CHARLES UNIVERSITY

FACULTY OF PHYSICAL EDUCATION AND SPORTS

Department of Physiotherapy

Case study of physiotherapeutic treatment of a patient after fracture of distal right tibia and distal right radius

Bachelor's thesis

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Abstract

Title: Case study of physiotherapeutic treatment of a patient after fracture of distal right tibia and distal right radius

Thesis aim: The aim of this thesis is to initially get an overview of all the parameters that act or are related to the present patient's problem. A review of anatomy, kinesiology, physiology and biomechanics to assess, understand the problem and provide the adapted rehabilitation program. Practically, the aim of the thesis is to show the relation with the theoretical knowledge and the application of the range of physiotherapeutic treatment learnt during the three years of studies. The practical part show the ability to identify the restricted components, to apply the needed treatment and assess the progress of the therapy applied.

Clinical findings: This study deal with a 17 years old patient with the diagnosis of fracture of the distal right radius and distal right tibia. The assessement reveal restriction of the mobility and joint play at ankle joint. The ankle joint is painful only during pressure in flexion direction. Any pathological parameter has been found, express and felt, the right wrist is healthy and shows the same normal physiological parameters as his left wrist.

Methods: All the used procedures were based on the literature given thought by Charles University in Prague, Faculty of Physical Education and Sports. Post isometric relaxation, mobilisation techniques related the ankle and foot joints, soft tissue techniques, active strengthening exercises has been the most used techniques. Also the ability to think by my own to find variety of exercises and combination of treatment that may be more efficient or that increases the interest of the patient.

Result: Following 10 therapeutic sessions for the ankle joint, the patient felt great decrease of pain following the first day of therapy, the mobility of the ankle joint as improved progressively.

Conclusion: The therapies performed during the work placement have been effective for the patient's situation.

Keywords: Broken distal right tibia, ankle joint, mobility restriction, ankle stiffness

Abstrakt

Název: Případová studie fyzioterapeutické léčby pacienta po zlomenině distální pravé holeně a distální pravé kosti vřetenní

Cíle práce: Cílem této práce je nejprve získat přehled o všech aspektech, které ovlivňují nebo souvisejí se současnými problémy pacienta. Dáje je v práci proveden přehled anatomie, kineziologie, fyziologie a biomechaniky k posouzení a pochopení problému pacienta a zajištění vhodného a uzpůsobeného rehabilitačního programu. Z praktického pohledu je pak cílem této práce provázání teoretických znalostí a praktických zkušeností z fyzioterapeutické léčby získaných během tříletého studia fyzioterapie. Praktická část této ukazuje schopnost identifikovat jednotlivé detaily, nezbytné pro aplikace potřebné léčby a zhodnocení postupu aplikované terapie.

Klinické nálezy práce: Tato práce se zabývá 17letým pacientem s diagnózou zlomeniny distální pravé holeně a distální pravé kosti vřetenní. Posuzování pacienta v rámci této práce odhaluje omezení pohybu kloubu kotníku a bolestivost kloubu kotníku při tlaku v ohybu. Nebyly nalezeny, ani pacientem vysloveny či vnímány jakékoliv patologické limity. Pravé zápěstí pacienta bylo zdravé a vykazovalo stejné normální fyziologické parametry jako pacientovo levé zápěstí.

Metody: Všechny použité postupy byly založeny na literatuře, doporučovanou Univerzitou Karlovou v Praze, Fakultou tělesné výchovy a sportu. Mezi nejčastěji používané techniky v rámci práce patřily post isometrická relaxace, mobilizační techniky související s kloubem kotníků a nohou, techniky měkkých tkání a aktivní posilovací cvičení. Student použil také vlastní nápady, aby vymyslel různá cvičení a kombinace léčby, která byla účinnější a která zvýšila zájem pacienta o léčbu.

Výsledek: po deseti terapeutických procedurách na kotníkový kloub pacient cítil významný pokles bolesti a postupné zlepšování pohyblivost kotníku.

Závěr: Terapie aplikovaná na pacienta v rámci práce během byla pro pacienta účinná.

Klíčová slova: zlomená distální pravá holenní kost, kotník, omezení pohyblivosti, ztuhlost kotníku

Declaration

I hereby declare that the produced work is entirely my own personal and individual. I state also that all the information, examination and therapeutic procedures present in the thesis were based on the knowledge i have been teached by all the professors of FTVS Charles University in Prague. The theoretical informations used has been sourced on a list of literature present at the end of the thesis.

I declare that no invasive methods were used during the practical approach and that the patient was fully aware of the procedure given at any time.

Prague, March 2018 **Mortreux Maxence**

Acknowledgement

I would like to express all my gratitude to my professors who spend time and energy to teach me to become a professional, in the techniques aswell as in the theorique. I would like to personally thank my supervisor PhDr. Lenka Strapova, Ph.D, for guiding me and for being a great and precious help during my bachelor thesis and during its supervision.

Dedication

I dedicate this thesis to my parents and big sister, without whom i would have never been able to access the physiotherapy studies at FTVS Charles University in Prague, their support has been unconditional and constant during all my time study. I will never thank them enough for giving me this chance.

I would like to dedicate this thesis to my father who has always been my greatest and main source of inspiration and who taught me strength, and endurance in my determination of achieving goals and adaptation when you are out your comfort zone.

I dedicate this thesis also to my sport trainer here in Prague, he has been an amazing support through the trainings by bringing me self confidence, the taste of going pass through limits and effort. He has been a great source of motivation and inspiration.

Table of content

1 Intoduction

The proposed following thesis subject is about a 17 years old man, who fractured the distal radius and the distal tibia after falling from 5 meter height. The fracture of the distal radius has been treated, exercised and rehabilitated by the ergotherapy department.

The thesis is divided into three parts, the first part concern the theoretical knowledge that describes the anatomy, the kinesiology, the biomechanics related to the ankle joint. Then it present the clinical picture of the patient's problems, the process of the fracture, the pathogenesis, the physiological reactions, the adaptations and surgical techniques related to the patient's fracture.

The second part of the thesis deal with the practical part, that integrate the first complete clinical assessment of the patient, posture, gait, movement patterns, neurological aspect, mobility of the joints play, joint rang of motion, soft tissue examination, muscle tonus and length. This part is completed with the day by day therapy treatment, and finally, end with the final complete examination and the conclusion that shows the degree of efficiency that the therapy treatment had been on the ankle joint.

2 Theoretical part

2.1 Anatomy of the components of the ankle joint and the foot

Lower leg injuries are quite common, around 10% of all total injuries involve the lower extremities in high sport level. Often, athletes sprain their ankles, which are mainly caused by the increased loads onto the feet when the position of the foot is plantarflexed, inverted or everted.

Other areas of the foot like the forefoot, midfoot, and rearfoot, absorb various forces and can consequently lead to injuries.

Stress fractures, tendinitis, musculotendinous injuries, or any chronic pain to our lower extremities such as the tibia are usually diagnosed. [10] [1] [25]

2.1.1 Bony structure

The joints of the lower limb are aligned in a straight line called mechanical longitudinal axis of the leg or even Mikulicz line. This line goes from the the head of the femur, through the intercondylar eminence of the tibia, and down to the center of the ankle mortise, between the medial and lateral malleolus.

The mechanical and anatomical axes crosses at tibial shaft area, but in the femoral shaft there are 6 divergences, resulting in the femorotibial angle of 174° in a leg with normal axial alignment.

A leg is considered straight when, with feet are brought together, both medial malleolus of ankles and both medial condyles of the knee are touching each other. [11] [14] [25]

2.1.1.1 Tibia

The tibia, also named shin bone is the largest bone located medially, bearing the weight bone of the leg. It articulates at its proximal end with the femur and fibula and at its distal end with the fibula and the talus bone of the ankle. [1] [14] [25]

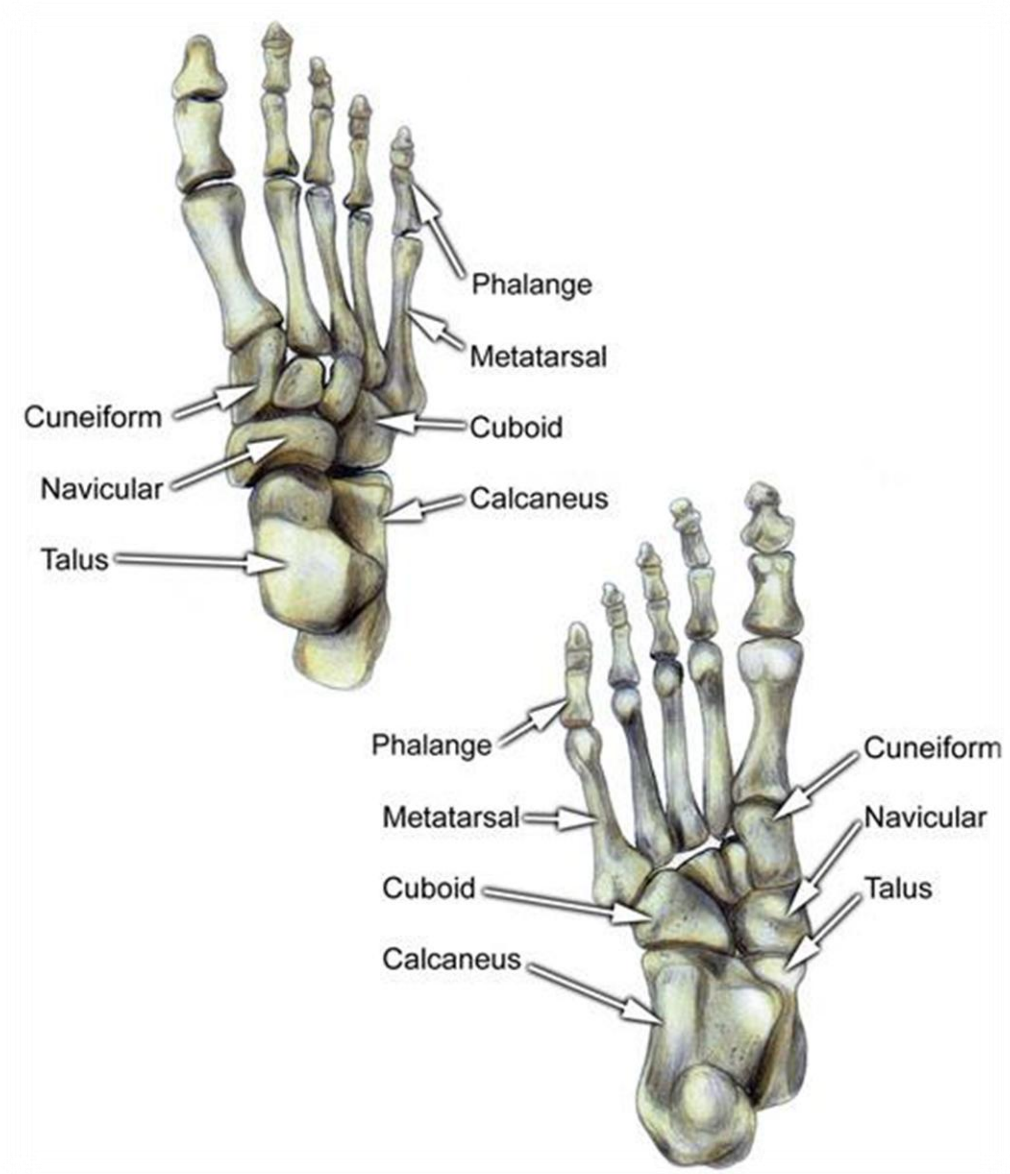
2.1.1.2 Fibula

The fibula forms proximally with the nee the tibiofibular joint. On the other hand, at its distal end, the fibula has an arrowhead-shaped and a lateral extra structure that forms the malleolus which articulates with the talus of the ankle. [1] [14] [25]

2.1.1.3 The foot

We distinguish three different groups of bones in the anatomy of the foot. From proximal to distal, we find the tarsal bones (7), the metatarsal bones (5) and the phalanges (14).

These bones include the talus and calcaneus located in the posterior part of the foot. The calcaneus is the largest and strongest tarsal bone. The anterior tarsal bones are the navicular, three cuneiform bones called first, second and third and the cuboid. [1][9] [14] [25]



Picture 1: Bony structure of the foot, dosal and ventral view [1]

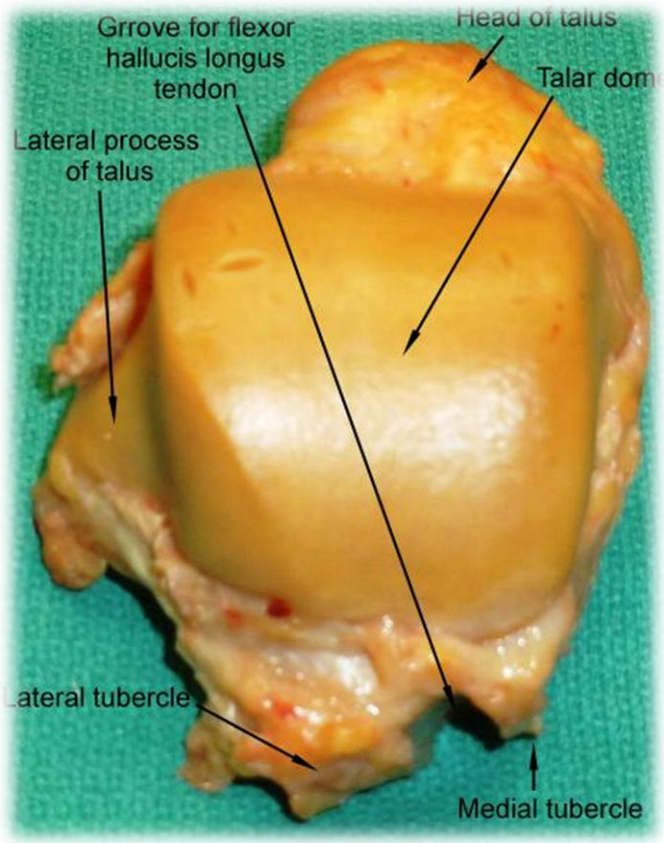
2.1.1.3.1 Proximal group

It consists in two large bones, the talus which is the main ankle bone and the calcaneus or commonly called the heel bone. [1] [11] [25]

Talus

The talus is the most superior bone of the foot and sits on the calcaneus. It articulates above with the tibia and the fibula to form the ankle joint. This bone is connected frontally with the intermediate tarsal bone, and on the medial side of the foot with the navicular bone.

The lateral sides of the talus have a snail-like shape. It has a rounded head, projected forward and medially at the end of a short broad neck. It connects posteriorly at medial and lateral tubercles. Under the tubercles are the grooves where the flexor hallucis longus tendon lays. [1][11] [14] [25]



Picture 2: Talar bone, dorsal view [2]

The superior aspect of the talus's body is elevated to fit into the socket formed by the distal ends of the tibia and fibula and creates the ankle joint. The upper surface of the elevated region articulates with the inferior end of the tibia. The medial surface articulates with the medial malleolus (tibia) and the lateral surface articulates with the lateral malleolus (fibula).

The inferior surface of the bony of the talus has a large oval concave facet for articulation with the calcaneus which is called posterior calcaneal articular facet. [1][11] [14] [25]

Calcaneus

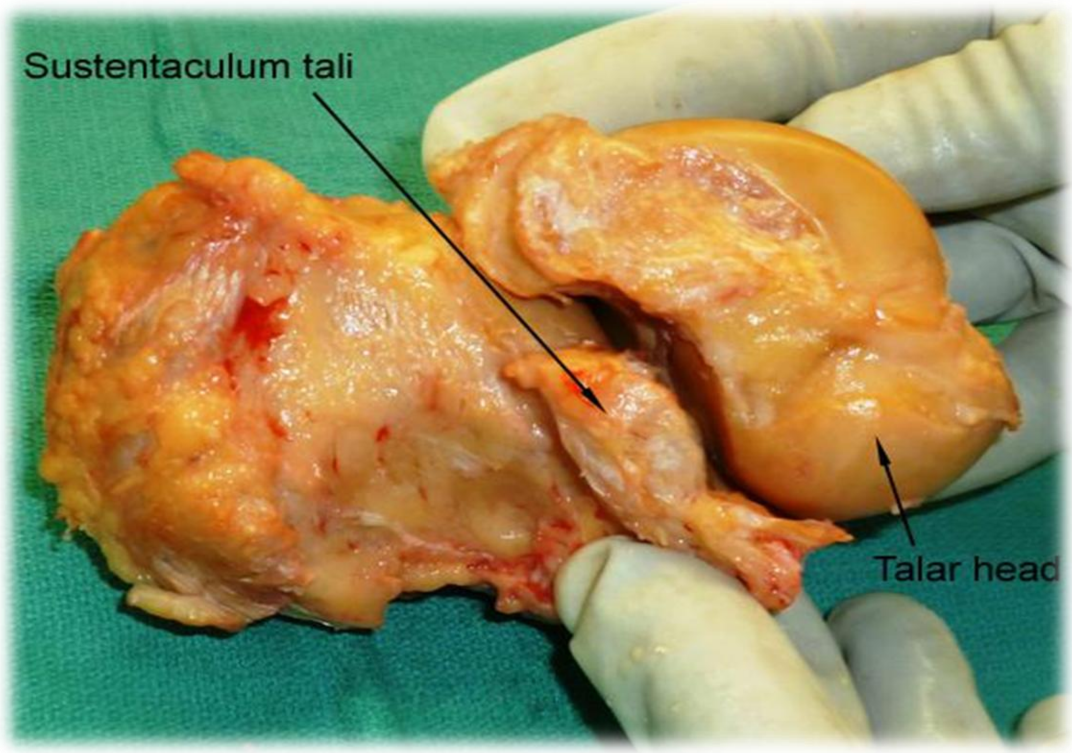
On the other hand, the calcaneus is the largest tarsal bone. It forms posteriorly the bony framework of the heel and anteriorly projects forward to articulate with one of the distal group of tarsal bones, cuboid, on the lateral side of the foot

The calcaneus is located beneath the talus and supports it, is an elongate, irregular, square shaped bone. His axis is generally oriented along the midline of the foot. It has a posterior surface where the calcaneal tendon inserts, more precisely on the middle part.

On the anterior medial superior border are the anterior and middle talar articular surfaces. More posteriorly and situated at the center of the bone the posterior articular surface.

The medial part is marked by two bony extra formations where are attached, posteriorly the calcaneofibular ligament and anteriorly the fibular trochlea. [1][9] [14] [25]

Picture 3: Lateral view of the calcaneus and cuboid bone [2]



Picture 4: Medial view of the talus and calcaneal bones [2]

2.1.1.3.2 Intermediate tarsal bone

Navicular bone

The navicular bone is boat like shaped. It is situated on the medial side of the foot, in front of the head of the talus and behind the three cuneiform bones. It forms the uppermost portion of the medial longitudinal arch of the foot and acts as a keystone for the arch.

Muscle tibialis posterior attaches at the tuberosity of the navicular bone. The plantar surface provides attachment to the spring ligament. The calcaneonavicular part of the bifurcate ligament is attached to the lateral surface. Talonavicular, cuneonavicular and cubonavicular ligaments attach to the dorsal surface. [1][10] [14] [25]

2.1.1.3.3 Distal group

Cuboid bone

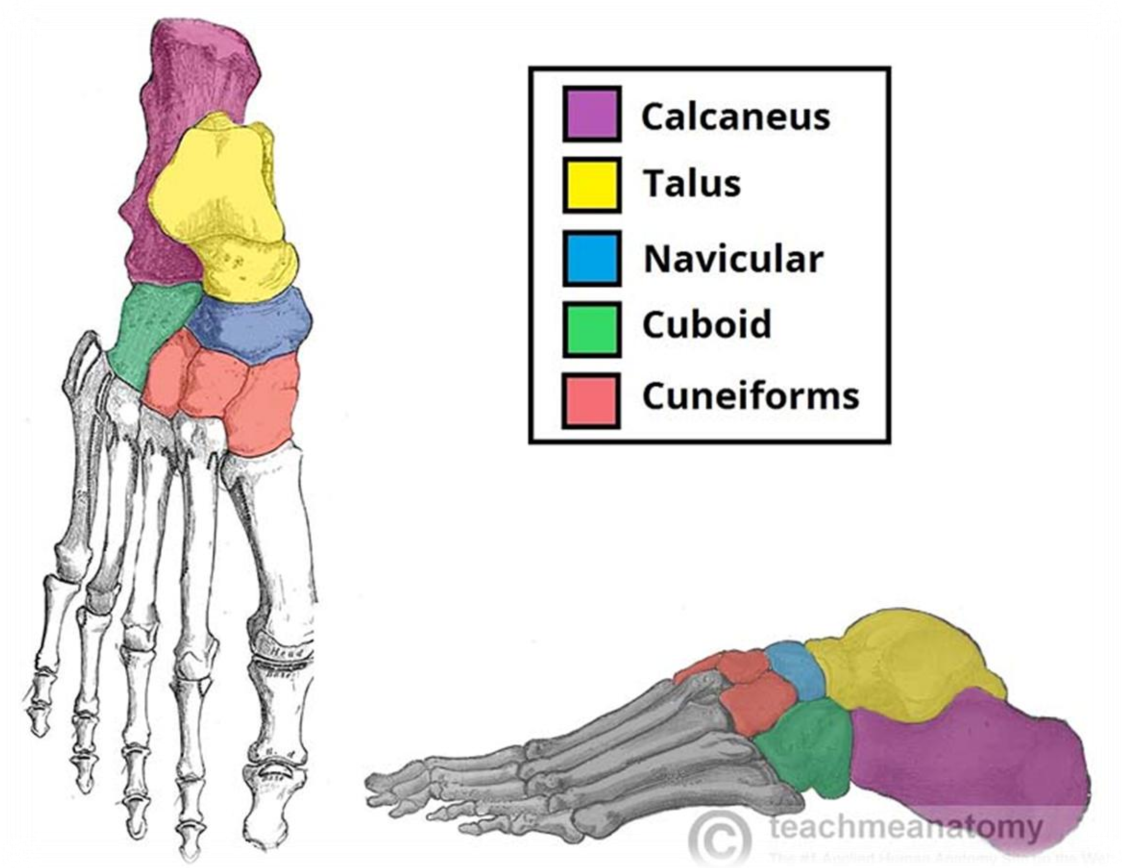
The cuboid is the most lateral excentered bone of the distal row. It is situated in front of the calcaneum and behind the 4th and 5th metatarsal bones. It has six surfaces, a cubic shape and a broader base oriented medially.The lateral surface is mainly occupied by the tendon of the peroneus longus .

The posterior part of the groove gives an attachment to the deep fibers of the long plantar ligament. A rough surface behind the groove gives an attachment to the plantar calcaneocuboid ligament, few fibers of the flexor hallucis brevis, and a fasciculus from the tendon of the tibialis posterior. The posteromedial part of the plantar surface provides insertion to a slip from the tibials posterior and provide an insertion base for the flexor hallucis brevis. [1][10] [14] [25]

Cuneiform bones

The medial cuneiform bones is the largest, the size decrease while migrating to the lateral side of the foot. Cuneiform bones have a wedge shaped bones. Medially, the edge of the wedge forms the dorsal surface. In the intermediate and lateral cuneiforms, the thin edge of the wedge forms the plantar surface.

The medial and lateral cuneiforms project more distally than the middle cuneiform to create a mortise for the base of the second metatarsal that articulates with the middle cuneiform. [1] [14] [25]



Picture 5: Tarsal bones of the foot [1]

2.1.1.3.4 Metatarsal bones

The metatarsal bones have a rounded shape. They are curved in the long axis and present a concave plantar surface and a convex dorsal surface. The base at the proximal end had wedge-shaped, it articulates proximally with the tarsal bones and by its sides with the following metatarsal bones and its dorsal and plantar surfaces where the ligaments attaches.

The head at the distal end presents a convex articular surface that connects with the phalanges. Its lateral sides are flattened and depressed, surmounted by a tubercle, for ligamentous attachment. The plantar surface has a space groove that extends anteroposteriorly to for the passage of the flexor tendons. [1] [14] [25]

2.1.1.3.5 Phalanges

The phalanges of the foot are likely identical in the structure with those of the hand, two are found in the great toe, and three are found in each of the other toes. The phalanges of the foot differ from phalanges of the hand. However, the bodies size of the foot phalanges are being much reduced in length and especially in the first row.

Each phalanx has a base, shaft and a distal head. The base of each proximal phalanx articulates with the head of the related metatarsal. The head of each distal phalanx is non-articular and flattened into a crescent-shaped plantar tuberosity under the plantar pad at the end of the digit. [1] [14] [25]

2.1.2 Joint Articulations and ligaments structure

2.1.2.1 Interosseous membrane of the leg

The interosseous membrane is a sheet of connective tissue that spans the distance between the tibia and fibular shafts. The collagen fibers descend obliquely from the interosseous border of the tibia to the interosseous border of the fibula.

There are two apertures in the interosseous membrane, one at the top and the other one at the bottom. It allows vessels to pass through between the anterior and posterior compartments of leg. The interosseous membrane not only links the tibia and fibula together, but also provides an increased surface area for muscle attachment.

The distal expanded end of the interosseous membrane is reinforced by anterior and posterior tibiofibular ligaments. The connective tissue link them firmly together which is an important component that influences the skeletal framework. [2][9] [13] [24][14]

2.1.2.2 The ankle joint

The ankle joint is a synovial joint located in the lower extremities. It is formed by the bones of the leg and the foot, tibia, fibula and talus bone. This joint is often a location where problems occurs because of the complexity of each functional components that carries the whole bodyweight and deal with a lot of pressure, and thus for a long time during the daily activities.

The ankle and foot are performing three main functions, the first is shock absorption as soon as the heel strikes the ground. The second is an ability to adapt to the ground shape. Finally the third main function is to provide a stable base of support, which represent the basic skill needed to enhance a correct healthy posture and pattern.

The ankle joint is a hinge joint that allows only dorsal and plantar flexion movements. Usually, the primary and common restriction of this joint is dorsal flexion. The fibula and tibia forms the talocrural (ankle) joint. However when the range of motion of the ankle and subtalar joints (talocalcaneal and talocalcaneonavicular) is taken together, the complex structure works as a universal joint.

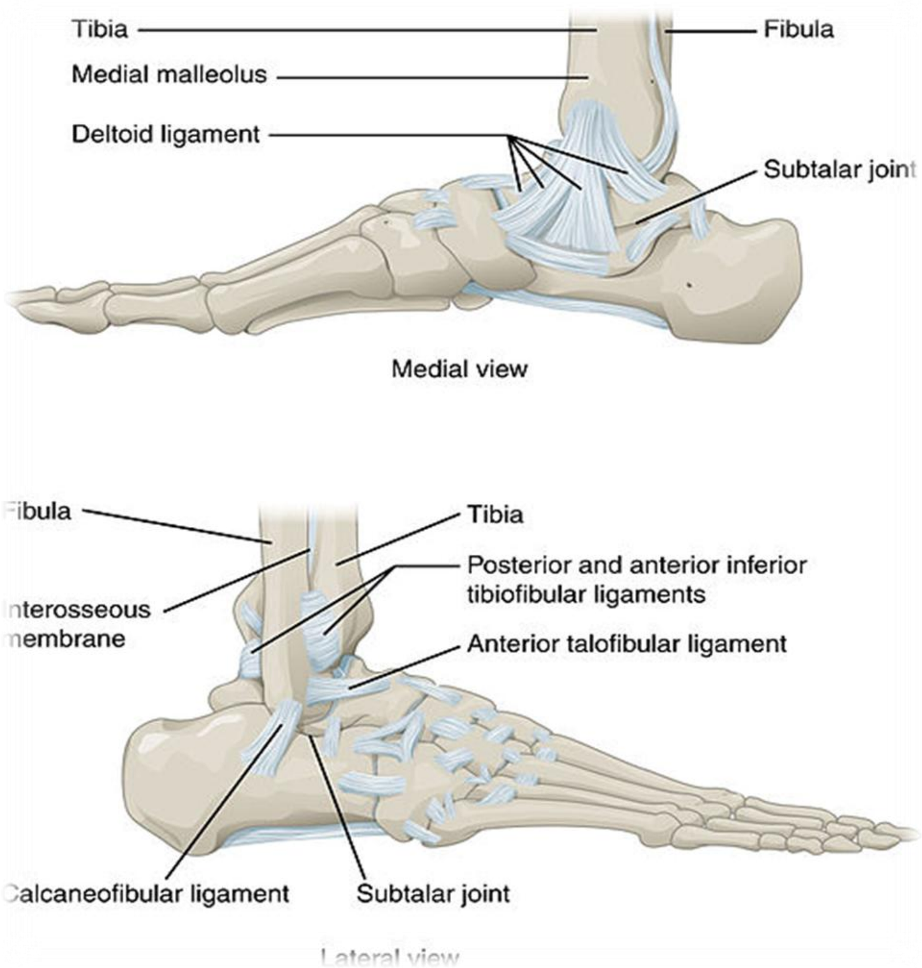
During motion, the fibula rotates inward during gait, the mortise widens when ankle goes from plantar to dorsiflexion and the syndesmosis structure limit external rotation. The combined movement of dorsiflexion and plantarflexion directions are greater than 100°; Bone-on-bone abutment beyond this range protects the anterior and posterior ankle capsular ligaments from injury.

There are three important ligaments that constitues the lateral ligament complex of the ankle joint. The anterior talofibular ligament, the calcaneofibular ligament and the posterior talofibular ligament. Another also important ligament is the deltoid ligament.

Type I collagen tissue constitutes the bulk of the capsule and supports ligaments of the ankle joint. The fibers density and orientation are leaded according the mechanical stress experienced by the joint.

Primary ligaments of ankle joint includes, for the medial part, the deltoid ligament and the calcaneonavicular ligament (also called Spring Ligament).

Concerning the lateral part, the primary ligaments are the syndesmosis ligaments, the anterior talofibular ligament (ATFL), the posterior talofibular ligament (PTFL), the calcaneal fibular ligament (CFL) and finally the lateral talocalcaneal ligament (LTCL). [1][2][10] [14] [24] [25]



Picture 6: Bony structure and ligaments of the ankle joint [1]

2.1.2.3 Deltoid ligament

The main function of the deltoid ligament is first, to restrict the valgus tilting of the talus, then to resist into eversion movement of the hindfoot, and finally to stabilizes the ankle against plantar flexion, external rotation and pronation.

Anatomically, the superficial layer crosses both ankle and subtalar joints, it takes his origins at the anterior colliculus and fans out to insert into the navicular neck of the talus, tibiocalcaneal, and posteromedial talar tubercle. The tibiocalcaneal portion is the strongest component in the superficial layer and resists to calcaneal eversion

The deep layer passes across the ankle joint only and work as a primary stabilizer of the medial ankle. It prevents lateral shift and external rotation of the talus.It take his origins from inferior, posterior aspects of medial malleolus and inserts on the medial and the posteromedial aspects of the talus.

Physical examination can be performed by an eversion test with ankle in neutral position, that evaluates superficial layer. To evaluate the deep layers and the syndesmosis, an external rotation stress test is applied. [2][12] [13] [14] [24] [25]

2.1.2.4 Anterior and posterior talofibular ligaments

The primary function of the anterior talofibular ligament is to limit inversion during plantar flexion, and to resists into anterolateral translation of talus in the mortise.

Anatomically, the posterior talofibular ligaments originates at the posterior border of fibula, runs perpendicular to longitudinal axis of the tibia and inserts on posterolateral tubercle of the talus.

Physical examination is done by anterior drawer in 20° of plantar flexion. A forward shift of more than 8 mm on a lateral radiograph is considered diagnostic for an Anterior Talofibular Ligament tear.

The primary function of the posterior talofibular ligament act as a supplementary role in ankle stability when the lateral ligament complex is intact. Stabilizes under greatest strain in ankle dorsiflexioacts to limit posterior talar displacement and external rotation within the mortise. There are no specific clinical test for isolated PTFL injury. [2][12] [13] [14] [24] [25]

2.1.2.5 Calcaneofibular ligament

The function of the calcaneofibular ligament is primarily to avoid excessive inversion in neutral or dorsiflexion position, then to restrains subtalar inversion, and finally to limit talar tilt within mortise.

Anatomically, the calcaneofibular ligament take his origin at the anterior border of fibula, and inserts on calcaneus distal to subtalar joint and deep to fibular tendon sheaths.

The physical examination of this ligament is an inversion (supination) test perform with ankle in slight dorsiflexion and talar tilt testwhere the angle formed by tibial plafond and the talar dome is measured. An inversion force is applied to hindfoot (Less than 5° is normal for most ankles). [2][12] [13] [14] [24] [25]

2.1.3 Muscles Components and functional characteristics

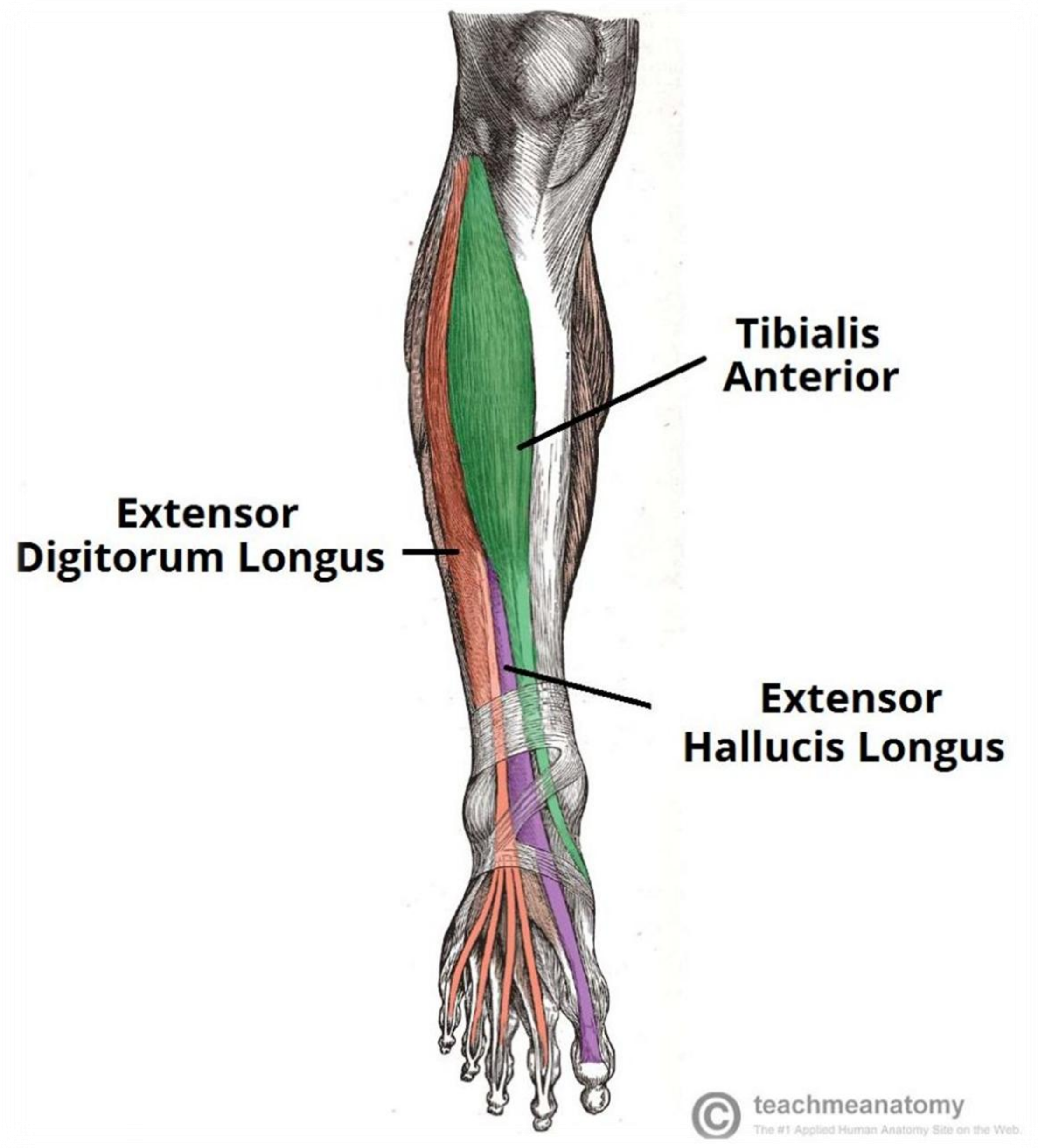
The muscles of the lower limb are divided by deep fascia into three compartments, anterior, lateral and posterior.

The anterior compartment of the lower limb performs a general dorsal flexion of the foot. One of the main muscle is the tibialis anterior located on the anterolateral surface of the tibia. The extensor hallucis longus is located partially deeper than the tibialis anterior and extensor digitorum longus muscles. The fibularis muscle is part of the extensor digitorum, where both have a common origin. [1][2] [14] [24] [25]

Muscles of anterior part of the lower leg	Origin	Insertion	Innervation	Blood Supply	Action(s)
Tibialis Anterior	Lateral condyle and body of Tibia	First metatarsal and first cuneiform bones	Deep fibular nerve (L4-L5)	Anterior Tibial Artery	Inversion of foot
Extensor digitorum longus	Anterior surface of middle third of fibula and interosseous membrane.	Middle and distal phalanges of toes 2-5	Deep fibular nerve (L4-L5)	Anterior Tibial Artery	Dorsal flexion of the foot + Extension of distal and middle phalanges of each toe.
Fibularis tertius	Distal third of fibula and interosseous membrane	Base of fifth metatarsal	Deep fibular nerve (L4-L5)	Anterior Tibial Artery	Dorsal flexion + Eversion of the foot
Extensor hallucis	Anterior surface of	Distal phalanx of	Deep fibular nerve (L4-L5)	Anterior Tibial Artery	Dorsal flexion of

longus	middle third of fibula and interosseous membrane.	great toe.			the foot + Extension of proximal phalanx of great toe.

Table 1: Anterior lower leg muscles [14] [24]

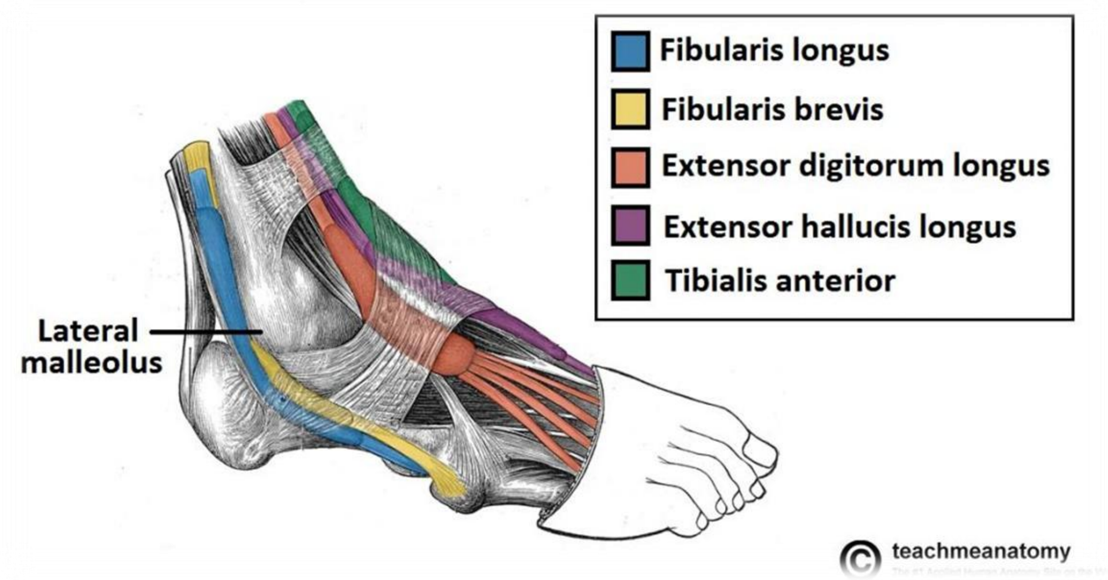


Picture 7: Anterior part of the leg muscles [1]

The lateral compartment of the leg contains two muscles which perform plantar flexion and eversion of the foot. These muscles are the fibularis longus and fibularis brevis. [1][2] [14] [24] [25]

Muscles of lateral part of the lower leg	Origin	Insertion	Innervation	Blood Supply	Action(s)
Fibularis longus	Head and body of fibula	First metatarsal and first cuneiform	Superficial fibular nerve. (L4/S1)	Posterior tibial + fibular Artieries	Plantar flexion and eversion of the foot.
Fibularis brevis	Distal half of body of fibula	Base of the fifth metatarsal	Superficial fibular nerve. (L4/S1)	Posterior tibial + fibular Artieries	Plantar flexion and eversion of the foot.

Table 2: Lateral lower leg muscles [14] [24]



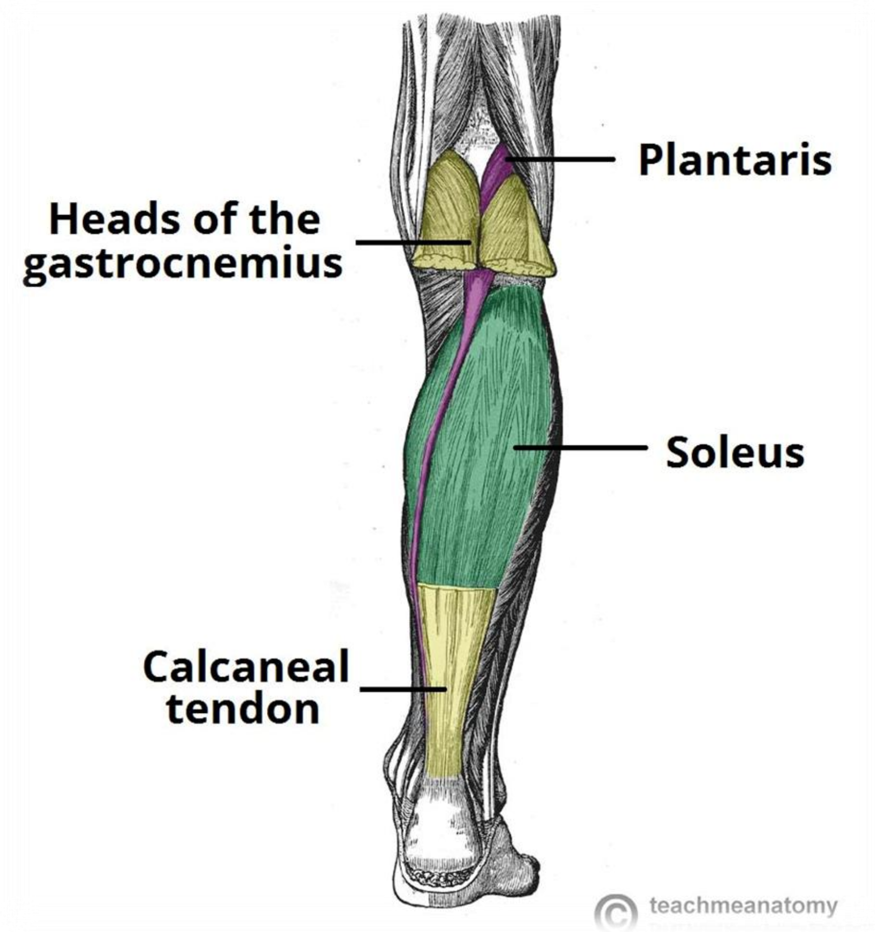
Picture 8: Distal muscles of the lateral part of the leg [1]

The posterior compartment of the leg result in a superficial and a deep muscle groups. The superficial group share a common insertion at calcaneal bone via the achilles tendon (the strongest tendon of the body). It inserts into the calcaneal bone of the ankle.

The superficial and most of the deep muscles perform plantar flexion of the foot. The superficial muscles of the posterior compartment are the gastrocnemius, soleus which are so called calf muscles. The plantaris muscle performs flexion of middle and distal of the four phanges. The two headed gastrocnemius muscle is the most superficial muscle and forms the prominence of the calf. The soleus, which lies deep to the gastrocnemius, is broad and flat. The plantaris on the other hand though is a small muscle that may be hard to find. It is located between the gastrocnemius and soleus muscles. [1][2] [14] [24] [25]

Muscles of superficial posterior part of the lower leg	Origin	Insertion	Innervation	Blood Supply	Action(s)
Gastrocnemius	Lateral medial condyles of femur and capsule of knee	Calcaneus by way of calcaneal (Achilles) tendon.	Tibial nerve (L4/S3)	Posterior tibial + popliteal and fibular arteries	Plantar flexion
Soleus	Distal half of body of fibula	Base of the fifth metatarsal	Tibial nerve (L4/S3)	Posterior tibial + popliteal artieries	Plantar flexion
Plantaris	Lateral epicondyle of femur	Calcaneus by way of calcaneal (Achilles) tendon.	Tibial nerve (L4/S3)	Popliteal artiery	Plantar flexion and flexion of the knee joint

Table 3: Superficial posterior muscle of the lower leg [14] [24]



Picture 9: Superficial muscles of the posterior leg compartment [1]

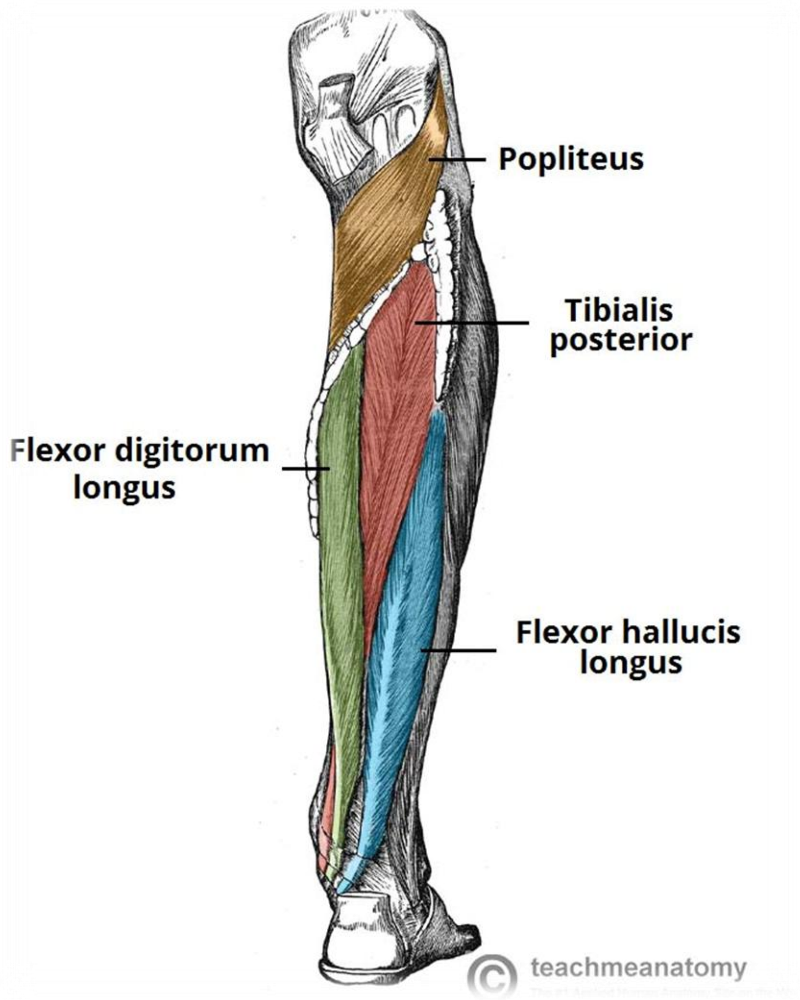
The deep muscles of the posterior compartment are the popliteus, tibialis posterior, flexor digitorum longus and flexor hallucis longus. The popliteus is a triangular muscle which forms the floor of the popliteal fossa.

The tibialis posterior is the deepest muscle located in the posterior compartment. It runs between the flexor digitorum longus and flexor hallucis longus muscles. The flexor digitorum longus is smaller than the flexor hallucis longus, even though the former flexes four toes and the latter flexes only the great toe at the interphalangeal joint. [1][2] [14] [24] [25]

Muscles of deep posterior part of the lower leg	Origin	Insertion	Innervation	Blood Supply	Action(s)
Popliteus	Lateral condyle of femur	Proximal tibia	Tibial nerve (L4/S1)	Inferior medial and lateral genicular arteries	Flexion of the leg at the knee joint and medially rotates tibia to unlock the extended knee.
Tibialis posterior	Proximal tibia, fibula and interosseous membrane.	Second, third and fourth metatarsals, navicular and all three cuneiforms.	Tibial nerve (L4/S3)	Fibular artery	Plantar flexion + inversion of the foot
Flexor digitorum longus	Lateral epicondyle of femur	Calcaneus by way of calcaneal (Achilles) tendon.	Tibial nerve (L4/S3)	Posterior tibial artiery	Plantar flexion and flexion of the knee joint

Flexor hallucis longus	Inferior two-thirds of posterior portion of fibula.	Distal phalanx of great toe	Tibial nerve (L4/S3)	Fibular artery	Plantar flexion of the foot, flexes the distal and proximal phalanx of each toe.

Table 4: Deep posterior muscles of the lower leg [14] [24]



Picture 10: Deep muscles of the posterior compartment of the leg [1]

2.2 Innervation of the lower limb

2.2.1 Tibial nerve

The nerve that is associated with the posterior compartment of leg is the tibial nerve. The tibial nerve is a major branch of the sciatic nerve which descends posteriorly through the popliteal fossa. This nerve passes under the tendinous arch formed between the fibular and tibial heads of the soleus muscle and passes vertically through the deep region of the posterior compartment of leg on the surface of the tibialis posterior muscle with the posterior tibial vessels. It leaves the posterior compartment of leg at the ankle by passing through the tarsal tunnel behind the medial malleolus. It enters the foot to supply most intrinsic muscles and skin. [1] [14] [24] [25]

2.2.2 Medial calcaneal nerve

The medial calcaneal nerve is often multiple and originates from the tibial nerve low in the leg near the ankle and descends onto the medial side of the heel. The medial calcaneal nerve innervates skin on the medial surface and sole of the heel. [1] [14] [24] [25]

2.2.3 Sural nerve

The sural nerve originates high in the leg between the two heads of the gastrocnemius muscle. It descends superficially to the belly of the gastrocnemius muscle and penetrates through the deep fascia approximately in the middle of the leg where it is joined by a sural communicating branch from the common fibular nerve. It passes down the leg, around the lateral malleolus and into the foot. The sural nerve supplies skin on the lower posterolateral surface of the leg and the lateral side of the foot and little toe. [1] [14] [24] [25]

2.3 Kinesiology of the Ankle Joint

The axis where the motion occurs extends obliquely from the posterolateral aspect of the fibular malleolus to the anteromedial aspect of the tibial malleolus.

The primary movers are the soleus and the gastrocnemius muscles. The synergists movers are fibularis longus, fibularis brevis, tibialis posterior, flexor hallucis longus, flexor digitorum longus, plantaris. The antagonists muscle group of the ankle joint are tibialis anterior, extensor digitorum longus, extensor hallucis longus and fibularis tertius. Muscles of the ankle that helps to neutralize the joint are the tibialis posterior and medial gastrocnemius that neutralize the eversion force created by the soleus, lateral gastrocnemius and the fibularis muscles.

During stabilization of the joint, muscles fibularis longus, fibularis brevis, fibularis tertius, tibialis posterior, flexor hallucis longus, flexor digitorum longus, extensor hallucis longus, and extensor digitorum longus are active. [5] [24] [27]

2.3.1 Arthrokinematics of Ankle joint

During the dorsiflexion of ankle at pronation, the talus migrates anteriorly and slides posteriorly. The opposite movements occur during the plantarflexion. Supination and pronation movements at the subtalar joint occurs as a result of sliding of the calcaneus on the talus around an oblique axis. During pronation and supination at the transverse tarsal joint, rotation occurs between the concave distal joint surface formed by the navicular, the spring ligament and the convex talar head.

At talocrural joint, the convex shape of the talus articulates with the concave shape of the mortise.At talocrural joint, the dorsal or posterior aspects glides and increases dorsiflexion. The talocrural joint ventral or anterior glide lead to an increase of plantarflexion. [5]

The overall rang of motion in the sagittal plane of between 65 and 75° of cumulated freedom. A value that include from 10 to 20° of dorsiflexion for 40 to 55°of plantarflexion. Regarding the frontal plane, the rang of motion reaches approximately 35° of cumulated freedom. It is composed of 23° of inversion and 12°of eversion. However, in our everyday activities, the rang of motion in the sagittal plane is deacreased. It reaches a maximum of 30° during walking, and 37° and 56° when ascending and descending stairs.[3] [24] [27]

2.3.2 The foot arch mechanism

The bones of the foot, instead of lying in a horizontal plane, they form a longitudinal and transverse arches relative to the ground. The medial arch is the highest of both medial and lateral.

The foot contacts points with the ground spread and distribute forces down to the floor during standing position and during its motion. [1] [5] [24] [27]

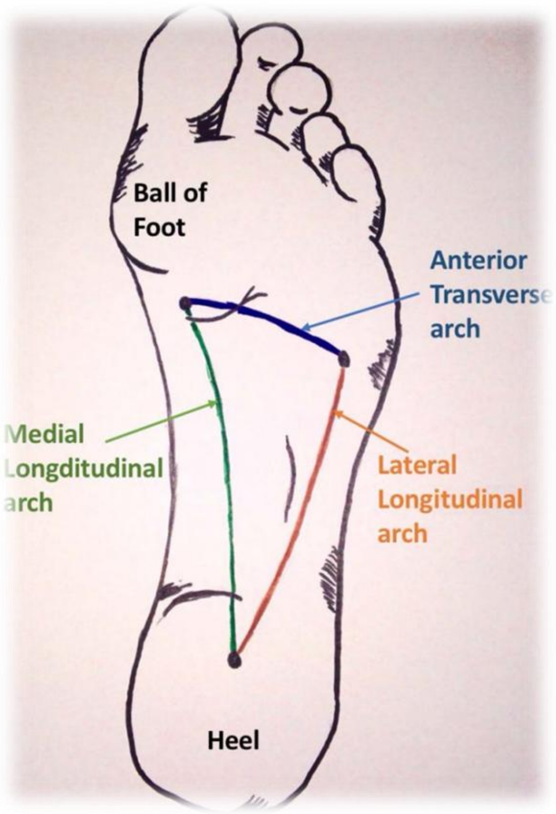
2.3.2.1 Medial and lateral longitudinal arches

The longitudinal arch of the foot is formed between the posterior end of the calcaneus and the head of the metatarsals. The highest point is found on the medial side, it forms the longitudinal arch and lowest on the lateral side.

The medial arch is formed by the talus bone, the three cuneiforms, the navicular and the first three metatarsal bones. The lateral arch is the lowest one, and the flattest. It correspond to the arch in contact with the floor while standing, and formed by the calcaneus, the cuboid and the four and fifth metatarsal bones. [1] [5] [24] [27]

2.3.2.2 Anterior tranverse arch

The transverse arch is located in the coronal plane of the foot. It is formed by the metatarsal bases, the cuboid and the three cuneiform bones. It links the two first arches mentioned before at their distal end.[5] [1] [24] [27]



Picture 11: Three arches of the foot [1]

2.4 Biomechanics of the Ankle Joint

2.4.1 Mechanical load

2.4.1.1 Characteristics of the foot

The foot is a triple axial joint, converge through the talus three main axis of movement. During rotation, the foot is able to adapt to uneven surfaces, all the joints are then involved to provide an ideal stable support for the ankle joint. Anatomically, the foot can be compared to a vault which is supported by the three arches of the foot as mentioned before. This vault-structure helps on analyzing the foot generally. When feet are joined together, the position of both calcaneal bones can be seen as a vault structure. The position of the calcaneus together with a slight valgus position stabilizes the body, especially during the walking motion. [3] [4] [28] [26]

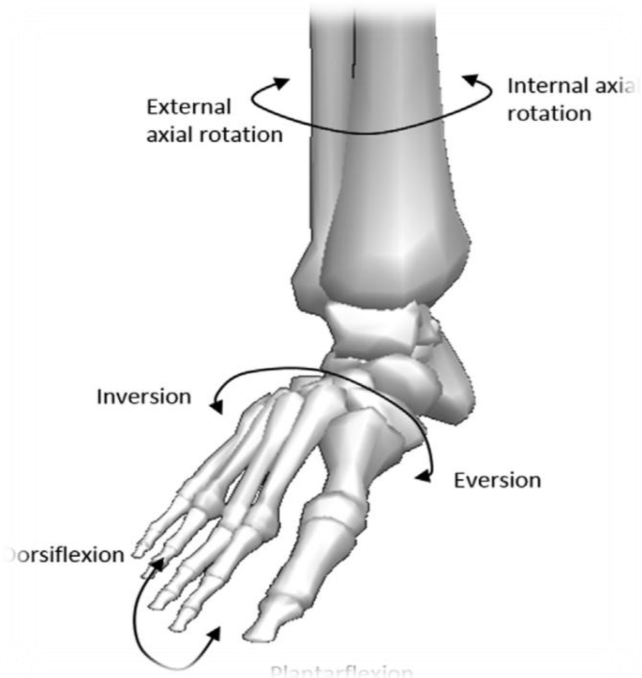
2.4.1.2 The ankle joint

As mentioned before, the ankle joint is a hinge joint with a diagonal axis of rotation. This inclinaison will contributes to stabilize the joint when more forces will be applied on the joint, for example carrying weight.

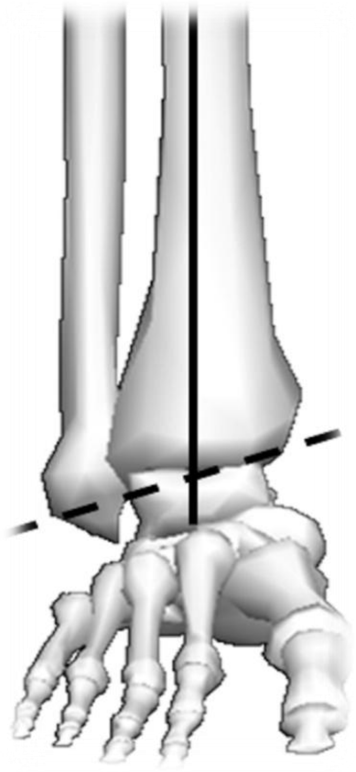
As mentioned earlier in the text, the tibiotalar joint is considered as a simple hinge joint. However, the axis of rotation of the ankle complex in the sagittal plane happens at the direct line that passes through the medial and lateral malleolus.

The axis of rotation in the coronal plane occurs at the intersecting point between the bimalleolar line and the axis of tibia (frontal plane).

The axis of rotation in the tranverse plane occurs at the intersection between the axis of tibia and the midline of the foot. [3] [4] [15] [26]



Picture 12 : Axis of rotation of the ankle [3]



Picture 13: Sagittal and frontal plane axis of rotation of the ankle joint [3]

2.4.1.3 Talocrural joint

Formed by the tibia, the fibula against the talus bone, the tibiotalar joint bears and load the weight at the tibial-talar interface. The talus bone has no direct muscle connection. Both malleolus of tibia and fibula act to constrain the talus, that forms the hinge of the joint.

The talus shape is weidest anteriorly, meaning that the stability is increased during dorsiflexion movement. In standing position, the stance itself is sufficient to provide resistance into eversion, direct action of the geometry of the tibiotalar joint. Except the bony structure, the soft tissues are providing the stability of the joint. [3] [15] [26]

2.4.1.4 The talo-calcaneonavicular joint

The distal tibia is twisted laterally compared to his proximal portion. The axis of angle that is considered to be rotated laterally is 20 to 30° in transversal plane and 10° inclined down the lateral side. The axis of the talo-calcaneonavicular joint is oblique to the axis of the ankle joint. It is rotated from the lateral posterior to the medial anterior. The talo-calcaneonavicular and ankle joint must be seen as a whole functional unit. These two joints are providing a motion that is found in sphenoid joints, with flexion, supination, pronation, abduction and adduction movements that allow a rotation. [3] [15] [26]

2.4.1.5 The Chopart's and Lisfranc's joints

These two joints are connected together by taut ligaments. First, they give an elasticity effect to the foot during overpressure that helps to absorb forces and second give a propulsion help. Finally, they constitue a solid transition support between the metatarsal bones and the ankle joint. [3] [15] [26]

2.4.2 Foot pressure distribution

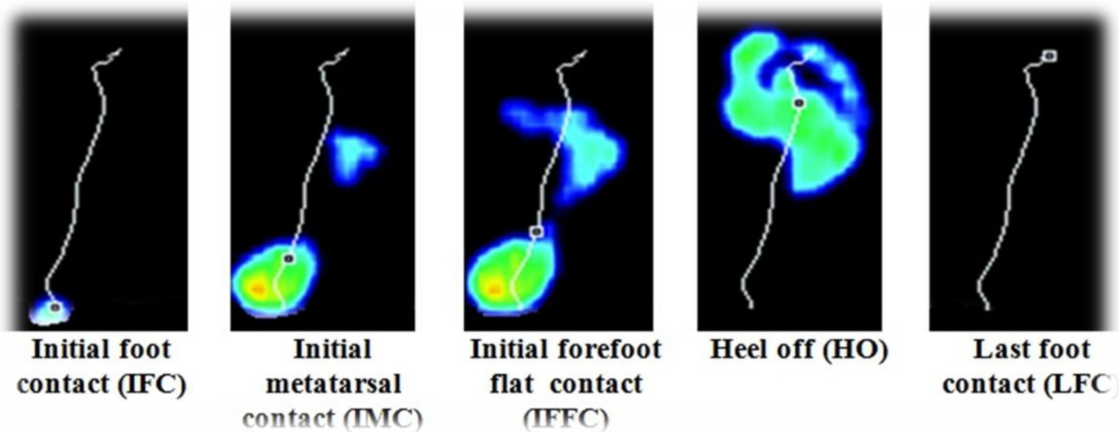
Several studies that concern the foot and ankle biomechanics have reported that plantar pressure variations are useful to determine the pathological element in the gait pattern.

At stance: The subtalar and talocrural joints bear 60-70% of the bodyweight, other parts of the foot help to bear the rest. Contact of weight bearing: talocrural and subtalar joints (up through tibia) bears 90% of the bodyweight with gait, fibula takes 10%. Concerning the foot, the weight baring is estimated at 57% of the bodyweight on the heel bone, 43% on the forefoot and arch.

Recent studies have estimated that the amount of weight bared on the rear of the foot was 60% of the bodyweight, 8% on the mid foot, 28% on the forefoot and 4% on the toes. [5] [4] [16] [17]

During walk: The total pressure distribution during the gait starts at the heel which the first portion of the foot to receive body weight pressure, followed by the midfoot and the forefoot. Then the load shifted to the toe for lift off. During the gait, the peak pressure is approximately at 18 to 36% of the stance phase when the heel, midfoot and forefoot are all in contact with the bottom support. The percentage average of the contact time of the heel is approximately 60% of the stance phase, the forefoot at 70 to

82% and the toes at 80-91% of the stance phase. The heel pressure in pathological subjects has tendancy to be lower than in healthy patients. [5] [4] [16] [17] [26]



Picture 14: Typical barefoot plantar pressure [17]

2.5 Ankle fracture diagnostic

2.5.1 Manual diagnosis:

It is important during the assessement, to assess for proximal fibular tenderness in order to rule out Maisonneuve fractures.

Then comes the papation of the soft tissues, all the ligamentous structure including the anterior talofibular ligament, the posterior talofibular ligament, the calcaneofibular ligament, the deltoid ligament complex and the anterior tibiofibular syndesmosis.

Aslso, an assessement of the rang of motion is perfomed, first actively then passively in all the direction, dorsiflexion, plantarflexion, inversion and eversion. The assessement is firstly done on the healthy leg to have a correct comparaison.

Finally, there are some special assessment tests that can be performed respecting the pain of the patient and his limitations. The external rotation stress test (Kleiger test) involves stabilising the distal tibia while performing an external rotation of the foot. The "squeeze" test, involves a proximal compression of the tibia against the fibula to the ankle joint. The drawer test for anterior tibiofibular ligament injury. The talar tilt test examines the integrity of the lateral ankle ligaments, mainly the calcaneofibular ligament. [4] [15] [19]

2.5.2 Ottawa rules:

Ankle X-ray is used in case of pain in the malleolar zone and any one of the following:

First, in presence of bone tenderness along the distal 6 cm of the posterior edge of the tibia, or at the tip of the medial malleolus or even at lateral malleolus. Second, in presence of an inability to bear weight both immediately and for four steps.

Additionally, it is indicated if there is any pain in the midfoot zone including foot injuries; Bone tenderness at the base of the fifth metatarsal, bone tenderness at the navicular bone, an inability to bear weight both immediately and in the emergency department for four steps. Ankle fractures are firstly evaluated by physical examination and then by x-ray. [4] [7]

2.5.3 Imaging:

Radiography: These classifications are nearly identical, but they have different emphases for the radiologist and orthopedic surgeon, respectively.

The Lauge-Hansen classification scheme has 4 injury patterns, first the supination-adduction (SA) or Weber A in the Danis-Weber scheme, second the supination external (SE) rotation or Weber B, third the pronation-abduction (PA) or Weber C1, and finally fourth the pronation external (PE) rotation or Weber C2.

Computed Tomography : CT scanning may be used to better define pilon fractures or triplane fractures.

Magnetic Resonance Imaging: MRI is not needed for the evaluation of most ankle fractures. This imaging technology can show additional injuries in children and for occult injuries, such as some concerning the talar dome, the soft-tissue injuries (ligament or tendons)

Ultrasonography: It is not usually used for the evaluation of patients with ankle fractures. However, this technique can depict fractures and associated soft-tissue injuries, especially injuries of the fibular tendons.

Nuclear imaging: Bone scintigraphy is not needed for the evaluation of most ankle injuries, but it can be used to look for occult injuries, especially injuries of the talar dome. [4] [7] [15]

2.6 Fracture types at ankle joint

The old classifications were describing the fractures according the number of malleoli involved in the traumatism. Today, two different classifications are used.

The first one comes from Danis-Weber, that gives three types, A,B,C described as; The infrasyndesmotic type (A), characterized by a fracture of the fibula tranversally at the level of the ankle joint without syndesmotic injury.

The transsyndesmotic type (B), characterized by a spiral fibula fracture at ankle joint level and with partial syndesmotic disruption.

And the suprasyndesmotic type (C), characterized by a proximal facture to the ankle joint with disruption of the syndesmosis.

The second classification system comes from Lauge-Hansen, who has established four basic types of injuries, pronation-abduction, pronation-lateral rotation (eversion), supination-adduction, and supination-lateral rotation (inversion) [6] [7] [8] [15] [19] [20]

Picture 15 : Weber suprasyndesmotic type X-ray [6]

Picture 16 : Weber suprasyndesmotic type [6]

2.7 Surgical intervention

In all case, before the ankle is fixed, the patient has to wait for a period of time of approximately 7-10 days after the injury, due to the swelling. It has been reported that this can lead to a highr risk of infections or wound complications after the surgery.

The goals of surgery starts always if needed with an anatomical reconstruction or reposition of the joint surface (cartilage lining), the protection of the ligamentous structures to maximize postoperative functional therapy of the joint. Reduction with congruency of the joint is one of the most important indications of a good end result. An uncorrect or wrong execution of the reduction may lead to osteoarthritis.

The duration of the surgical treatment depends on the soft-tissue findings. The surgery depends on the appearance of the ankle joint on X-ray and the type of ankle fracture.

While not always necessary, and not routinely removed, never before 6 months, unless infection of the hardware occurs. Surgery for ankle fractures can be done with 3 kinds of metal plate and multiple screws, the type of plate and screws depends on the type of fracture. It has been estimated that 10% of patients will complain of pain over the plate and screws.

Minor ankle fractures can be treated non surgically, requiring a treatment with boot or cast without needing surgeries even if in most of the case it is necessary. [7] [8] [19] [20]

2.8 Post traumatic surgeries

In post operative care, during the first day, the foot is wrapped with a bandage with a splint to stabilize it. Ice, and leg elevations are provided. Eventually some medicine is prescribed by the doctor.

The first week after the surgery, the patient are generally contraindicated of fully loading the bodyweight on the injured ankle. However, crutches, walker, wheelchair can be used. Legs are still elevated at lying position.

After two weeks, generally a first control is set up by the doctor, an X-ray is taken. Structure over the foot is removed, a removable splint is given to the patient. The contraindication of weight baring on the involved ankle stays until the surgeon agreed for a load.

After 6 weeks, another control is done with another X-ray. The physical therapy can starts. Soft tissues therapy, scar therapy, joints mobilisation, muscle stretching, active movement exercises are performed during the treatment. Cold and hot therapy can be used to reduce the swellness. At this stage, the patient can fully walk with boots according to the doctors.

Finally after 8 to 12 weeks, the activities practiced can be more advanced, running will be expected 3 months after.

The dorsiflexion and plantarflexion components of ankle pronation and supination are limited by the joint capsule, as well as by ligaments and muscles that cross the joint. Ankle plantarflexion is limited initially by tension in the muscles that dorsiflex the ankle and then by anterior capsular and ligamentous structures, including the anterior talofibular ligament and the tibionavicular fibers of the deltoid ligament. Ankle dorsiflexion is limited by tension in the soleus and gastrocnemius muscles, particularly if the knee is extended when the movement occurs. Posterior capsular and ligamentous structures, including the calcaneofibular ligament, the posterior talofibular ligament, and the tibiotalar fibers of the deltoid ligament, also limit ankle dorsiflexion, particularly with the knee flexed. Inversion and eversion of the subtalar and transverse tarsal joints are limited by tension in the lateral and medial collateral ligaments of the ankle, respectively. [9] [7] [8] [15] [19] [20]

2.9 Kinetic chain reaction

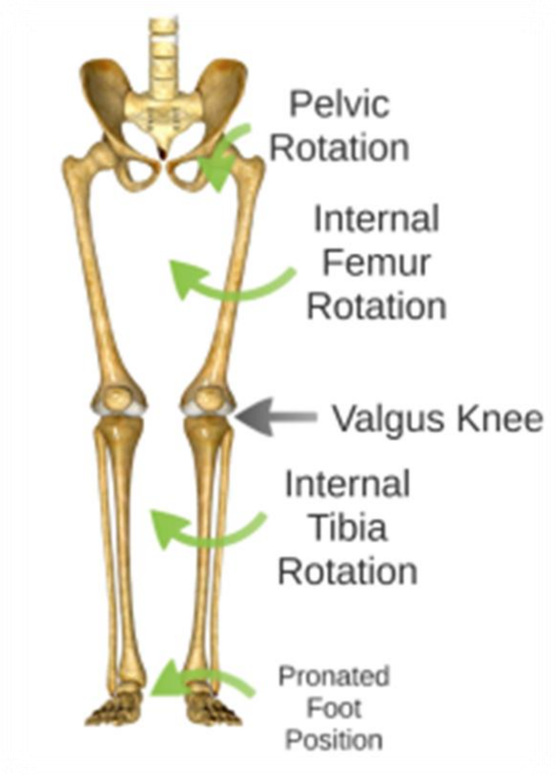
In the kinectic chains, the transition of foot from pronation to supination is an important function that helps when the foot needs to adapt to uneven surfaces and to react as a rigid lever during the push off. When pronation occurs, the metacarpal joints unlocks to provide the needed flexibility to the foot and assists in maintain the balance. When supination occurs, the metacarpal joints locks to provide the needed rigidity to the foot and maximize the stability. A stucked pronated pronated foot leads to hypermobility of the midfoot and place greater demand on the neuromuscular structures that stabilize the foot and maintain upright stance. The postural stability is affected by foot position in both conditions, static and dynamic. Chain reactions occur secondary to positioning of the foot.

In closed chains, the kinetic reaction with over-pronated foot;

We observe a *calcaneal eversion* followed by an *adduction and plantarflexion of talus*, with *medial rotation of talus*, then *medial rotation of tibia and fibula*, then *valgosity of the knee*, *medial rotation of femur* and finally *anterior tilting of pelvis*.

In closed chains, the kinetic reaction with over-supinated foot;

We observe a *calcaneal inversion*, followed by an *abduction and dorsiflexion of talus*, with *lateral rotation of talus*, then *lateral rotation of tibia and fibula*, then *varosity of the knee*, *lateral rotation of femur*, and finally, *posterior tilting of pelvis*. [31] [21]



Picture 17: Kinetic chain reaction with pronated foot position [18]

2.10 Pathophysiology of the ankle injuries

The primary motion of the ankle at the true ankle joint (tibiotalar joint) is plantarflexion and dorsiflexion. Inversion and eversion occur at the subtalar joint. Excessive inversion stress is the most common cause of ankle injuries for two anatomic reasons.

First, the medial malleolus is shorter than the lateral malleolus, allowing the talus to invert more than evert.

Second, the deltoid ligament is stabilizing the medial aspect of the ankle joint that offers a stronger support than the thinner lateral ligaments.

However, when eversion injury occurs, it often damages the bones, supportive ligamental structures and loss of joint stability. The posterior malleolar fractures are usually associated with other fractures and/or ligamentous disruption. They are commonly associated with fibular fractures and are often unstable. Transverse malleolar fractures usually represent an avulsion-type injury. Vertical malleolar fractures result from talar impaction. [2] [7] [9] [15] [28]

2.11 Epidemiology of ankle fracture

Among all the ankle injuries, only 15% are ankle fractures. The fracture distribution according to the OTA classification is reported as 24.1% of type A, 65.8% of type B and 10.1% of type C. Unimalleolar fractures are 70% among all fractures, bimalleolar fractures represent 20% and trimalleolar fractures about 10%.

Ankle fracture is mainly caused by traumatisms like falling, twisting injuries and sports-related injuries. It does not only concern the older, but also in the young and active population. In children, ankle fractures have an incidence of 1 in 1000 per year. Pediatric ankle bones are susceptible to medial malleolar and transitional fractures of the distal tibia. The male/female ratio for ankle fracture is 2:1.

Surly, risk factors associated with an increased risk of sustaining foot and ankle fractures including smoking, diabetes, obesity, previous falls and/or fractures, very high or low levels of physical activity, and low bone mineral density. The higher level of activity in younger males, particularly in risk taking and sports activities, might explain the high rates of ankle and foot fractures in this age group. [2] [4] [9] [13] [15] [22] [23]

2.12 Prognosis

The prognosis can be improved with prompt, accurate diagnosis and appropriate treatment and referral. Isolated, nondisplaced lateral malleolus fracture, the most common ankle fracture, has a favorable prognosis and heals unremarkably.

Usually, the results expected after an anatomical reduction of displaced ankle fractures are positive. Post traumatic arthritis has been described in 10% of patients despite an anatomic reduction. One arthroscopic study find that 79% of patients present some degree of chondral injuries, especially in patients with Weber C fractures/Pronation external rotation injuries. [2] [4] [9] [13] [20]

3 Special chapter

3.1 Methodology

My Bachelor work placement has been done at RNB (Rehabilitacni Nemocnice Beroun) in Beroun. The practice was from the monday 8th of January 2018 till the 19th of January 2018.

The practical part has been done with the consent of the patient. The concern personed has recieved and read the conditions regarding the use of his personal informations. For that, the patient signed an approvement document, sent to the Ethics Committee of the Faculty of Phycical Education and sport at Charles University and approved.

The case study i have decided to choose concern a patient who after falling from 5 meter height, fractured his both distal right radius and tibia. The main problem concern the ankle joint area. The first day i met the patient, his wrist was already in excellent recovery condition, only the ankle joint was problematic. The patient was everyday following some ergotherapy courses at the center. The one hour session consisted in soft tissue techniques, stretching or wrist flexors and extensors, strengthening the grip, mobilizing the wrist and hand joints. Finally, maintaining or improving the hand sensomotor functions. Regarding the complete and effective treatment that the patient was following, i have consequently decided to focus on the ankle joint only.

I have been able to work with my patient for 5 days, 3 first consecutive days with week end break followed by two last. Every day, the patient had several appointments with me, mainly 3 times a day. The first meeting was at the swimming pool, followed by a manual treatment to finish later by an active strengthening session. That result in a total of 15 sessions, in 6 days of therapy.

3.1.1 Status present

Diagnosis: Fracture of distal right radius and tibia after falling from 5 meters.

Name: J.P

Birth date: 2000

Height: 192 cm

Weight: 85 kg

BMI: 23

Subjective:

The patient felt good on acceptance to hospital. The pain in the ankle joint is intermittent, and not present during the night. The sleeping quality is normal, good.

Objective:

Upon acceptance of hospitalisation, the patient was oriented and lucid. No internal organs pain during palpation. The patient is independent and walk with two crutches with contraindication of baring more than 50% of his bodyweight on the right ankle. The lower leg doesn't present any tromboembolic sign. The sensations at ankle joint are normal. Wrist movement is limited with minor swelling without haematoma. The scar after surgery is healed.

3.1.2 History Anamnesis

The patient was by himself when he fell down from 5 meter, from a light pole. The patient was accepted to rehabilitation after fall from 5 meter on 26/11/2017. He was hopitalised on the general hospital všeobecná fakultní nemocnice in Prague from 26/11/2017 to 06/12/2017. CT showed fracture of distal distal tibia. Reposition of OS per cochleam. The operation was on the 28/11/2017.

After removing stitches, the patient felt like pulsation beat in his ankle, the prevention of tromboembolism has been stopped on the 26/12/2017. The last control done in trauma department has been done on the 3rd of January 2018. The 5th of December 2017, manipulation of talocrural joint.

3.1.3 Injury Anamnesis

Except the present problem the patient didn't had any injuries.

3.1.4 Surgery Anamnesis

Except the surgery of distal tibia and distal radius on 26/11/2017 in všeobecná fakultní nemocnice v praze, the patient didn't had any other surgeries.

3.1.5 Diet Anamnesis

The patient is having an omnivorous normal diet.

3.1.6 Family Anamnesis

The patient is living with his parents.

3.1.7 Social Anamnesis

Living with parents, friends aswell can help. The patient is left handed student. He practices recreational sport (floorball)

3.1.8 Occupational Anamnesis

The patient is student in highschool.

3.1.9 Allergy Anamnesis

N/A

3.1.10 Pharmacological Anamnesis

Fraxiparin (anticoagulent), no pain killers.

3.1.11 Hobbies Anamnesis

Practicing ice hockey with friend for pleasure, the patient doesn't have fixed main sport. He likes practicing for fun collectives games like football, and floorball aswell.

3.1.12 Abuses Anamnesis

Drink alcohol sometimes.

3.1.13 Prior Rehabilitation

None

3.1.14 Excerpt from patient's health care file

None

3.1.15 RHB indications

Contraindication : the patient has restricted weight baring on the right leg, limited to 50% of the bodyweight.

- Minimum 1 hour of pause between walks.
- Exercising lower extremities without pain
- Practice walking stereotype sur 2 crutches
- Practicing ankle dorsiflexion
- Walking on stairs
- Obstacles unstable ground
- Sensomotoric and stability training
- Increase strenght in lower extremities and hip
- Soft tissue and scar treatment
- Mobilisation of patella, head of the fibula, stretch of plantar flexors.
- CPM, bike exercice
- Manual lymphodrainage
- Exercices in swimming pool
- Ergotherapy: individual exercices (wrist work)

3.2 Case study

3.2.1 Initial Kinesiologic Examination

3.2.1.1 Postural examination

Right side :

The right foot is slightly advanced compared to the left foot, small folds are visible on the lateral edge of the foot at talocalcanear joint, under fibular malleolus.

- The right ankle is bigger than the left.
- Right knee is slightly bent.
- Right hip looks to be positioned more forward than the left hip.
- Lumbar spine slightly hyperlordotic
- Thoracic hyperkyphosis, with shoulders protracted and internally rotated. The right shoulder is more protracted compared to the left.
- head is protracted

Left side :

- Right foot slightly positioned forward. (As comparison, the left foot doesn't reveal as much folds as it was visible on the right foot.)
- Right ankle is bigger than the left.
- Right knee is slightly bent
- The right hip is advanced compared to the left one
- Lumbar spine slightly hyperlordotic
- Thoracic hyperkyphosis, with shoulders protracted and internally rotated. The right shoulder is more protracted than the left one.
- The head is protracted

Front side :

- Arches of both foot are medially flattened, more marked on the right.

Medial stance is visible, the part of the right ankle at the level of medial malleolus of tibia is more proeminent than the same part of the left foot. The right ankle is generally more swollen than the left. The right ankle itself too is generally bigger in comparison to the left.

- Right patella is more internally rotated than the left. the right knee is slightly bent.
- Right leg slightly abducted
- Left quadriceps is slightly bigger than the right
- Left arm triangle is bigger than the right
- Left shoulder is higher and shorter than the right
- The head is sligthly side bent to the left side

(I have to mention that the patients after 10 minutes of stance asked to sit. He felt dizzy and was pale. With the supervisor, we laid the patient and brought his legs up, higher than the head. The patient feels better and after several minutes of pause the patient feels ready to keep going the assessment.)

Back side :

- Arches of both feet are flattened, more marked on the right.

Medial stance is visible, the part of the ankle at the level of medial malleolus of tibia is more proeminent than the same part of the left foot. The right ankle is generally more swollen than the left. The shape of the ankle with the calcaneus may show valgosity of calcaneal bone. Achilles tendon is sligthly curved (angle to the lateral side) in distal portion.

- Right knee more internally rotated and slightly bent.
- Right leg slightly abducted
- Slight C shape of the lumbar spine toward the left side is more visible when the flexion of the knee is increasing. As long as the patient stands, the posture quality get worse.
- The thoracic spine is kyphotic
- Scapulas are both abducted, the medial distal border of the right scapula is bulked.
- The arm triangle is bigger on the left side
- Both shoulders are internally rotated and protracted, the right shoulder in more protracted. The left trapezius looks shortened.
- Head is protracted and slightly side bent to the left side.

- **Two scale test :** L: 53kg R: 32kg

Conclusion of postural and two scale test:

The combination of the two test is really important here because the patient's stance had tendancy to be shifted to the left side naturally. The patient has adopted an analgetic posture for the right ankle.

Both feet present flat foot arches, with bigger right ankle compared to the left, proeminence of medial part of the ankle. The calcaneus looks like into valgose position. The achilles tendon remain slightly curved in the distal part toward lateral side.

The right foot is slightly positioned forward, with a knee slightly bent, and a slight abduction of the hip.

The right crest looks higher than the left.

The lumbar spine is slightly lordotic and draw a C curve, the thoracic spine is kyphotic with protracted head.

The left thoraco triangle is bigger than the right one, with the left shoulder higher with the right one more protratcted than the left.

The posture of the patient is really bad and requires to be corrected.

According to the visual assessment, the bad posture is due to the analgesic and overpressure relief changes.

When the patient is instructed to stand on both leg straight while trying to be (according is natural feeling) better centered. (In this case i want to assess the changes with both leg straight and a weight bare on the right ankle that approach 50% of the patient's bodyweight (around 42 kg).

Positionned, the patient is able to stay naturally in this position without feeling any uncomfortable. Many problems seen on the pelvic position, lumbar C shape, and shoulders are now disappeared or much less marked.

Only remains the foot arch, the ankle size and shape, the hyper thoracic kyphosis, the higher left shoulder, and the protracted head.

3.2.1.2 Pelvis examination

ASIS: same level PSIS: Same level Crest: Same level

Conclusion: Pelvis doesn't present any problem in the position of both pelvic bone.

3.2.1.3 Anthropometric measurements

- **Measurements of ankle circumference :**

Picture 11 : Ankle circumference

R : 32 cm L : 27cm

Right ankle is bigger than the left at malleolus height.

- **Measurements of thigh circumference :** *(10 cm above knee cap)*

R : 56,5 cm L : 57,7 cm

Right thigh is less big due to muscle mass atrophy.

- **The anatomical length:** R: 88 cm L: 88cm

- **<u>The physiological length</u>:** R: 98 cm L: 98 cm

3.2.1.4 Palpation examination

Ankle: The region around medial malleolus is quite tough, it gets smoother when reaching the pad of calcaneus area. The swelling and stiffness looks more concentrated at talocrural and talus level.

Scars: On the foot: Scars are really small (one or two suture point), the scars are quite tough, they are movable but it's hard to bend it.

The scar colour is bluish

3.2.1.5 Muscle tone

Muscle / Tonus	Left	Right
Popliteus muscle	N	N
Plantaris muscle	N	N
Gastrocnemius muscle	N	↗
Soleus	N	↗
Tibialis anterior	N	↗

Table 5: Muscle tone examination of the lower leg [according Lewit]

3.2.1.6 Rang Of Motion Measurement

At start position, when the patient is totally relaxed, sitting or lying (prone or supine), differences are observed between both feet:

1- the right foot has greater plantar flex than left

2- the right foot has greater eversion than the left foot

The right leg seems to be longer than the left leg from the big toe, the right leg is longer from approximately one distal phalangs of the big toe. Due to the greater eversion added to greater plantar flexion, the leg looks longer.

- **Check of length of legs:**

First of all, with the patient lying in supine, i assesed visually and passively the length of legs. Screening to find differences. Once the patients heels are supported and fixed from the calcaneus and the plantar aspect, i could finally compare both foot in order to have a better accuracy in my diagnosis during the complementary exams.

According to the anthropometric measurement:

- The anatomical length: R: 88 cm L: 88cm
- the physiological length: R: 98 cm L: 98 cm

3.2.1.7 Active motion

- **Left ankle**;

  Dorsiflexion : 22°

  Extension : 46°

  Inversion : 29°

  Eversion : 20°

- **Right ankle;**

  Dorsiflexion : 9° (the barrier is really hard)

  Extension : 35°

  Inversion : 33°

  Eversion : 11°

- **Left wrist;**

  Dorsiflexion : 72°

  Extension : 80°

  Radialduction : 14°

  Ulnaduction : 25°

- **Right wrist;**

  Dorsiflexion : 69°

  Extension: 80°

Radialduction : 14°

Ulnaduction : 28°

3.2.1.8 Passive motion

- **Left ankle ;**

  Dorsiflexion : 25°

  Extension : 50°

  Inversion : 33°

  Eversion: 25°

- **Right ankle** ;

  Dorsiflexion : 10°

  Extension : 41°

  Inversion : 37°

  Eversion : 13°

- **Left wrist ;**

  Flexion : 82°

  Extension : 85°

  radialduction : 18°

  Ulnaduction : 29°

- **Right wrist ;**

  Flexion : 81°

  Extension : 84°

  Radialduction : 18°

  Ulnaduction : 30°

Conclusion: The main problem in the rang of motion comes from the right ankle, that present a restriction in every direction except inversion that is this time greater than the left ankle. The dorsi flexion with eversion shows the biggest restriction.

Nb: During assessement of passive inversion, i've notice a greater mobility in the talonavicular, cuboid/cuneiform joints and tarsometatarsal joint, on the medial side in external rotation. However, absolutely no movement is visible on the calcaneal bone. While doing the same move in both feet, the healthy one show the calcaneal bone bending on the side to allow fluent inversion of the foot. On the right foot, while doing passive inversion, the calcaneal bone is not visible at all.

3.2.1.9 Neurological examination

3.2.1.9.1 Superficial sensations

Superficial sensations :

L3: Both legs present normal physiologic and equal sensations

L4: Both legs present normal physiologic and equal sensations

L5: Both legs present normal physiologic and equal sensations

S1: Both legs present normal physiologic and equal sensations

C6: Both arms present normal physiologic and equal sensations

C7: Both arms present normal physiologic and equal sensations

C8: Both arms present normal physiologic and equal sensations

Nociception: No pain felt

Thermoreceptors: No irritative or burn sensation felt.

3.2.1.9.2 Proprioceptive and balance assessement

- **Rhomberg I, II, III**: the rhomberg tests have been both succesfully, the patient has good physiological response.
- **Vele test :** Grade 1. Any overactivation of toes is visible, no claw or hammer toe.

The proprioceptive and balance test has been performed aswell with different type of surfaces, always with both foot in contact with the floor. The assessement of balance and proprioception is limited due to the contraindication.

Conclusion: The patient is able to keep his balance, we will notice a tendancy to overactivate the left foot due to the bodyweight shift tendancy.

3.2.1.9.3 Deep tendon examination

Tendon	Response
Biceps (C5-C6)	2
Brachioradialis (C6)	2
Triceps (C7)	2
Wrist flexors (C8)	2
Patella tendon (L2-4)	2
Achilles tendon (L5-S2)	2

Table 6: Deep tendon reflexes examination [according to deep tendon reflexes scale]

3.2.1.9.4 Deep sensations and pyramidal lesion tests

- Kinesthetic sensation: Normal findings in toes and shin test

Signs of pyramidal injuries of UE.	Right		Left	
	Positive	Negative	Positive	Negative
Juster sign	●	✓	●	✓
Hoffmann Sign	●	✓	●	✓
Tromner Sign	●	✓	●	✓
Mayer Sign	●	✓	●	✓
Janisevski Sign	●	✓	●	✓
Palm-chin reflex	●	✓	●	✓
Thumb-chin reflex	●	✓	●	✓

Table 7: Pyramidal lesion tests for upper extremities [29] [30]

Signs of pyramidal injuries of LE.	Right		Left	
	Positive	Negative	Positive	Negative
Extension response				
Babinski reflex	●	✓	●	✓
Roche Reflex	●	✓	●	✓
Brissaud's reflex	●	✓	●	✓
Sicard's sign	●	✓	●	✓

Vitek's Bridge phenomenon	•	✓	•	✓
Chadock's reflex	•	✓	•	✓
Oppenheim's sign	•	✓	•	✓
Gordon's sign	•	✓	•	✓
Flexion response				
Rossolimo's reflex	•	✓	•	✓
Zukovsky-Korlinov	•	✓	•	✓
Mendel-Bechterew	•	✓	•	✓
Weingrow's Phenomenon	•	✓	•	✓

Table 8: Pyramidal signs of the lower extremities [29] [30]

3.2.1.10 Joint play examination

Picture 18: Patient's ankle shape [Author's files]

Distal phalangial joint (big toe included):

Joint play free, smooth barrier

Interphalanhial joint (big to included):

Joint play free, smooth barrier

Metatarsophalangial joint (big toe included):

Joint play free, smooth barrier

General screening test:

On one hand, while assessing the general joint play of the foot, i could feel and observe an adaptation or change in the rang of motion.

The more distal the joint were from the tallus, the greater was the difference of joint play compared to the left foot.

Visible only during inversion and eversion.

<u>The metatarsophalangial joint:</u>

Greater mobility from medial part, 1st distal, and from lateral 4 and 5th metatarsal head.

Lisfranc's joint:

Greater mobility in rotation on the right foot than the left. It doesn't mean that the joints of the left foot are restricted, i would say that the joints of right foot are slightly hypermobile in rotation movements.

The phenomenon is essenstially visible in metatarsophalangial joint because of mobility between each metatarsal joint, easier to increase than in Lisfranc's joint.

On the other hand, according to the findings of the general screening, I tried to be more precise in my screening test. I've noticed a difference aswell in the curvature in the medial part of the foot, I was trying to side bend the foot (in medial and lateral directions) from distal metatarsal heads of foot while fixing the ankle joint to ovoid at maximum movement from talus joint.

I've noticed again a slight difference with the healthy foot, the right foot in medial send bending was slightly greater from tarsal and metatarsal joint. The greater mobility was coming from 1st metatarsophalangial joint.

I would like to mention aswell that from this part, i already highly suspect the talocrural, talocalcaneaonavicular, and chopart's joint to be restricted or probably are at the origin of the findings.

Chopart's joint :

The joint play is restricted in the dorsal shift, the barrier is felt at the end of the motion, the barrier is harder and get tougher than the left foot.

The restriction is more obvious while assessing the tiny joint play in rotation, the barrier was felt from both side, each time that same side was raising cranially.

Talocalcaneonavicular joint :

Restricted in all directions.

<u>Caudal direction</u>: Traction can be performed, the space between the calcaneus and the tallus can be felt, but it happens much sooner than the left foot.

<u>Lateral and Medial directions</u>: Same feeling as for the caudal direction. It is possible to shift the calcaneal bone but the barrier felt is hard. While shifting the calcaneus, at restriction, the shifting become side bending. The feeling has been felt in both directions.

Talocrural joint :

The talocrural is hardly movable, the ventral shift is very tough and restricted.

Talonavicular joint :

Slight move is felt, the barrier is instantly felt in dorsal direction just after engaging the shift.

Cuboid/cuneiform/ navicular joints :

The Cuboid and cuneiform joints play are free, the barrier is soft. It feels the same in both foot.

The joint play between the calcaneus and the navicular bone + the cuboids with the calcaeus are restricted in dorsal direction.

The restriction is feels like it's coming from the tallus part.

- **Radioulnar joint** :

The joint is free, ulna and radius are movable against each other without feeling any hard barrier or restriction

- **Radiocarpal joint (Dorsal shift)** :

The radiocarpal joint is free, the radial head is moving freely against scaphoid, lunate, triquetrum and articular disc are all movable against each other without feeling any hard barrier or restriction.

Carpocarpal joints examination (Ventral shift) :

The second raw of carpal bones are moving freely against the proximal raw of carpal bones. Both raws are movable against each other without feeling any hard barrier or restriction.

Intercarpal joints:

With pincer grip, i assessed the mobility of capitate bone against his neighbors. In all cases, all carpal bones are movable freely, no pathological barrier is felt.

Metacarpal joints :

Joints between each metacarpal bones are freely movable, no pathological barrier or blockage is felt.

Carpometacarpal joints:

All 2 to 5 carpometacarpal joints are free. Any blockage or pathological restriction is felt.

The articulation of first metacarpal bone of the thumb with the trapezium is free of blockage and pathological manifestations.

Metacarpophalangial joint:

All joints are free of restriction or pathological barrier. Every directions has been tested, ventral, dorsal and rotation.

Interphalanhial joint :

Interphalangial joints are free. In ventral or dorsal shift, any blockage or pathological barrier is felt.

Distal phalangs joint :

Phalangial joints are free. In ventral or dorsal shift, any blockage or pathological barrier is felt.

3.2.1.11

3.2.1.12 Gait analysis

The analysis of the gait has been done with crutches, regarding the contraindication that forbid weigth baring over 50% of the bodyweight on the right leg (injured one).

Picture 19: Gait analysis of the patient [Author's file]

Without instruction or corrections:

At rest, the patient has alway the right leg bended, the weight baring is shifted to the left side.

Approximately 80% of the bodyweight is barred on the left leg. It is not possible with the two scale test to reveal it because of the crutches, without crutches, his posture is changing.

While walking (3 point gait), the step length are different, the steps done by the right leg is bigger than the left. If the steps are different so the rythm of steps will be aswell, the right step with the crutches is longer (especially before enhancing the swing phase with one leg stance on right leg.

The right foot step:

- (1) heel strike
- (2) flat foot, arch of foot is inexistant, the load of the ankle is medial
- (3) loading on metatarsal heads
- (4) particulary more on the last 3 metatarsal heads.

During the last step of the right foot, when the weight has to bear on the toes, inducing dorsi flexion of the foot, the heel is driven medialy (with bending of knee), coming from external rotation of hip, replacing the extension of hip to compensate the dorsiflexion restriction.

The left foot step:

- (1) distal metatarsal head
- (2) loading of lateral side of foot, the loading is lateral to medial
- (3) flat foot arch of foot is not existant, the load of the ankle is medial
- (4) hell strike, it is more an heel touch, because the weight is remaining at metatarsal heads.

Crutche and stairs:

The patient is able to go up and down stairs with the correct gait. The problem of flat foot, medial loading, and hip compensation on the right is still noticable.

Conclusions: The gait has been performed uncorrectly.

From heel strike to complete load and hip extension during the gait have to be improved.

The step pattern is modified by the ankle restriction and also the crutches effect that allow the patient to rest on arm and having different posture than without.

The walking pattern with the crutches is good, it is a 3 point gait, walking or stairs walking is good.

3.2.1.13 Movement stereotype assessement

Hip abduction (According to Janda): The hip abduction is done without compensation of other extra muscles or any signs of overactivation.

The test allows me to assess the strength of gluteus medius/minimus. The trendelenburg test is not suitable due to the contraindications.

Hip extension (According to Janda): The hip extension is done with slight compensation from the low back (slight hyperextension). No other sign of compensation is seen.

The test allows me to assess the gluteus maximus's strength. The patient is able to perform the move with instructions.

Squat : The squat pattern has been evaluated actively. Chosen to reveal where are the failing point(s), or weaknesses, or movement restrictions. Because squat is a functional movement, base of many complex movements used in our daily living.

Squat (According to Kolàř) : Bodyweight squat against gravity without help and instructions against the wall: the squat position and pattern is wrong:

- Position of foot are not at the same level. The right foot is forward and situated more away from the body. The left foot is too much rotated externally, the right foot is at straight position.
- When the patient engage the descending phase;
- Both knees are moving to the median line and consequently drives the foot to flat arch and medial ankle stance position.
- The head is protracted, shoulders internally rotated and protracted that drives consequently the thoracic spine into kyphosis with even lumbar spine into slight flexion which is not suitable.

The descending phase can be performed until an angle that doesn't pass down 150° knee flexion. At the moment the patient feels a hard barrier and restriction in ankle in the anterior part at talocrural level. He describes it as a sudden stop. The patient's back is leaning forward to keep the balance is lost. If the patient tries to go further down he falls, he falls on the buttock. Because he it is not possible to flex enough the right ankle, his right cannot moves at tip toes level and so keep the gravity point.

Conclusion:

The hip abduction and extension has shown the capability of the patient to perform those moves without difficulties against gravity.

Concerning the squat: This test is functional, base of many movement that patient and people are lead to perform in their everyday life activities. The squat has shown poor foot arch strength, insufficient knee stabilisation (rotate internaly while approching the 90° hip and knee flexion. Probably that hip stability and strenght has to be improved (which would have been more visible around 90° and below squat position).

The squat move is restricted due to lack of ankle mobility in dorsiflexion.

3.2.1.14 Length test

Length test of gastrocnemius and soleus are limited because of the resctriction of dorsiflexion in the ankle.

During the squat test: the patient mentioned a stretch feeling at calves lever, indicating shortness of soleus muscles. (bent knee)

No stretch is felt while doing passive dorsiflexion of right ankle with leg straight.

Shortness of triceps surae after ankle injury and surgery is quite highly probable to my mind. Lack of ROM in dorsiflexion, decrease of load, plus lot of rest makes the probabilities to find shortness higher. I suspect the gastrocnemius to be sortened aswell.

3.2.1.15 Special test

Hand grip and Pinch grip assessement: The patient is able to fully use the right hand as well as the left one. The patient didn't notice any kind of weakness, any particular uncomfortable feeling, the patient confirm that his strength, mobility, sensations are in a normal state, the same feeling as before the injury. The patient is able to walk with crutches, grab weigth and hold it against gravity in full pronation position.

Concerning the pinch grip, the patient is able to perform thumb opposition with the most important finger, the index and aswell with all last 3 fingers.

Fine motor skills:

- "Pinch and circle test" : able to oppose index with thumb and exerce circumduction of the wrist

3.2.1.16 Examination conclusion

The conclusion of the examination shows that the ankle is the joint that has problems, mainly in the restriction of talocrural joint and joints in relation with calcaneal bone in every directions a restriction can be felt.

The posture has been modified or/and adapted regarding the injuries. No restrictions, blockages, consequences on the body has been noticed concerning the right injured wrist. The wirst is at the same normal physiological health as the left healthy one.

The ankle mobility has consequences on the posture, the gait and on some functional moves (pick up an object on the floor). Any problems have been found at the neurological, balance and proprioceptive level.

The muscle tonus around ankle joint, especially the muscles that provide or help during plantar flexion or and eversion of the foot have a tonus higher than the left leg.

The posture and the gait have to be corrected to limit the impact of compensation due to lack of mobility.

3.2.1.17 Rehabilitation plan

3.2.1.17.1 Short term rehabilitation plan

- ✓ Increasing the ankle mobility
- ✓ Improving foot position
- ✓ Relaxing hypertonic muscles around the ankle joint
- ✓ Stretching shortened muscles
- ✓ Reduce swellness
- ✓ Scar care
- ✓ Improve quality of functional and postural movements (gait and posture)

3.2.1.17.2 Long term rehabilitation plan

- ✓ Increase the ankle mobility
- ✓ Restoring the right leg condition (same as left)
- ✓ Stimulation of joint and plantar proprioception
- ✓ Restoring correct posture and weight bare.

- ✓ Starting to exercice with progressive 100% weight bare on right ankle after end of CI.
- ✓ Stretching of Gastrocnemius and soleus muscle

3.2.2 Therapy process

3.2.2.1 Day 1

Date of the therapy: 10/01/2018

- Examined person: J.P Year: 05/09/2000
- Diagnosis: Rehabilitation of a right broken distal radius and right distal tibia

- Patient:

  Subjective: Patient fells generaly good on acceptance to rehabilitation, he doesn't feel plain in the ankle

  Objective: The patient is relaxed and ready to start his first rehabilitation time. He is willing to improve his ankle mobility and ready to be focused on it to get the best result possible.

  Walk with crutches, no glasses.

  Height: 192 cm

  Weight: 85 kg

  BMI: 23

  CI = + 50% weight baring on the right ankle

- Differential balance:

  The problem expressed by the general examination of the patient shown that the biggest problem and the most restricted problem is the restriction of mobility in the ankle. The ankles poor mobility impact on the posture, the gait and the functional movements.

- Examination by physiotherapist: Done in the general examination (same day of 1st therapy)

- Examination's conclusion: Done in the general examination (same day of 1st therapy)

- Proposed therapy:
  - ✓ Soft tissue techniques (soft ball)
  - ✓ Scar therapy
  - ✓ Strengthening of foot arch and 3 points position
  - ✓ Mobilisation of talocrural joint (dorsal/ circumduction)/chopart's joint/Talocalcaneaonavicular joint/ Calcaneal bone
  - ✓ Traction of ankle joint with PIR
  - ✓ Correction of the gait pattern
  - ✓ Correction of posture with help of (two balance scales)

3.2.2.1.1 Session 1

Picture 12 : Swimmingpool therapy

1st session : 40 minutes swimming pool :

- Walking with focus on the right gait
- Walking on lateral side of the foot
- Walking on medial side of the foot
- Walking tip toes
- walking with foot from bottom to full ankle extension
- Walking on heels
- Walking from heel to toes
- Walking with full plantar flexion
- Leg kicking supine/prone with speed/force variation
- Leg circumduction (involves all the movements of the ankle and hip joint, cumulated in one compound movement)
- Duck walk
- Deep Squat position

- Duck walk with one knee touch on floor at every step

3.2.2.1.2 Session 2

The scar and soft tissue therapies were done with a soft ball and the scar treatment with S waves/ skin squeeze compression, stretch alternatively.

The mobilisation of joints has been performed without pain over 2/10 in dorsi flexion during talocrural joint mobilisation.

The correction of the gait and posture has been done actively with some strenghtening of the foot arch (foot arch strenghtening, 3 points stance, external rotation of hip, walking pattern with loading on 1- heel, 2- leteral side of foot, 3- tip toes)

- Result of therapeutic unit:

  The result of the therapeutic unit has been positive. The gait and posture was totally different and much better than during the examination. The patient feels restriction at talocrural joint still, and the pain has slightly decreased during dorsi flexion at barrier level.

- Self-therapy:

  - For self therapy, i've asked the patient to train him to walk by himself and thinking about the correct pattern.
  - I've recommended him to perform for stairs walk to improve his general strength condition.
  - While standing, performing some knee circumductions to have an increase movement in the ankle joint in every directions.

Picture 20: Dorsiflexion direction self mobilization [Author's file]

3.2.2.2 Day 2

Date of the therapy: 11/01/2018

- Examined person: J.P date: 05/09/2000
- Diagnosis: Rehabilitation of a right broken distal radius and right distal tibia

- Patient:

  Subjective: Patient fells generaly good on acceptance to rehabilitation, he doesn't feel pain in the ankle

  Objective: The patient is relaxed and ready to start his first rehabilitation time. He is willing to improve his ankle mobility and ready to be focused on it to get the best result possible.

  Walk with crutches, no glasses.

  Height: 192 cm

  Weight: 85 kg

BMI: 23

CI = + 50% weight baring on the right ankle

- Differential balance:

During the pool exercises it is the time i've chosen to try to, while having a conversation with him, trying to look for some clues that would make me improve my treatment. Regarding his personal feelings during activites of daily living or during the treatment or exercises, it has been clear that the talocrural joint, talocalcaneonavicular are at the origin of the restrictions.

The talocrural joint needs more dorsiflexion and plantarflexion, when the talocalcaneal joint needs more freedom at side shifting, and talonavicular more side bending.

- Proposed therapy:
  - ✓ Soft tissue techniques (soft ball)
  - ✓ Scar therapy
  - ✓ Stance modifications and passive stimulation of plantar aspect of the feet
  - ✓ Strengthening of foot arch and 3 points position
  - ✓ Mobilisation of talocrural joint (dorsal/ circumduction)/chopart's joint/Talocalcaneaonavicular joint/ Calcaneal bone
  - ✓ Traction of ankle joint
  - ✓ PiR for triceps surae
  - ✓ Correction of the gait pattern
  - ✓ Correction of posture with help of (two balance scales)
  - ✓ Strengthening the lower legs
  - ✓ Improving mobility actively

3.2.2.2.1 Session 1

1st session : 40 minutes swimming pool :

- Walking with focus on the right gait
- Walking on lateral side of the foot
- Walking on medial side of the foot

- Walking tip toes
- walking with foot from bottom to full ankle extension
- Walking on heels
- Walking from heel to toes
- Walking with full plantar flexion
- Leg kicking supine/prone with speed/force variation
- Leg circumduction (involves all the movements of the ankle and hip joint, cumulated in one compound movement)
- Duck walk
- Deep Squat position
- Duck walk with one knee touch on floor at every step

3.2.2.2.2 Session 2

The scar and STT therapies were done with a soft ball and the scar treatment with S waves with skin squeeze compression, alternative stretch.

The mobilisation of joints has been performed without pain over 2/10 in dorsi flexion during talocrural joint mobilisation.

Added to the treatment, some active/passive mobilizations were done on the right ankle joint.

Picture 21 : Ankle mobility exercices [Author's file]

3.2.2.2.3 Session 3

The correction of the gait and posture has been done actively with some strenghtening of the foot arch (foot arch strenghtening, 3 points stance, external rotation of knee, loading on 1- heel, 2- leteral side of foot, 3- tip toes)

Strengthening of general leg:

- Bike riding (to increase the complex link between strength and stretch)
- Squat modifications as half squat with straight back on the wall, leg extension to increase the quadriceps strength, activation and strengthening of gluteus muscles (hip extension, abduction)
- Ankle active flexion to extension.
- Some part of the strengthening therapy was mixed with some general body conditioning like: push ups ; all four walk ; DNS positions 3,4 months.

Why chosing thoses types of exercices?:

- To improve the mobility of ankles and wrists.
- To improve the stability of joints (muscle strenghtening)

- To improve the proprioception in the injured joints
- To reduce the apprehension of pain or to rise patient's self estime.

- Result of therapeutic unit:

The restriction at talocrural joint decreases, the pain continue to decreased during dorsiflexion at barrier level. The rang of motion has objectively improved, and subjectively the patient feels that the ankle barrier in dorsiflexion is less hard, more free.

The sport session was the first for the patient since the injury.

The sport session has been set up according to the required moves i wanted (ankle, wrist, legs and core activation, in a functional movement) and what he prefers.(For exemple push ups.)

After the session, i've noticed the patient was more motivated to improve and he was feeling really much more concerned about it. He mentioned that during this type of strengthening, he felt that he was contributing actively to the improvement of his condition, he was investing himself aswell. The training raised his self confidence and motivation for the therapy process.

- Self-therapy:

  - For self therapy, i've asked the patient to keep improving his walking pattern, not to train more, but while he is moving, to pay attention to his gait pattern.
  - Self treatment on scar

3.2.2.3 Day 3

Date of the therapy: 12/01/2018

- Examined person: J.P Year: 05/09/2000
- Diagnosis: Rehabilitation of a right broken distal radius and right distal tibia

- Patient:

  Subjective: Patient fells well on acceptance to rehabilitation

Objective: Every morning at the swimming pool i have the possibility to examine the gait of the patient and objectively assess the improvement. The gait pattern technically remain good but the walk lenght is longer, more confident and sure.

Walk with crutches, no glasses.

Height: 192 cm

Weight: 85 kg

BMI: 23

CI = + 50% weight baring on the right ankle

- Differential balance:

During the pool exercises it is the time i've chosen to try to, while having a conversation with him, trying to look for some clues that would make me improve my treatment. Regarding his personal feelings during activites of daily living or during the treatment or exercises, it has been clear that the talocrural joint, talocalcaneonavicular are at the origin of the restrictions.

The talocrural joint needs more dorsiflexion and plantarflexion, when the talocalcaneal joint needs more freedom at side shifting, and talonavicular more side bending.

- Proposed therapy:
    - ✓ Soft tissue techniques (soft ball)
    - ✓ Scar therapy
    - ✓ Improvement of sensomotor functions
    - ✓ Strengthening of foot arch and 3 points position
    - ✓ Mobilisation of talocrural joint (dorsal/ circumduction), Talocalcaneaonavicular joints
    - ✓ Traction of ankle joint
    - ✓ Stretch with PIR for triceps surae
    - ✓ Improvement of the gait pattern
    - ✓ Correction of posture with help of (two balance scales)
    - ✓ Strengthening the lower legs
    - ✓ Improving mobility actively

3.2.2.3.1 Session 1

1st session : 40 minutes swimming pool :

- Walking with focus on the right gait
- Walking on lateral side of the foot
- Walking on medial side of the foot
- Walking tip toes
- walking with foot with full active ankle plantar flexion
- Walking on heels
- Walking from heel to toes
- Walking with full plantar flexion on tip toes
- Leg kicking supine/prone with speed/force variation
- Leg circumduction (involves all the movements of the ankle and hip joint, cumulated in one compound movement)
- Duck walk
- Deep Squat position
- Duck walk with one knee touch on floor at every step

3.2.2.3.2 Session 2

The scar and STT therapies were done with a soft ball and the scar treatment with S waves with skin squeeze compression, alternative stretch.

The mobilisation of talocrural and talocalcaneonavicular joints has been performed without pain over 2/10.

Added to the treatment, some active/passive mobilizations were done on the right ankle joint.

Picture 22 : Swiming pool exercising [Author's file]

Picture 23 : Sensomotoric and mobility training [Author's file]

3.2.2.3.3 Session 3

The correction of the gait and posture has been done actively with some strenghtening of the foot arch (foot arch strenghtening, 3 points stance, external rotation of knee, loading on 1- heel, 2- leteral side of foot, 3- tip toes)

Strengthening of general leg:

- Bike riding (to increase the complex link between strength and stretch)
- Squat modifications as half squat with straight back on the wall, leg extension to increase the quadriceps strength, activation and strengthening of gluteus muscles (hip extension, abduction)
- Ankle active flexion to extension.
- Some part of the strengthening therapy was mixed with some general body conditioning like: push ups ; all four walk ; DNS positions 10, 11 months.

- Self-therapy:

  - For self therapy, i've asked the patient to keep watching over his walking pattern, not to train more, but while he is moving, to pay attention to his gait pattern.
  - Self treatment on scar
  - Work on tripod and foot arching

3.2.2.4 Day 4

Date of the therapy: 15/01/2018

- Examined person: J.P   Year: 05/09/2000
- Diagnosis: Rehabilitation of a right broken distal radius and right distal tibia

- Patient:

  Subjective: Patient fells generaly good on acceptance to rehabilitation, he doesn't feel pain in the ankle

  Objective: The gait continues to improve in the fluency, the mobility of the ankle tend

  Walk with crutches, no glasses.

  Height: 192 cm

  Weight: 85 kg

  BMI: 23

CI = + 50% weight baring on the right ankle

- Differential balance: The talocrural joint needs more dorsiflexion and plantarflexion, when the talocalcaneal joint needs more freedom at side shifting, and talonavicular more side bending.

- Examination by physiotherapist: Done in the general examination (same day of 1st therapy)

- Examination's conclusion: Done in the general examination (same day of 1st therapy)

- Proposed therapy:
  - ✓ Soft tissue techniques (soft ball)
  - ✓ Scar therapy
  - ✓ Strengthening of foot arch and 3 points position
  - ✓ Mobilisation of talocrural joint (dorsal/ circumduction)/chopart's joint/Talocalcaneaonavicular joint/ Calcaneal bone
  - ✓ Traction of ankle joint
  - ✓ PiR for triceps surae
  - ✓ Correction of the gait pattern
  - ✓ Correction of posture with help of (two balance scales)
  - ✓ Strengthening the lower legs
  - ✓ Improving mobility actively

3.2.2.4.1 Session 1

1st session : 40 minutes swimming pool :

- Walking with focus on the right gait
- Walking on lateral side of the foot
- Walking on medial side of the foot
- Walking tip toes

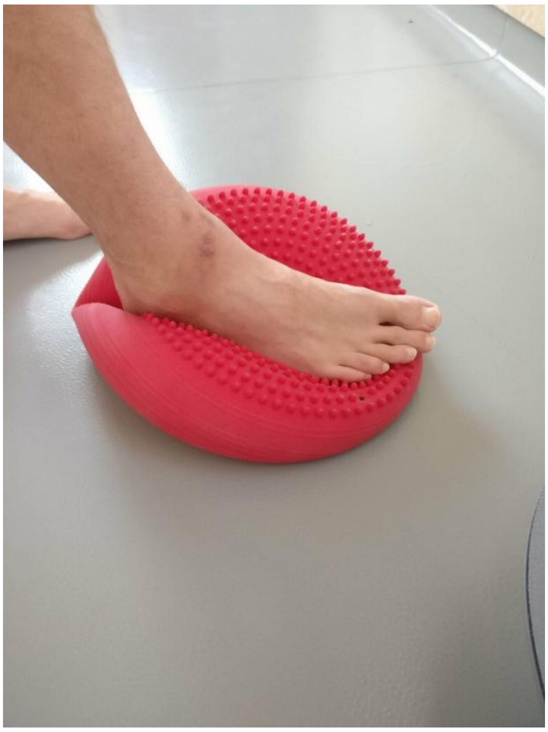
- walking with foot from bottom to full ankle extension
- Walking on heels
- Walking from heel to toes
- Walking with full plantar flexion
- Leg kicking supine/prone with speed/force variation
- Leg circumduction (involves all the movements of the ankle and hip joint, cumulated in one compound movement)
- Duck walk
- Deep Squat position
- Duck walk with one knee touch on floor at every step

3.2.2.4.2 Session 2

The scar and STT therapies were done with a soft ball and the scar treatment with S waves with skin squeeze compression, alternative stretch.

The mobilisation of joints has been performed without pain over 2/10 in dorsi flexion during talocrural joint mobilisation.

Added to the treatment, some active/passive mobilizations were done on the right ankle joint.



Picture 24 : Sensomotor stimulation [Author's file]

3.2.2.4.3 Session 3

The correction of the gait and posture has been done actively with some strenghtening of the foot arch (foot arch strenghtening, 3 points stance, external rotation of knee, loading on 1- heel, 2- leteral side of foot, 3- tip toes)

Strengthening of general leg:

- Bike riding (to increase the complex link between strength and stretch)
- Squat modifications as half squat with straight back on the wall, leg extension to increase the quadriceps strength, activation and strengthening of gluteus muscles (hip extension, abduction)
- Ankle active flexion to extension.
- Some part of the strengthening therapy was mixed with some general body conditioning like: push ups ; all four walk ; DNS positions 10, 11 months.

- Result of therapeutic unit:

  The ankle freedom improvement increases session after session, so does the patient abilities.

- Self-therapy:

  - For self therapy, i've asked the patient to keep improving his walking pattern, not to train more, but while he is moving, to pay attention to his gait pattern.
  - Self treatment on scar
  - Work on tripod and foot arching
  - Self stretch of triceps surae

3.2.2.5 Day 5

Date of the therapy: 16/01/2018

- Examined person: J.P Year: 05/09/2000
- Diagnosis: Rehabilitation of a right broken distal radius and right distal tibia

- Patient:

  Subjective: Patient fells generaly good on acceptance to rehabilitation, he doesn't feel plain in the ankle

  Objective: The patient is relaxed and ready to start his first rehabilitation time. He is willing to improve his ankle mobility and ready to be focused on it to get the best result possible.

  Walk with crutches, no glasses.

  Height: 192 cm

  Weight: 85 kg

  BMI: 23

  CI = + 50% weight baring on the right ankle

- Differential balance:

  The problem expressed by the general examination of the patient shown that the biggest problem and the most restricted problem is the restriction of mobility in the ankle. The ankles poor mobility impact on the posture, the gait and the functional movements.

- Proposed therapy:
  - ✓ Soft tissue techniques (soft ball)
  - ✓ Scar therapy
  - ✓ Strengthening of foot arch and 3 points position
  - ✓ Mobilisation of talocrural joint (dorsal/ circumduction)/chopart's joint/Talocalcaneaonavicular joint/ Calcaneal bone
  - ✓ Traction of ankle joint
  - ✓ PiR for triceps surae
  - ✓ Correction of the gait pattern
  - ✓ Correction of posture with help of (two balance scales)
  - ✓ Strengthening the lower legs
  - ✓ Improving mobility actively

3.2.2.5.1 Session 1

1st session : 40 minutes swimming pool :

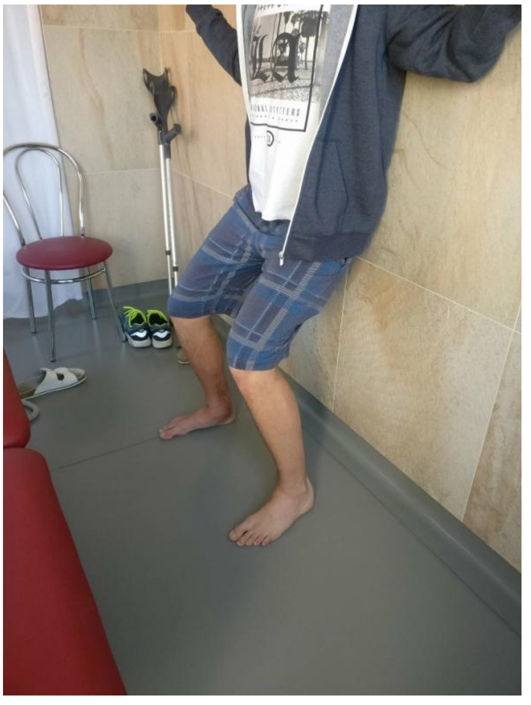
- Walking with focus on the right gait
- Walking on lateral side of the foot
- Walking on medial side of the foot
- Walking tip toes
- walking with foot from bottom to full ankle extension
- Walking on heels
- Walking from heel to toes
- Walking with full plantar flexion
- Leg kicking supine/prone with speed/force variation
- Leg circumduction (involves all the movements of the ankle and hip joint, cumulated in one compound movement)
- Duck walk
- Deep Squat position
- Duck walk with one knee touch on floor at every step

3.2.2.5.2 Session 2

The scar and STT therapies were done with a soft ball and the scar treatment with S waves with skin squeeze compression, alternative stretch.

The mobilisation of joints has been performed without pain over 2/10 in dorsi flexion during talocrural joint mobilisation.

Added to the treatment, some active/passive mobilizations were done on the right ankle joint.



Picture 25 : Squat exercise [Author's file]

3.2.2.5.3 Session 3

The correction of the gait and posture has been done actively with some strenghtening of the foot arch (foot arch strenghtening, 3 points stance, external rotation of knee, loading on 1- heel, 2- leteral side of foot, 3- tip toes)

Strengthening of general leg:

- Bike riding (to increase the complex link between strength and stretch)
- Squat modifications as half squat with straight back on the wall, leg extension to increase the quadriceps strength, activation and strengthening of gluteus muscles (hip extension, abduction)
- Ankle active flexion to extension.
- Some part of the strengthening therapy was mixed with some general body conditioning like: push ups ; all four walk ; DNS positions 10, 11 months.

- Result of therapeutic unit:

(final kinesiological examination)

- Self-therapy:

  - For self therapy, i've asked the patient to keep improving his walking pattern, not to train more, but while he is moving, to pay attention to his gait pattern.

  - Self treatment on scar

  - Work on tripod and foot arching

  - Self stretch of triceps surae

3.2.3 Final kinesiological examination

3.2.3.1 Postural examination

Right side :

- The right foot is slightly advanced compared to the left foot (less marked than the first examination)
- Lumbar spine slightly hyperlordotic
- Thoracic hyperkyphosis, with shoulders protracted and internally rotated.
- head is protracted

Left side :

- Right foot slightly positioned forward.
- Lumbar spine slightly hyperlordotic
- Thoracic kyphosis, with shoulders protracted and internally rotated.
- The head is protracted

Front side :

- Arches of both foot are slightly medially flattened (improvement since the first examination).
- Left quadriceps is slightly bigger than the right

Back side :

- Arches of both feet are flattened, both side are equal. the right foot position has improved.

The shape of the ankle with the calcaneus still shows slight valgosity of calcaneal bone (improvement of the position).

Achilles tendon shape has normal physiological shape, the same as the left foot.

- The thoracic spine is kyphotic
- Both shoulders are internally rotated and protracted.
- Head is protracted

- **Two scale test :** L: 46kg R: 39kg

Conclusion of postural and two scale test:

The posture has change as soon as the posture was corrected, only remain a tendancy to rest on the healthy leg and partialy relief the bodyweight pressure on the right ankle. However, when the pain has decreased, this tendancy tend to persist only after strengthening session. The patient is aware of this tendancy and correct himself. Only remains the foot arch, the pad and calcaneal shape, the hyper thoracic kyphosis and the protracted head.

3.2.3.2 Rang of motion measurement

Active motion:

- **left ankle**;

  Dorsiflexion : 22°

  Extension : 46°

  Inversion : 30°

  Eversion : 20°

- **Right ankle ;**

  Dorsiflexion : 19°

  Extension : 41°

  Inversion : 32°

  Eversion : 13°

- **Left wrist;**

  Dorsiflexion : 72°

  Extension : 80°

Radialduction : 14°

Ulnaduction : 25°

- **right wrist;**

Dorsiflexion : 69°

Extension: 80°

Radialduction : 14°

Ulnaduction : 28°

Passive motion:

- **left ankle ;**

Dorsiflexion : 26°

Extension : 50°

Inversion : 33°

Eversion: 25°

- **Right ankle** ;

Dorsiflexion : 24°

Extension : 45°

Inversion : 35°

Eversion : 21°

- **Left wrist ;**

Flexion : 82°

Extension : 85°

radialduction : 18°

Ulnaduction : 29°

- **Right wrist ;**

Flexion : 81°

Extension : 84°

Radialduction : 18°

Ulnaduction : 30°

Conclusion:

The rang of motion has improved and tend now to reach a physiological state. However, during functional movements that require an increased dorsiflexion of ankle, the foot is very limited compared to the left ankle.

3.2.4 Muscle tone

Muscle / Tonus	Left	Right
Popliteus muscle	N	N
Plantaris muscle	N	N
Gastrocnemius muscle	N	↗
Soleus	N	↗
Tibialis anterior	N	N

3.2.4.1 Movement stereotype

Squat (according Kolàř):

The patient is able to descend until 115/120 ° knee flexion, the talocrural joint is still the limiting component in this complex move. The lack of rang of motion lead to stance instability and eventually pain over 2/3 out of 10 at full limit of dorsiflexion that was allowed by the ankle joint.

The patient is able to perform complete and painless squat with support that allows him to not fall back, and to focus on the quality of execution in each components that needs to be improved (foot arch , external rotation of the knee, to remain centered in order to keep 50% of bodyweight on both legs so the strength is equally distributed and ankle dorsi-flexion which is the first key to achieve this exercise).

The squat have been improved, first of all in the ankle mobility, and second in the quality of leg strength during the descending and ascending phase. The knee was more stable, the ankle had more marked foot arch.

3.2.4.2 Gait analysis

The gait analysis has improved a lot very fast, after 2 sessions, the patient was able to correct some compensation stereotypes of the correct gait. The right hip extension is still restricted due to the restriction of the dorsiflexion of right ankle.

The rythm of steps and its duration tend to be equal. The compensations pattern observed during the first day of examination are not present anymore when the patient focuses on the pattern. The limitation of rang of motion is still the limitant factor for total correct walking pattern, the restriction is present at calcaneal bone.

3.2.4.3 Anthropometric measurements

Ankle circumference : (At malleolus): R: 27 cm L: 27cm

A slight difference is still visible, the right ankle remains slighlty swollen, at proximal achilles tendon on sides and under the bi malleolar line of right ankle.

3.2.4.4 Joint play examiantion

Distal phalangial joint (big toe included):

Joint play free, smooth barrier

Interphalanhial joint (big to included):

Joint play free, smooth barrier

Metatarsophalangial joint (big toe included):

Joint play free, smooth barrier

General screening test:

During the general screening assessement, the difference in inversion and eversion tend to be equal this time. A restriction is still visible at tallus region.

The metatarsophalangial joint:

Joint play free, smooth barrier

Lisfranc's joint:

Joint play free, smooth barrier

Chopart's joint :

Joint play free, the barrier is harder than the left ankle.

Talocalcaneonavicular joint :

Caudal direction: The mobility is greater, a hard barrier can still be felt.

Lateral and Medial directions: Same feeling, the mobility of the joint is greater than before but the barrier felt is still hard, the rang of motion is still limited compared to the left ankle.

Talocrural joint :

The talocrural is now more free, but the ventral shift is very tough and restricted.

Cuboid/cuneiform/ navicular joints :

Joint plays are free and movable, the barrier is smooth.

3.2.4.5 Palpation

The stiffness at the dorsum part of the ankle has decreased, the tissues are still stiff and tensed but the improvement is feeling.

Same feeling with the scar, the scars are small, so the stiffness is harder to decrease. However an improvement is feel, the scar are easily movable, most of stiffness is concentrated on the center of the scar.

3.2.4.6 Final examination conclusion

After 5 days of therapy, the condition of the patient has improved a lot. The posture is now more centered and balanced, 7 kg difference is observed between the right and left leg weight bare. The patient is aware of this tendancy and correct himself.

Only remains the foot arch, the pad and calcaneal shape, the hyper thoracic kyphosis and the protracted head.

The rang of motion has improved and tend now to reach a physiological state. However, during functional movements that requires an increased dorsiflexion of ankle, the foot is very limited compared to the left ankle. When the patient is doing an active bodyweight squat, the limitations due to the ankle is felt, expressed by the patient and objectively seen. The tough barrier is felt after the maximum of passive motion at around 24°.

The patient is now able to have a correct gait pattern, a slight difference at calcaneal bone is still visible.

The more soft tissues stiffness has reduced, as well as for the scar. Improvement is noticeable.

The joints plays are all free except the talocrural joint and the talocalcaneonavicular where, an improvement of the motion is obviously seen and felt but still restricted. The barriers felt are tough and doesn't allow to increase it with big force.

3.2.4.7 Evaluation of effectivness of therapy

Initial	Final
Postural: Flat foot arches Resting state on the left leg (knee bent, right foot pushed forward, hip look uneven) Upper body posture (thoracic hyperkyphosis, internal rotation of shoulder and protracted head)	Postural: Improvement of the arches of feet. Center of gravity is more centered to the body, so the general posture improved. (foot less protracted, knee extended, hip straight) Upper body (less kyphosis in thoracic spine, shoulder are more opened and so the head less protracted)
Two scale test: L: 53kg R: 32kg	Two scale test: L: 46kg R:39 kg
Ankle circumference: R:32 cm	Ankle circumference: R: 27cm
Rang of motion active: Dorsiflexion: 9° Plantarflexion: 35°	Rang of motion active: Dorsiflexion: 19° Plantarflexion: 41°

Inversion: 33° Eversion: 11°	Inversion: 30° Eversion: 13°
Rang of motion passive: Dorsiflexion: 10° Plantarflexion: 41° Inversion: 37° Eversion: 13°	Rang of motion passive: Dorsiflexion: 24° Plantarflexion: 50° Inversion: 33° Eversion: 21°
Scar: Stiffness, restricted	Scar: Improvement, smoother.
Joint plays: talocrural joint, talocalcaneonavicular joint. All very restricted.	The restrictions are improving, the joints freedom is greater, the barrier is smoother. So that the rang of motion is greater.
Gait Falling into flat foot after heel strike with poor loading of lateral part of foot. Extension compensation with hip external rotation.	Gait: Improvement of the load, longer time and better fluency during the loading phase. No external rotation during hip extension
General active function: Squat test with front support: 150° knee flexion	General active function: Squat test with front support: 110/115° knee flexion

Table 9: Effectiveness of the therapy comparaison

At the end of the treatment therapy, with the agreement of my patient, i made up a serie of questions. The patient agreed to answer them to to share some personal feeling and informations. I asked him to answer with his real point of view.

1- What was your feeling after the injury ?

Answer :

- Before, i felt so much pain, i tried to walk but it wasn't possible and that made me angry
- After, Every movements was painful, i felt sad and angry because again walking wasn't possible

2- How did you feel during rehabilitation?

Answer :

- +/- 10 days in hostpital, i didn't feel good, my leg was hurting, i was having pain killers and i could just sleep. When i had my leg fixated (splint), my mood slightly increased and i've started to move a litlle bit.

- At home; When i came home, my mood went back to a normal state after few days.I had the choice of the food, the sleeping time, and my girlfriend sometimes came so since the mood is good. The pain feeling stoped.

-First checking; Last week at home after the first checking by the doctor, i could unfixate my leg, clean it and exercice a bit, then put the fixation back.

- Second checking; I could get rid of everything and my leg was finally free, i was really happy. I was allowed to start walking (with crutches).

3- How your rehabilitation in RBN?

- When i came here i was a bit sad because i was again at the hospital, but people here are really nice so my mood went back to normal really quickly. At the beginning, my leg hurt when i was walking but thanks to the therapies it has improved rapidly and now i don't feel pain except during excessive dorsiflexion.

4- How was the rehabilitation with the practicians?

At the first hospital (všeobecná fakultní nemocnice v praze), i underwent a surgery, nobody talked to me unless i asked or when they needed me to sign something. They told me almost nothing about my rehabilitation. Here people are really nice and carefull, i have started doing something.I am greatfull that you chose me because i have a better follow during my rehabilitation process. I have more therapies with you and you showed me what to do in the swimingpool. I have improved so much from the beginning, so your methods are effective, and having treatments with you was nice.

4 Conclusion

The therapy that I performed was effective and my patient was pleased. We were achieving all our goals and we were performing all our proposed therapies, consequently, we achieved as much as we could in our limited period. It has been a real challenge sometimes to keep having new ideas, and to increase the accuracy of the treatment. It was a lot of questioning the first days.

During the practice, I learnt a lot concerning the relation patient/professional. The experience is valuable and by being able to practice every day my theoretical and practical knowledge was confidence for further independent work.

Since the rehabilitation time, i kept contact with my patient and he tells me about the improvement of his ankle. He told me that after being able to bare the full weight on the right ankle and keeping the exercices he did with me, he improved really fast and had been able to walk and slowly run without any pain.

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6 Supplements

6.1 Ethical Board

6.2 INFORMOVANY SOUHLAS

6.3 Table of tables

6.4 Table of pictures

6.5 List of Abbreviations

Anterior talofibular ligament - ATFL

Posterior talofibular ligament - PTFL

Calcaneal fibular ligament - CFL

Lateral talocalcaneal ligament - LTCL

Abduction - ABD

Adduction - ADD

Rang of motion - ROM

Post isometric relaxation - PIR

Normal - N

Lower extremities - LE

Upper extremities - UE