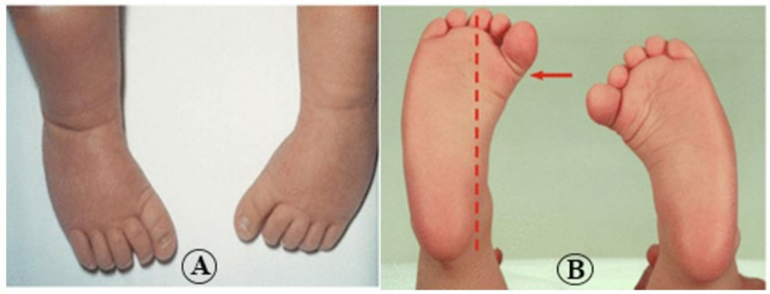


Figure 21: *A: Normal and B: Adductus varus foot.*

Berg [58] extended his study of 124 feet of adduction radiographs and presented simple adduction (51 feet), complex adduction with the midfoot pushed to one side (42 feet), simple adduction with the hindfoot in valgus (16 feet), and complex adduction with the midfoot pushed to one side and the hindfoot in valgus (15 feet). Simple adduction may be considered a third deformity of clubfoot, as clubfoot presents with two other abnormalities: marked hindfoot eversion and ankle inversion. The prevalence of hallux valgus varies, Cornwall., *et al.* [59] reported 8.8% to 15% of the population, but others have suggested a much higher prevalence. Genetics has been shown to account for only two to four percent of all cases of hallux valgus. Abnormal intrauterine position is one of the most widely accepted theories of the cause of hallux valgus, supported by studies showing a disproportionate number of affected infants in first-time mothers. Most authors report a slight male predominance with a ratio of approximately 1.3:1. Various classifications have been reported to determine the severity of the deviation (mild, moderate, and severe), the criteria being clinical with assessment of range of motion and adduction correction, or radiographic with assessment of metatarsal angle. Reports of a high percentage of self-correcting cases have led many orthopedists to adopt a policy of observation rather than aggressive treatment. However, studies by Ponseti and Becker (1966) [56] and Rushforth (1978) [60] have shown that at least 14 percent of their MTA cases fail to correct spontaneously and require treatment. Persistent MTA cases become more structured and fixed as the months go by, making conservative correction increasingly difficult, especially in children over 12 months of age [61].

The difficulty in deciding whether to treat MTA aggressively or simply wait for spontaneous correction is because current subjective assessment of MTA does not provide a reliable method for predicting which feet will fail to correct spontaneously and therefore require treatment [58]. An attempt by Berg (1986) [58] to objectively assess MTA with X-rays was not supported by reliability studies and ethical considerations need to be considered in exposing infants to X-ray radiation for assessment purposes only, which is not necessary for diagnosis and does not provide predictive value regarding treatment options or outcome. The split heel method developed by Bleck (1973) [62] has provided a reliable measure of forefoot adduction but its clinical application is limited. The forefoot adduction device (FAMD), developed from Bleck's forefoot adduction concept, is a noninvasive, reliable and objective method of measuring forefoot adduction but the measurement must be performed on plantar photographs [63]. In the biomechanical literature, it has been suggested that although MTA is rarely painful in children, the excessive pronation that occurs to compensate for forefoot adduction can cause secondary problems in the lower extremities later in life with symptoms [64]. It seems unethical to delay treatment of a foot deformity that is likely to be of considerable persistence but will respond well to treatment in childhood. Serial fixation patches have become the mainstay of MTA treatment largely because alternative methods fail to address the components necessary to correct the deformity [61].

When the cast is removed, the night cast used for many months to maintain foot alignment needs to be replaced regularly as the child grows. Surgery may be indicated in cases where the fixed deformity does not respond to conservative treatment [56]. The prefabricated polypropylene splint designed by Chong (1991) [61] was found to be an effective and cost-effective treatment for MTA. These splints are not available in Australia, so this reviewer designed a custom thermoplastic splint that embodies the correcting properties of a plaster cast and can save the time of changing the plaster cast and splint at night.

McHale and Lenhart [65] first reported the results of this procedure in the literature in 1991. Others have since reported the results of patients treated with a combination of open and closed wedge osteotomies. This study reports the results of this procedure in correcting forefoot adduction in a variety of populations.

Several surgical procedures have been described for the treatment of forefoot adduction. Some involve soft tissue release; Other procedures involve multiple bone surgeries to relieve the problem.

Clinical

Chart based on demographic data, preoperative symptoms, surgical data, and complications. The infant or child presents with fixed adduction of the forefoot relative to the hindfoot. The lateral border of the foot is convex and the medial border of the foot is hollow. The head of the fifth metatarsal bone is protruding and the forefoot is slightly everted. In more severe cases, there is a prominent medial crease in the forefoot. The hindfoot is slightly everted. The heel cord does not retract (Figure 22).

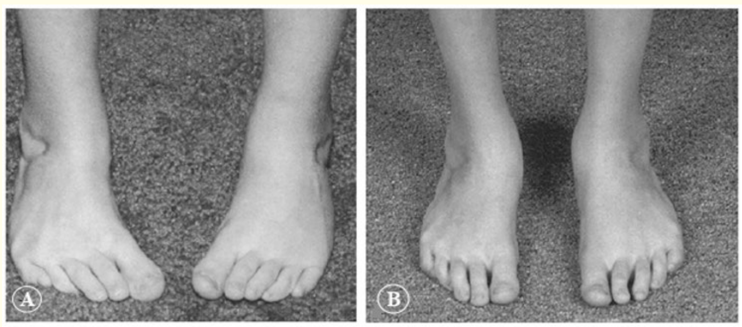


Figure 22A and 22B: *A: Clinical appearance of foot preoperatively in a 5-year-old boy with a diagnosis of metatarsus adductus. B: Clinical appearance of the foot 2 years postoperatively; the lateral border is straight.*

The flexibility of the defect should be assessed. In mild clubfoot, stroking the lateral border of the foot will result in active correction of the odd forefoot. In moderate clubfoot, the examiner can passively correct the forefoot. The rigid complexes have deep creases in the mid-forefoot and cannot be passively corrected to neutral.

Clinical assessment

Assessment of pre-strategic readiness showed that all patients had satisfactory hindfoot alignment without lateral, medial, or interosseous stiffness. The forefoot was equidistant (Figure 20) when assessed by the Bleck method [62] in all patients. The stratified assessment was based on modifications of the Heyman., *et al.* criteria [66] satisfactory results were considered normal alignment of the forefoot or mild to moderate to severe inward turning of the toes (assessed by the Bleck method), with parents and physicians satisfied with the results, and unsatisfactory results were considered moderate to severe deformities requiring further treatment, with parents and physicians dissatisfied with the results.

Radiographs

X-rays or other imaging studies are usually not necessary because the natural course of most cases is benign and self-healing. However, with persistent deformities, simulated or weight-bearing postures may demonstrate wedge formation in the trapezius and drift velocity in the metatarsals.

X-ray analysis of these feet is difficult because different authors use different parameters to assess forefoot deformity. Although the mean first metatarsal-first metatarsal angle of the Reflex Adjustment group was recorded clinically and qualitatively, we found the second metatarsal-second metatarsal angle, as reported by Simons [67], to be inconsistent and unreproducible. Pre- and post-algorithm evaluation of lateral column ratios determined that the procedure improved the relative lengths of the columns.

Postoperative evaluation classifies radiographic results as satisfactory (angle within normal limits) or unsatisfactory (angle less than -10°) (Figure 23).

Two radiographic measurements are used to evaluate results:

- First metatarsal-first metatarsal angle: This angle is formed by the metatarsal axis and the first metatarsal axis. In a normal foot, the metatarsal axis is lateral to the metatarsal axis and ranges from 0° to 20°. In forefoot adduction, whether due to adductor pollicis or partial calcaneal dislocation, the metatarsal axis is medial to the metatarsal axis.
- Scaven-first metatarsal angle: This angle is formed by the metatarsal axis and the transverse axis of the scaphoid. In the normal foot, this angle ranges from 80° to 100° and an angle greater than 100° indicates a metatarsal adduction position [69].

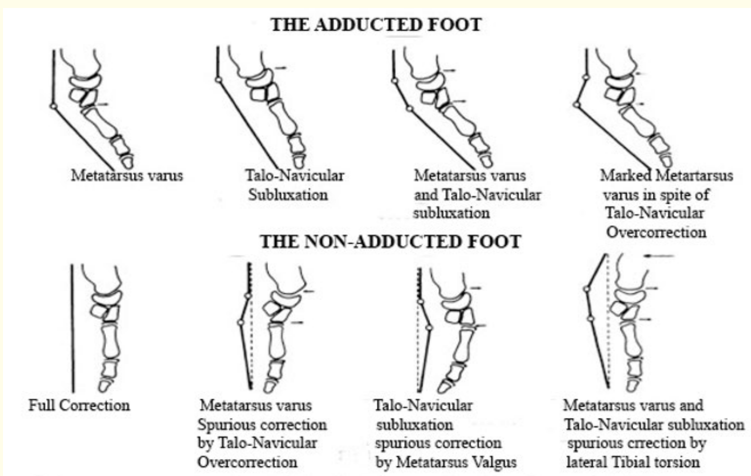


Figure 23: *Residual deformities which may be seen in the adducted or non- adducted foot after operative correction.*

By measuring both angles, the true cause of the forefoot adduction can be determined and whether there is an ankle dislocation or a metatarsal dislocation (Figure 21) summarizing the possible combinations. The remaining adduction can be due to an ankle dislocation or a metatarsal dislocation, a combination of both, or a severe metatarsal dislocation with metatarsal overcorrection. A nonadducted foot, i.e. a clinically normal foot, may be completely corrected or may be maladjusted (such as a metatarsal dislocation) that is clearly corrected by metatarsal overcorrection or a metatarsal dislocation that is clearly corrected by metatarsal flexion or a metatarsal dislocation and/or a metatarsal dislocation that is clearly corrected by external tibial torsion.

Classification

Bleck describes two classification systems. The heel bisector classification describes the relationship between the heel axis and the forefoot. A line is drawn through the heel axis extending into the forefoot, and the bisector moves laterally through the forefoot as the severity increases [62] Another system classifies metatarsal adduction according to flexibility. With the heel held by a fulcrum at the base of the fifth metatarsal, the forefoot is pushed laterally to determine the extent to which the lateral contour of the foot can be adjusted.

Feet that are excessively adjustable are referred to as “flexible”. The metatarsal position may be normal but if the toes are aligned with the metatarsals they will appear medially displaced [69]. Objective measurements of MTA have been attempted using X-rays [58], the heel cup method [62] and more recently the forefoot adduction device.

Common subjective assessment procedures

Flexibility is assessed by estimating the degree of passive correction of the forefoot from the expected neutral position of a normal foot while the hindfoot is stable. In the literature, the flexibility classification appears to be the most commonly used criteria for classification, where:

- Flexible:
- The forefoot can easily be passively moved away from the midline of the foot partially flexible.
- The forefoot can be passively moved away from neutral position stiff.
- The forefoot cannot be passively moved away from neutral position [55].
- Moderate: The metatarsals are more adducted and the great toe is separated from the other toes. There is a clear convex lateral border and the foot can only be adjusted to a neutral position.
- Severe: The metatarsals are adducted and often directed posteriorly. The great toe is separated and the heel may be in a neutral or deviated position. The medial border is concave, often with deep skin folds and the lateral border is convex with the base of the fifth metatarsal protruding. The foot cannot be adjusted to a neutral position actively or passively.

Classification of MTA on radiographs

Radiographs are not considered essential for the diagnosis of MTA but can provide quantification by angular measurements to classify the severity and determine appropriate management [53].

The talocalcaneal angle is the angle between the vertical bifurcation of the head of the talus and the vertical bifurcation of the calcaneus (Figure 24). In a normal foot, the calcaneal bifurcation usually intersects the cuboid or the base of the fourth metatarsal if the cuboid is not visible on radiographs. In MTA, this line is located in the middle third of the cuboid or base of the fourth metatarsal. The talocalcaneal angle is usually 200-300. In MTA, this angle exceeds the upper limit of normal due to the anterior and medial displacement of the metatarsal head relative to the calcaneus, indicating a valgus position of the hindfoot and distinguishing MTA from clubfoot [56].

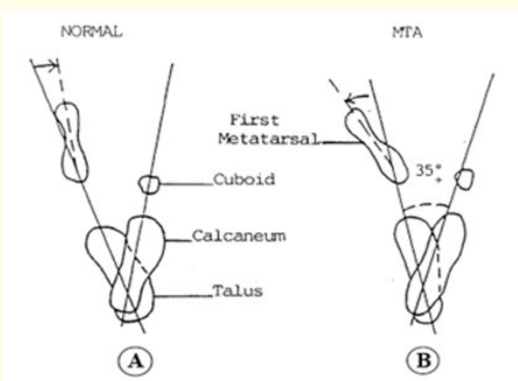


Figure 24A and 24B: *Talocalcaneal angle A-B. A: Normal foot - the first metatarsal line is lateral or parallel to the talar bisection and the calcaneal bisection, bisects the cuboid; B: MTA - the first metatarsal line is medial to the talar bisection and the calcaneal bisection intersects the medial one third of the cuboid [56].*

MTA angle

MTA angle is the angle formed between the longitudinal bisector of the second metatarsal bone and the perpendicular to the longitudinal axis of the medial cuneiform bone, ranging from 100 to 200 in normal people. This angle also increases in MTA (Figure 25).

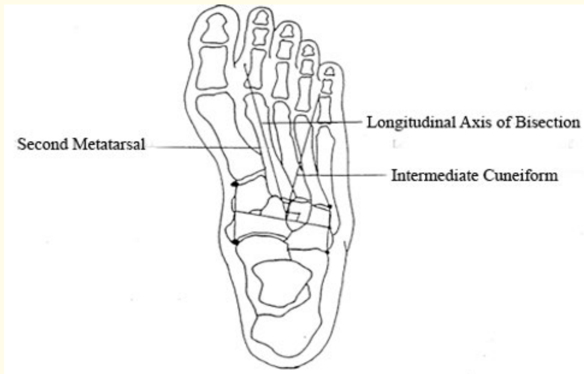


Figure 25: *The MTA angle. The longitudinal axis of the intermediate cuneiform is determined by marking the mid point between the first tarsometatarsal joint and the talonavicular articulation on the medial side and the mid point between the calcaneocuboid articulation and the fourth tarsometatarsal joint.*

Berg (1986) [58] attempted to develop a comprehensive radiographic assessment to differentiate MTA from normal infant feet based on the spectrum of nomenclature found in the literature (Figure 24). He describes the normal infant foot on radiographs as follows:

- Forefoot: A line drawn through the longitudinal axis of the first metatarsal parallel to or diverging horizontally from a line drawn through the longitudinal axis of the talus.
- Midfoot: A line through the longitudinal axis of the calcaneus should bisect the cuboid or base of the fourth metatarsal if the cuboid is not ossified.
- Hindfoot: The talocalcaneal angle on the A/P view should be between 20°-35°. Four variants of the deformity vary in complexity, based on the talocalcaneal and talus angles of the first metatarsal.

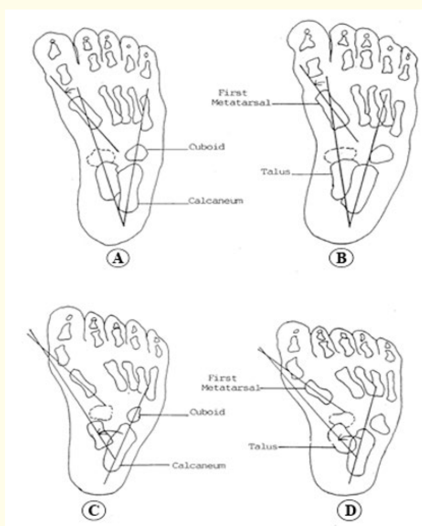


Figure 26A-26D: *Radiographic classification of MTA. A: Simple MTA, B: Complex MTA, C: Simple skewfoot, D: Complex skewfoot [58].*

No reliability studies have been performed to determine the accuracy of the construction of the required angles (Figure 26). Due to the size and immaturity of the infant's bones, the accuracy of the angles drawn is questionable. It is also necessary to consider the ethics of exposing infants to X-ray radiation when they are non-diagnostic and do not provide decisive predictive value regarding treatment options and outcomes [58].

Bleck's Heel Bisector

Bleck (1971) [64] took a silicon mold impression of the subject's foot to determine that the heel-bearing image was an ellipse with a constant vertical axis (heel bisector). In a study of 1,000 children with 'normal' feet, aged 6 months to 16 years, he found that the heel bisector intersected the second and third toes in 85 per cent, but he did not state the range of toe deviation in this group or how reliable his method of assessment was. He later (1982) classified MTA according to the degree of variation from this midline 'norm':

- Mild - The heel bisector intersects the third toe.
- Moderate - The heel bisector lies between the third and fourth toes or intersects the fourth toe.
- Severe - The heel bisector lies between the fourth and fifth toes or intersects the fifth toe.

Bleck (1971) [64] also described the angle of the midfoot contour with the heel bisector, but did not mention his reference points or the reliability of constructing this angle. In normal feet, he stated that this angle was measured as 30-7° and in adducted feet, this angle was 10°-25°. Assess foot deformity according to Bleck's Classification [64] (Figure 27).

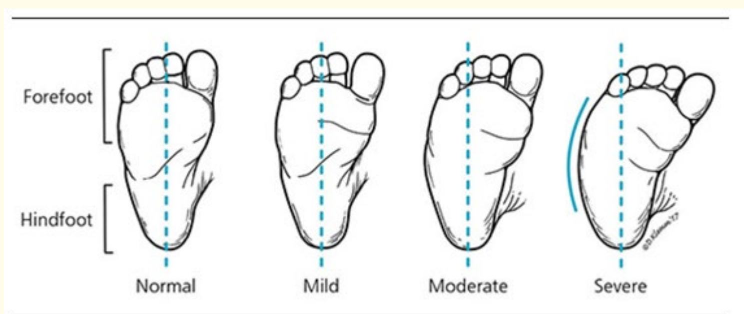


Figure 27: *Heel bisector defines relationship of heel to forefoot from left to right: normal (bisecting second and third toes), mild metatarsus adductus (bisecting third toe), moderate metatarsus adductus (bisecting third and fourth toes), and severe metatarsus adductus (bisecting fourth and fifth toes) [64].*

Forefoot adduction device

Dwyer (1989) [71] incorporated Bleck's ideas into the development of a standard heel bisector reference system, the Forefoot Adduction Device (FAMD). The FAMD consists of three standard heel ellipse sizes with the same axial ratio and therefore the same heel bisector, established from a sample of 61 normal subjects (aged two years to adulthood) (Appendix 3). The sole of the foot was photographed with the subject standing on a transparent plastic box and the photographed image was then projected onto a wall. The FAMD was printed on a transparent plastic sheet placed over the projected image of the foot with the best-fit heel ellipse aligned with the heel indentation and the heel bisector aligned with the longitudinal axis of the heel ellipse. The intersection of the heel bisector between the second and third toes was assigned a value of zero, based on the findings of Bleck (1971) [63] for normal feet. The deviation of the heel bisector from this zero value was estimated visually to the nearest eighth of the toe. A measurement error of 0 +/- 0.25 toe-in (FAMD) was considered to be of no clinical significance.

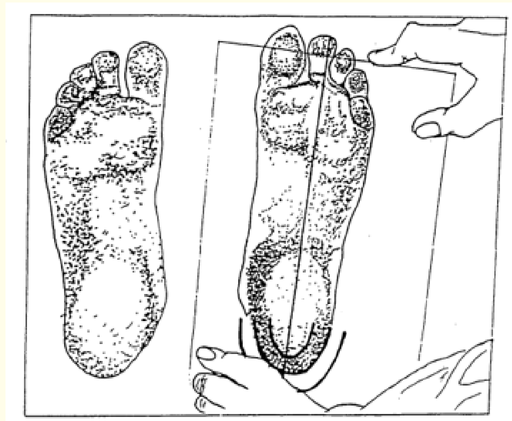


Figure 28: *Measurement of forefoot adduction. Forefoot adduction was measured by Dwyer using the FAMD on a photographic image of the sole of the foot (modified from Dwyer 1989).*

Results from Dwyer's (2017) [71] study showed high intra-rater reliability (Figure 28). The 90 percent confidence intervals at initial testing were 0.103 to 0.173 with a mean of 0.138 toes (FAMD) and at re-evaluation were 0.112 to 0.176 with a mean of 0.144 toes (FAMD). The test/rest confidence intervals were virtually identical, indicating a high level of consistency. The mean difference of -0.006 toes (FAMD) (SD = 0.167) was not significant, suggesting to Dwyer that there was no rater bias. The inter-rater reliability findings were inconclusive. The 90 percent confidence interval for independent raters' measurements of the same subject examined by Dwyer [80] was 0.273 to 0.427 with a mean of 0.35 toes (FAMD). This confidence interval (0.154 toes) was larger than that obtained by Dwyer (0.07 toes), indicating more variability in the measurements of the independent raters. The mean difference of 0.217 toes (FAMD) also indicated that the independent raters were consistently biased in over-reading the toe deviation toward the third toe by 0.25 toes (FAMD). However, Dwyer stated that this finding was still within the acceptable margin of error (+/- 0.25 toes, FAMD) and attributed it to differences in experience between the two raters using the FAMD. Dwyer [80] found a mean toe deviation of 0.12 toes (FAMD) (median 0.00 toes, FAMD) which she found consistent with the findings of Bleck (1971) [56]. The accuracy of FAMD was not affected by normal foot development (age), sex, or whether the foot was assessed as right or left. This assessment method is simpler than the method used by Bleck (1971) [56] but still does not provide the clinician with an immediate, objective assessment and, as Dwyer noted, is only partially validated.

Summary of MTA assessment and classification

Subjective assessment is most commonly used in clinical settings to assess MTA. Measurements taken from radiographs may be unreliable, especially in infants whose bones have not fully ossified. The closed forefoot device is a simple, non-invasive tool that provides a reliable measurement of foot shape in people over the age of two, which can be classified as mild, moderate and severe. The device can be adjusted to allow the clinician to obtain an objective measurement at first glance, but its reliability needs to be tested in children of a wide range of ages (including 0-2 year olds) with 'normal' feet.

Treatment - Surgery

The natural process of flexible hindfoot adduction is a spontaneous correction with continued growth. Although passive stretching is often recommended, there are no studies documenting its effectiveness. Inappropriate aggressive treatment may result in lateral deviation and valgus deformity.

Most cases of flexible hindfoot adduction with mild deformity will correct without treatment. Passive stretching exercises are often recommended although some argue that parental stretching is ineffective and can be harmful, especially if not performed properly. Shoe inversion is often performed for moderate or severe hindfoot adduction before 6 months of age. Sequential correction splinting may be helpful for stiff or incomplete hindfoot adduction. The typical age group for casting is 6 to 12 months. Mild plantar flexion should be used when casting short legs to minimize the risk of developing a valgus foot. Inverted shoeing is recommended after casting to maintain correction.

Forefoot adduction is rarely performed before age 5. Mild forefoot adduction is likely to correct spontaneously before age 5. Mild forefoot adduction persists into adulthood without disability. If a severe case in a young child is not casted earlier, release of the abductor hallucis longus with or without osteotomy of the middle toe and first tibia has been successful. Pain or problems with shoe fitting are typical indications for such a procedure.

Mild, passively correctable deformities may resolve spontaneously by age 3 or 4 (Ponseti 1966), and remaining mild deformities are benign. If the foot is only partially or not flexible, continuous reduction and casting or splinting may be effective, usually for 6 months to 1 year. A prospective randomized trial of casting versus orthotic treatment for refractory forefoot adduction demonstrated that the orthotic group had greater improvement in heel bisector measurements. However, footprint and radiographic improvement were noted with both methods without the development of hindfoot varus. The orthotic program requires more active parental involvement but is less expensive.

Surgical treatment is rarely indicated but may include abductor hallucis longus release, medial capsulotomy, or osteotomy (Figure 27). However, these surgical treatments are not supported by reliable outcome data and have been described as having high failure rates. In the rare case of an older child with persistent disabling deformity, options include open wedge osteotomy of the medial sphenoid bone with or without closed wedge osteotomy of the cuboid bone or two to four metatarsal base osteotomies (Figure 29).

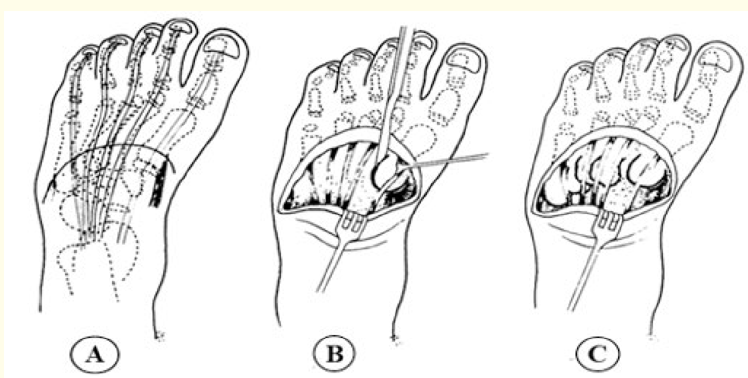


Figure 29A-29C: *Drawings show the steps of the operation to correct adduction deformity of the fore part of the foot. The outlines of the fore part of the foot and bones are accurate tracings of roentgenograms made before operation and immediately after the cast was removed.*

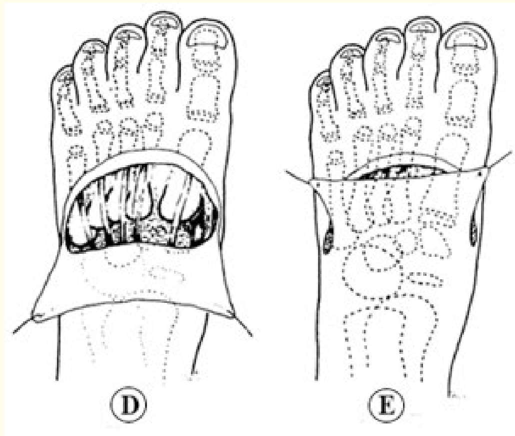


Figure 30D and 30E: *D: The fore part of the foot can then be abducted to the corrected or abducted position without much resistance, as shown in drawing. One can also expose the cuneiform bones and cut the ligaments surrounding them. E: Note that the superimposition and the apparent varus deformity or inward twisting of the middle three metatarsals is now greatly improved as shown in drawing. The wound is closed and a well molded plaster cast is applied, with the fore part of the foot maintained in the corrected position.*

Double osteotomies address the problem by lengthening the medial column by removing a wedge from the lateral column (Figure 30). This operation affects both sides of the deformity, allowing for better correction than a single procedure on just one column.

Double tarsal osteotomies, including closed wedge cuboid osteotomies and open medial wedge cuboid osteotomies, have been described for older children with symptomatic varus. Often the cuboid bone is too small or too soft to be used for open medial wedge cuboid osteotomies, so allografts are required. In particularly severe deformities, cuboid and medial wedge osteotomies may be combined with multiple osteotomies at the base of the metatarsal bones.

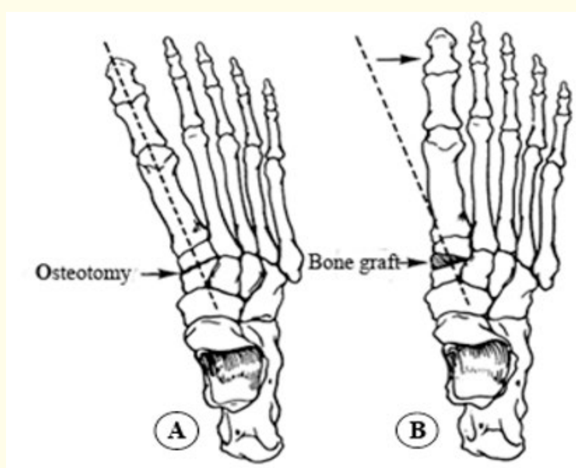


Figure 31A and 31B: *Opening wedge osteotomy of the first cuneiform. A: The defect is replaced by a triangle shaped bone graft (autogenous or homogenous) and B: The osteotomy is held in the corrected position by a transfixation pin [72].*

Our finding of 56% residual forefoot adduction after staged posterior release [73] is very similar to that reported by Lowe and Hannon (1973) [74] (Figure 31). In their series, various surgeries, including osteotomies, were performed on 73 feet and 52% of feet had residual adduction, mainly due to metatarsal subluxation. These authors suggested that treatment outcomes in clubfoot would be improved if more attention was paid to significant metatarsal subluxation, by isolating the origin of the abductor hallucis longus with tenotomy as an adjunct.

Main and Crider (1978) [75] reported 69% forefoot adduction in a group of 63 feet and found that the cause of the residual deformity was metatarsal subluxation. Dislocation of the medial scaphoid joint was found to be the most important factor influencing both foot shape and ankle external rotation. According to them, translation of the talus-scaphoid joint correlated with a good outcome after surgical treatment, and the timing of surgery determined the degree of translation that could be achieved; therefore, they advocated early translation of the talus-scaphoid joint. In our study, the presence of initial varus foot was not important, and the difference between our results and those of Main and Crider may be explained by different surgical approaches: while their series included patients treated with the posterior release theory or the limited posterior release theory (including release of the adductor hallucis but not the talus-scaphoid joint), Turco placed great emphasis on open reduction of the talus-scaphoid joint and emphasized internal fixation (1971, 1979) [74].

Despite the residual forefoot adduction in our series, single-stage internal fixation appears to be an effective method for correcting clubfoot regardless of age, provided that greater attention is paid to metatarsal varus. To improve these results, the age at surgery was reduced and abduction of the great toe and release of the short plantar fascia were added to the surgical procedure. In the first group of patients aged 3 to 10 months (22 feet), the modified procedure successfully corrected forefoot adduction in 91% of feet [76].

Hung., *et al*. [77] reported: Open wedge osteotomy combined with closed wedge osteotomy combined with fibula graft for foot closure in children (Figure 32). The authors of this study were a retrospective study of 54 feet with 36 feet having recurrent clubfoot and 19 feet having congenital adduction. Orthopedic examination included gait, presence of other extra-foot deformities, components of foot deformity, range of motion. Feet were evaluated for forefoot adduction using the Bleck method. Radiographic evaluation: The ossification center at the medial cuneiform is visible on the anteroposterior view. Specific measurements were taken for the length of the medial column and the length of the cuboid. The shafts of the talus, calcaneus, shafts of the first and fifth metatarsals. In the anteroposterior view of the foot, the anterior talar angle, the anterior talar-first metatarsal angle, the calcaneus-fifth metatarsal angle, and the lateral talar-first metatarsal angle were measured.

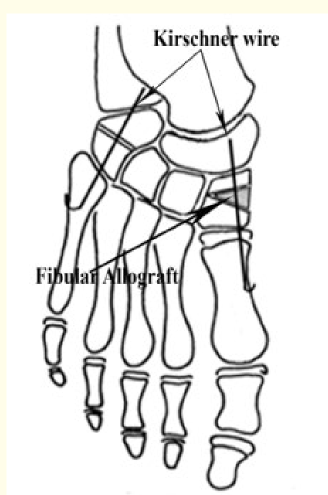


Figure 32: *The bone graft is seated into position of the foot.*

Surgical technique: Cuneiform and cube osteotomy with fibula graft (Figure 31). Evaluation according to Heymn., *et al*. The mean age at surgery was 64 months; Additional surgical techniques for unequal/cuboid osteotomy: Plane fasciotomy: 14/54, Abductor hallucis longus tendon lengthening: 27/54, Achilles longus tendon lengthening: 16/54; Follow-up time: 62.5 months. Overall surgical results (RCF & CMA): Excellent: 17, Good: 27, Fair: 06; Poor: 04. Acceptable results (Excellent + Good): 44/54 (81.5%) (Figure 33).

Figure 33A and 33B: *A: Kirschner wires from the medial cuneiform into the navicular bone; B: Kirschner wires from the cuboid into the calcaneus bone.*

Complications

As with any foot surgery, painful scarring may occur. Branches of the sural nerve are particularly at risk during block exposure. Injury to the growth plate of the first metatarsal may result in brachymetatarsia or angular deformity. Release of the medial capsule of the tarsometatarsal joint is no longer favored due to high recurrence rates. Hallux valgus may occur after release of the abductor hallux valgus. Excessive casting or splinting of the mildly adducted metatarsal bones may result in hindfoot valgus and further foot deformity.

Conclusion

Children may be born with foot deformities for a variety of reasons. Some may be due to genetic defects, while others may be due to congenital trauma or developmental or functional abnormalities during pregnancy. In some cases, maternal medications during pregnancy may also contribute to foot deformities in infants. However, early detection and prompt treatment can help prevent long-term problems and ensure normal foot development. Most treatments include conservative measures, such as monitoring, stretching, and splinting, which can be easily performed in a family medicine setting. Cases requiring orthopedic surgery should be evaluated by a pediatric foot and lower extremity specialist. When surgery is indicated, the procedure is usually delayed for six to nine months so that the child can better tolerate anesthesia.

Clubfoot can occur in one or both feet. The condition is usually diagnosed prenatally by prenatal ultrasound. Congenital flatfoot is also characterized by a rigid, unalignable foot. The Ponseti method is the international standard treatment for clubfoot and has a high success rate when started in the first few weeks of life. Both conditions require prompt treatment to prevent long-term problems. It is important that families adhere to the entire treatment regimen, as stopping braces too early can cause the clubfoot to return and may require surgery.

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