The Ankle: Anatomical and Cadaveric study

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Abstract:

This paper provides an introduction to the anatomical and cadaveric study of the ankle, introducing the bony anatomy involved in motion of the foot and ankle. The complexity of the ankle anatomy influences significantly the joint's biomechanical performance, and this paper discusses the anatomical component of the ankle joint complex, and the joints at which it is proposed they occur. It provides insight into the ligaments that are critical to the stability and function of the ankle joint. It describes the movements involved in a normal gait. 2 formalin fixed adult male cadavers are used for dissection in this study.

Keywords: ankle joint, subtalar joint, talocrural joint, tibiotalar joint

1.1 Introduction;

Ankle joint or Talocrural joint is approximately a uniaxial hinge variety of joint. The lower end of the tibia bone and its medial malleolus together with the lateral malleolus of fibula and inferior transverse tibiofibular ligament, form a deep recess (mortise) for the body of the talus. Although this joint appear to be a simple hinge variety, its axis of rotation is dynamic, shifting during dorsi flexion and plantar flexion. Dorsiflexion is to 10^0 with the knee straight, and to 30^0 with knee flexion (Because of relaxation of the calcaneal tendon). Plantar flexion is to 30^0. Dorsiflexion is the posture 'tight packed,' with optimum concordance and ligament stress. From this posture, all main thrusting motions are practiced in walking, running and jumping. The malleoli surround the talus, and no appreciable lateral movement will occur except in relaxation without stretching the lower tibiofibular syndesmose and minor bending of the fibula. The superior talar surfaces border in front, and in dorsiflexion the malleolar gap is

increased by slight lateral rotation of the fibula by 'give' at the inferior tibiofibular syndesmosis and gliding at the superior tibiofibular joint[1].

Articulating surface[2]:

Articular surface of ankle joint are covered by hyaline cartilage. This talar trochlear surface, which is convex parasagittal and gently concave transversely, is wider in front; the distal tibial articular surface is reciprocally curved. The talar articular surface for the medial malleolus is a proximal area on the medial talar surface, and is fairly flat, comma shaped and deeper anteriorly. The large lateral talar articular surface is triangular and vertically concave, while the articular surface on the lateral malleolus is reciprocally curved. Posteriorly, the edge between the trochlear and fibular articular surface of the talus is beveled to a narrow, flat triangular area that articulate with the inferior transverse tibiofibular ligament, all surfaces are continuous. The bones are connected by a fibrous capsule, medial (deltoid), anterior and posterior talofibular and calcaneofibular ligaments.

Upper articular surface

Upper articular surface is formed by:

(i) The lower end of the tibia including the medial malleolus,

(ii) The lateral malleolus of the fibula, and

(iii) The inferior transverse tibiofibular ligament.

All these structures collectively form a deep socket.

Inferior articular surface:

The inferior articular surface is formed by the articular areas on the upper, medial and lateral aspects of the talus bone.

Ankle joint is structurally very strong. The stability of this Joint shall be ensured by:

i. Close interlocking of the articular surfaces;

ii. Strong collateral ligaments on the sides;

iii. The tendons that cross the joint, which are four in front, and three on posteromedial side and two on posterolateral side.

The ankle joint is a strong synovial hinge variety of joint formed between the distal end and medial malleolus of tibia bone, the lateral malleolus of the fibula bone, and the trochlea of talus bone. Ankle joint is stable because of

1. The powerful ligaments and tendons around it and
2. The relatively great depth of the socket formed by the medial and lateral malleoli within which the trochlea of the talus is fitted.

The socket offers flexibility because of the body of the fibula. If the talus is forced laterally, the lateral malleolus moves outwards (a movement accompanied by medial movement of the shaft of the fibula acting with the tibiofibular ligaments as a fulcrum). This can in serious cases lead to fibula fracture in the leg. The socket of the ankle joint is deepened posteriorly by the inferior part of the posterior tibiofibular ligament (transverse tibiofibular ligament).

1.2 Material and Methods:

For the cadaveric study of Ankle joint, following things were needed:

Instruments for Dissection[3]

The following dissecting instruments should be procured:

- A scalpel
- Two pairs of forceps:
  - One pair with blunt and rounded ends
  - A fine pair with sharp-pointed ends
- Two pairs of scissors:
  - A fine pair
  - One large pair

- A blunt-tipped metal probe or seeker
- Other instruments which you will occasionally need, such as bone forceps, various saws and a long-bladed knife.

Fig.1.1: Showing instruments used in dissection

1.3 Surface Anatomy:

It can be studied on a living subject or the cadaver, place cadaver in the supine position and palpate the following structures in it-

- Iliac crest
- Anterior superior iliac spine
- Pubic tubercle
- Patella
- Medial femoral epicondyle
- Lateral femoral epicondyle
- Medial malleolus and
- Lateral malleolus

Skeleton of the Leg

- On the tibia
  - Medial condyle
  - Lateral condyle
  - Shaft (body)
  - Anterior border
  - Medial malleolus
  - Soleal line
- On the fibula
  - Head
  - Neck
  - Shaft (body)
  - Lateral malleolus
- Seven tarsal bones
  - Talus
  - Calcaneus
  - Navicular
  - Cuboid
  - Three cuneiform bones
    - First (medial)
    - Second (intermediate, middle)
    - Third (lateral)
- On the calcaneus
  - Calcaneal tuberosity
  - Sustentaculum tali
- **Five metatarsal bones** and the **tuberosity of the fifth metatarsal bone**
- **14 phalanges-** first toe has only two phalanges, whereas the other toes each have three phalanges

1.4 Steps for Dissection of Ankle Joint[4]:

1. Review the bony landmarks related to the ankle joint. On the distal end of the fibula identify the **lateral malleolus**. On the distal end of the tibia, identify the **medial malleolus**. On the talus, identify the **trochlea**. Review the tarsal bones.
2. Cut and reflect the tendons, vessels, and nerves that cross the anterior aspect of the ankle joint. Leave a 7.5-cm-long portion of the tibialis anterior tendon attached to the medial cuneiform and first metatarsal bone.
3. On the medial aspect of the ankle joint, cut and reflect the flexor digitorum longus muscle Retract the tendon of the tibialis posterior muscle anteriorly. Do not cut it.
4. Clean and define the **medial (deltoid) ligament of the ankle**. Identify its four parts:
    a. Posterior tibiotalar ligament
    b. Tibiocalcaneal ligament
    c. Tibionavicular ligament
    d. Anterior tibiotalar ligament
5. On the lateral side of the ankle, identify the tendons of the fibularis longus and fibularis brevis muscles. Open the superior and inferior fibular retinacula. Retract the tendons of the fibularis longus and fibularis brevis muscles anteriorly.
6. Clean and define the **lateral ligament of the ankle**
    Identify its three parts:
    a) Posterior talofibular ligament
    b) Calcaneofibular ligament
    c) Anterior talofibular ligament
7. Dorsiflex and plantar flex the ankle joint. Observe that these are the only actions of the ankle joint.

1.5 Ligaments[5];

Joint is supported by: Fibrous capsule, deltoid or medial ligament lateral ligament.

Capsule of the ankle joint:

As the ankle joint is a hinge type joint, the main ligaments of Ankle joint are lateral and medial ligament. The anterior part of the fibrous capsule of ankle joint is thin and consists mainly of transverse fibres. It extends from the anterior margin of the distal end of the tibia to the superior surface of the neck of the talus. The posterior part of the capsule extends from the posterior margin of the distal end of the tibia and the posterior tibiofibular ligament to the posterior surface of the body of the talus.

Medial (deltoid) ligament[6]:

Medial or deltoid ligament is very strong ligament radiates from the distal border of the medial malleolus to the medial side of the talus, the sustentaculum tali, the medial edge of the plantar calcaneo-navicular (spring) ligament, the navicular bone, and the neck of the talus. As such, the medial ligament not only strengthens the ankle joint, but also holds the calcaneus and the navicular against the talus.

Lateral ligament[7]:

The lateral ligament is consists of three bands—

1. Anterior talofibular ligament
2. Posterior talofibular ligament, and
3. Calcaneofibular ligament.

The anterior and posterior ligaments are thickenings of the fibrous capsule.

The anterior talofibular ligament passes anteriorly from the anterior border of the lateral malleolus to the neck of the talus.

The posterior talofibular ligament is much stronger. It runs medially and backwards from the fossa of the lateral malleolus to the posterior tubercle of the talus bone.

The calcaneofibular ligament is a round cord which passes inferiorly from the distal end of the lateral malleolus to the lateral surface of the calcaneus. It is separate from the articular capsule of the ankle joint and functions also as a ligament of the talocalcanean or subtalar joint which it crosses.

Synovial membrane[8]:

The synovial membrane lines the fibrous capsule of Ankle joint but is separated from it by pads of fat which lie deep to the anterior and posterior parts of the capsule. There is a short extension of the synovial membrane between the tibia and fibula, inferior to the thickened lower end of the interosseous membrane. All structures passing from the leg into the foot (except the tendocalcaneus) lie close to the ankle joint. Tendons, vessels, and nerves from the posterior compartment lie on the posteromedial surface, those from anterior compartment lie on the anterior surface; and those from the lateral compartment (fibular tendons) lie on the posterolateral surface.

1.6 Movements[9]:

At the ankle joint plantar flexion and dorsiflexion are the only significant movements. The trochlea tali is wide anteriorly, and the socket formed by the malleoli is also broader in front. Thus, the talus fits tightly into the socket when the foot is dorsiflexed. When the foot is plantar flexed, the talus is slightly loose, and some lateral movement is possible.

Table No.1.1: Muscles acting on the ankle joint[10]

Muscle	Origin	Insertion	Action	Nerve supply
Gastrocnemius	Femur, lateral condyle, medial condyle	Calcaneus	Plantar flexion	Tibial

Plantaris	Femur, lateral condyle	Calcaneus	Plantar flexion	Tibial
Soleus	Tibia, soleal line and medial border Fibula, posterior surface	Calcaneus	Plantar flexion	Tibial
Fibularis longus	Fibula, lateral surface	First metatarsal, base Medial cuneiform	Plantar flexion	Superficial fibular
Fibularis brevis	Fibula, lateral surface	Fifth metatarsal base	Plantar flexion	Superficial fibular
Tibialis anterior	Tibia, lateral surface Interosseous membrane	First metatarsal, base Medial cuneiform	Dorsiflexion	Tibial
Tibialis posterior	Interosseous membrane Adjacent parts of tibia and fibula	fibula Navicular, tuberosity Medial cuneiform All tarsals, except talus Metatarsal bases, 2–4	Plantar flexion	Tibial
Fibularis tertius	Fibula, anterior surface	Fifth metatarsal base	Dorsiflexion	Deep fibular
Extensor hallucis longus	Fibula, anterior surface	Hallux, base of distal phalanx Ankle	Ankle dorsiflexion Tarsal, inversion Hallux, extension	Deep fibular
Extensor digitorum longus	Fibula, anterior surface	Extensor expansion toes 2–5	Ankle, dorsiflexion Toes, extension 2–5 all joints	Deep fibular
Flexor hallucis longus	Fibula, posterior surface	Hallux, distal phalanx, base	Ankle, plantar flexion Hallux, flexion all joints	Tibial
Flexor digitorum longus	Tibia, posterior surface	Terminal phalanges toes 2–5	Ankle, plantar flexion Toes, 2–5 flexion all joints	Tibial

Table No.1.2: Movements at Ankle Joint[11]

Movement	Muscles	Nerve supply
Plantar flexion	Gastrocnemius	Tibia
	Soleus	Tibial
	Plantaris	Tibial
	Tibialis posterior	Tibial
	Flexor digitorum longus	Tibial
	Flexor hallucis longus	Tibial
	Peroneus longus	Superficial fibular
	Peroneus brevis	Superficial fibular
Dorsiflexion	Tibialis anterior	Deep fibular
	Extensor hallucis longus	Deep fibular
	Extensor digitorum longus	Deep fibular
	Peroneus tertius	Deep fibular

1.7 Blood supply[11]:

From anterior tibial, posterior tibial, and peroneal arteries.

1.8 Nerve supply[11]:

From deep peroneal and tibial nerve.

Conclusion:

The ankle joint is traditionally considered a hinge joint permitting a rotatory movement in the sagittal plane - the dorsal and plantar flexion of the foot. This is however a gross simplification of the ankle's incredibly complicated work. Stability in the ankle joint is partially protected by the shape of the bones which make up the joint - i.e. the distal part of the tibia with the medial malleolus, the lateral malleolus and trochlea of the talus - and partly the ligamentous structures which surround the joint laterally, medially and between the distal portions of the tibia and fibula. Injuries to the ligaments of the ankle joint are common and are often sustained during sports performances. Considering the increase in athletic activities

through recent years, ruptures in the ligamentous structures of the ankle joint may be assumed to constitute a growing problem, as they may give rise to chronic instability and posttraumatic osteoarthritis. The specific role of the individual ligamentous structures in ankle stability still remains uncertain.

Fig.1.2: Photograph showing lines of dissection of lower limb

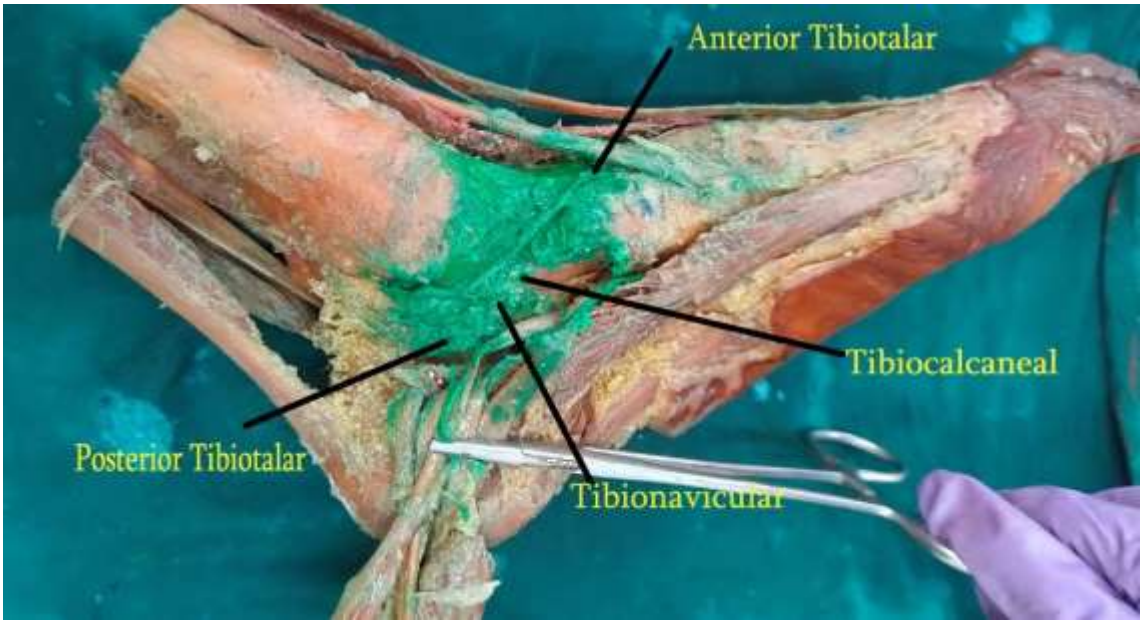

Fig.1.3: Photograph showing Deltoid Ligament of Left Ankle Joint

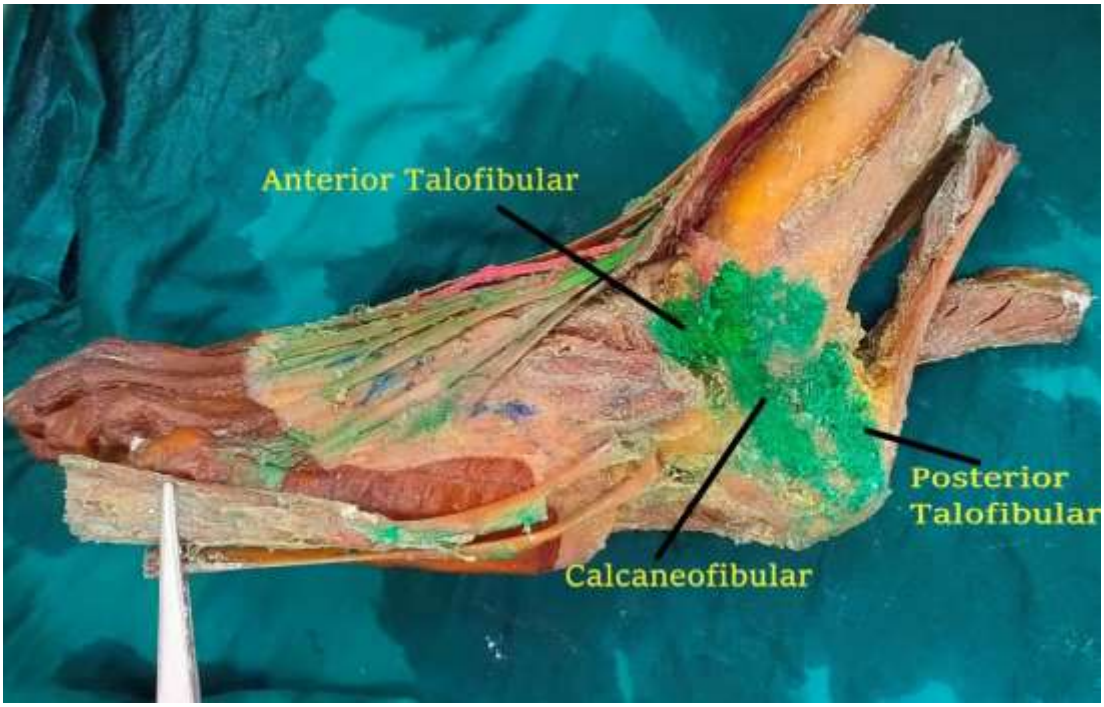

Fig.1.4: Photograph showing Lateral Ligament of Left Ankle Joint

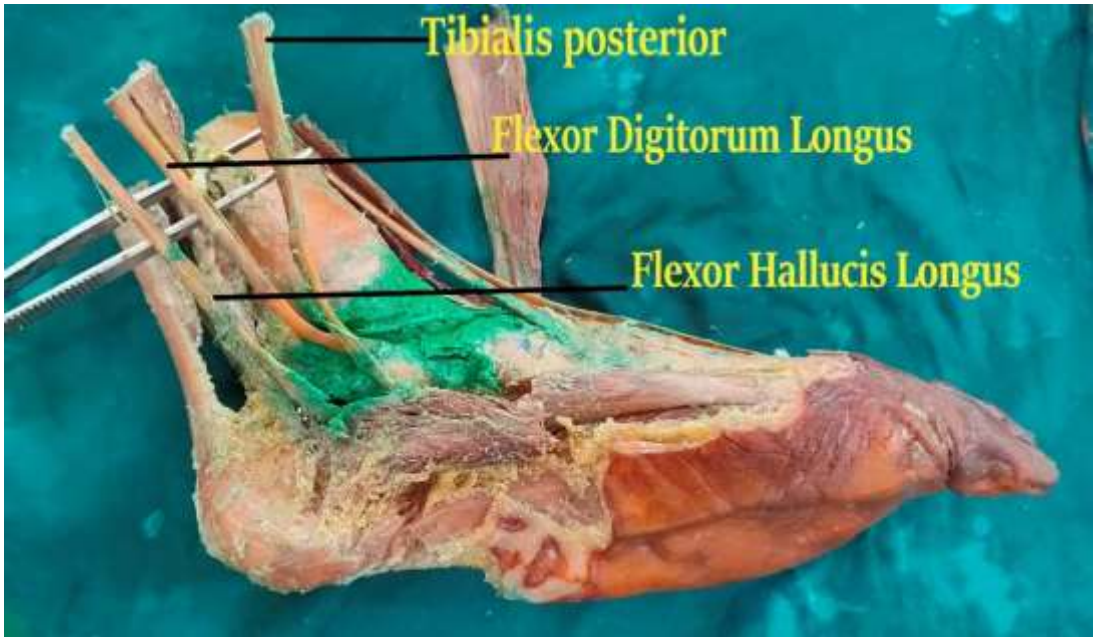

Fig.1.5: Photograph showing Posteromedial Relation of Left Ankle Joint

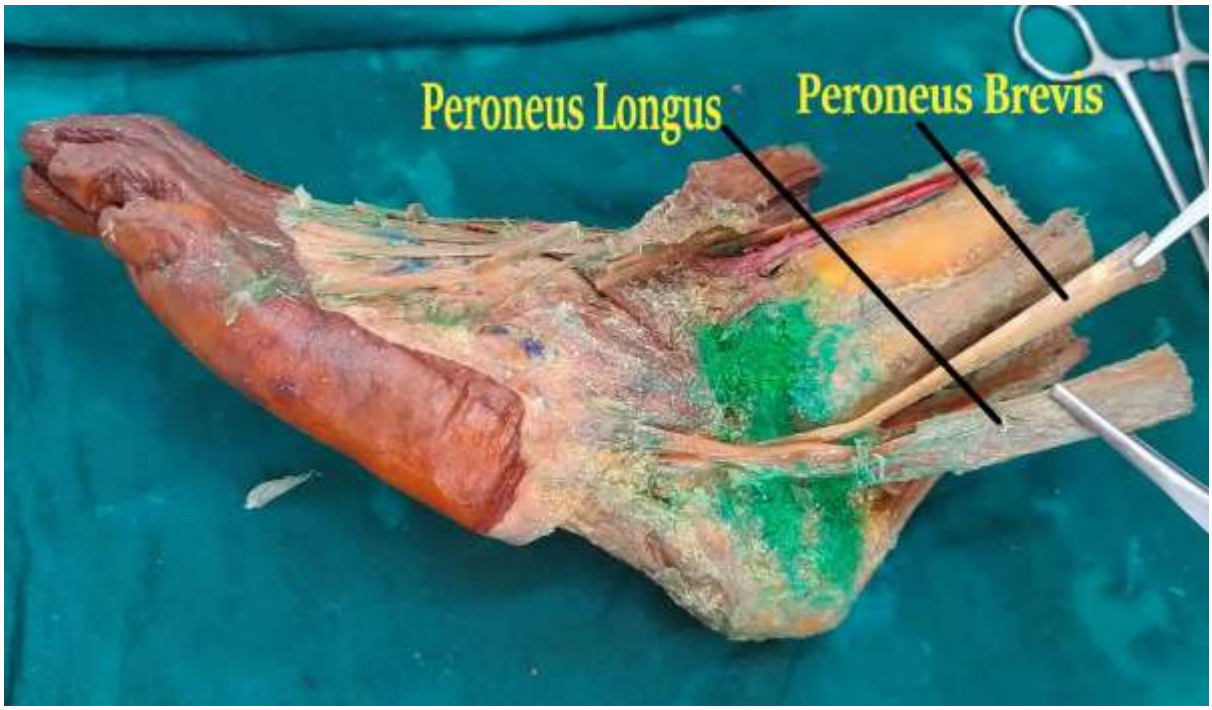

Fig.1.6: Photograph showing Posterolateral Relation of Left Ankle Joint

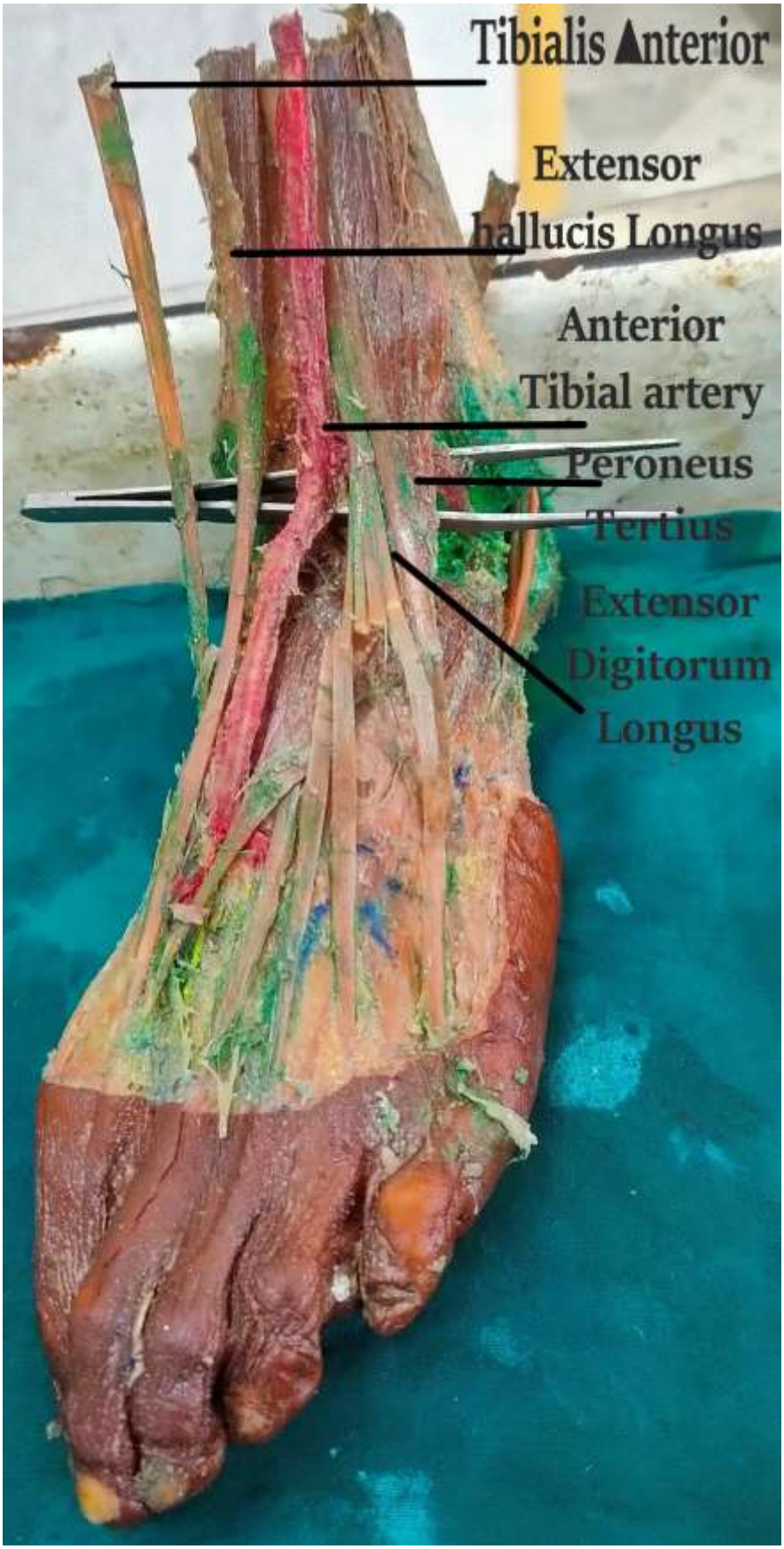

Fig.1.7: Photograph showing Anterior Relation of Left Ankle Joint

Fig.1.9: Photograph showing Achillies Tendon of Left Ankle Joint

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