THE UNIVERSITY OF TOLEDO MEDICAL CENTER

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ORTHOPAEDIC MONTHLY

VOLUME 8, ISSUE 8 AUGUST 2018

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Compartment Syndrome

Compartment syndrome is an increased pressure in a closed space or a compartment which will result in decreased perfusion and ischemia to the muscles and nerves. This may cause irreversible damage to the contents of that closed space, which may eventually lead to Volkmann's ischemic contracture. At the muscular level, ischemia for four hours can cause damage, but this damage is reversible. Compartment syndrome for 4-6 hours will cause variable ischemia. Compartment syndrome for 8 hours will cause irreversible damage, this is why it is called a surgical EMERGENCY!

Compartment syndrome is caused by hemorrhaging or swelling within the muscle. This volume increase is seen in fractures to the tibia or the forearm. This muscle injury will cause edema and this will increase the volume inside the compartment. A decrease in the volume of the compartment may be due to a tight cast or dressing. A high index of suspicion is necessary to diagnose compartment syndrome. It is important for the physician to go over the history of the patient and perform a physical examination. With compartment syndrome, the provider will notice that there is pain that is out of proportion to the pain expected from the injury or from the surgery. Pain getting worse that isn't relieved by analgesics is an indicator. The extremity should be examined for a swollen and tense compartment and pain with passive stretch. Paralysis and no pulse are both late findings which indicate that the damage may be irreversible.

If the compartment pressure is greater than 30 mmHG (absolute measurement), or within 30 mmHG of the diastolic pressure, then immediate fasciotomy should be done. The highest pressure is usually at 5 cm from the injury or the fracture.

Compartment syndrome should be treated initially with a bandage and dressing removal, then the cast should be split, followed by a

thorough examination. Once the diagnosis is established, the physician will need to do a four compartment fasciotomy. Fasciotomies can be done with the classic two incisions, or it can be done with one incision. All four compartments must be released!

A fasciotomy should be done early and in the operating room. If necessary, the fasciotomy may be done at the bedside. In order to perform a single incision for a fasciotomy of the lower leg, the physician makes an initial skin incision half way between the tibia and the fibula. The anterior compartment and the lateral compartment should be released. The superficial posterior compartment is located and released after retracting the peroneal muscles anteriorly. A cobb or retractor may be used for this purpose. The deep posterior compartment is released by retracting the tibialis anterior muscle laterally from the tibia, then incising the interosseous membrane. When you feel the posterior aspect of the tibia, this means that the posterior compartment is released and entered.

Tendons at the Ankle Region

We remember the arrangement of the anterior ankle structures by using a mnemonic, "Tom Has a Very Nice Dog". In this mnemonic, T stands for Tibialis Anterior; H, the extensor Hallucis Longus; V, Vessels, N, Nerve; and D, Extensor Digitorum Longus.

In order to remember the structures at the medial side of the ankle, physicians remember the mnemonic, "Tom, Dick, and Harry". The T, D, a, n, and H of Tom, Dick, and Harry, correspond with the tibialis posterior, flexor digitorum longus, posterior tibial artery, tibial nerve, and flexor hallucis longus.

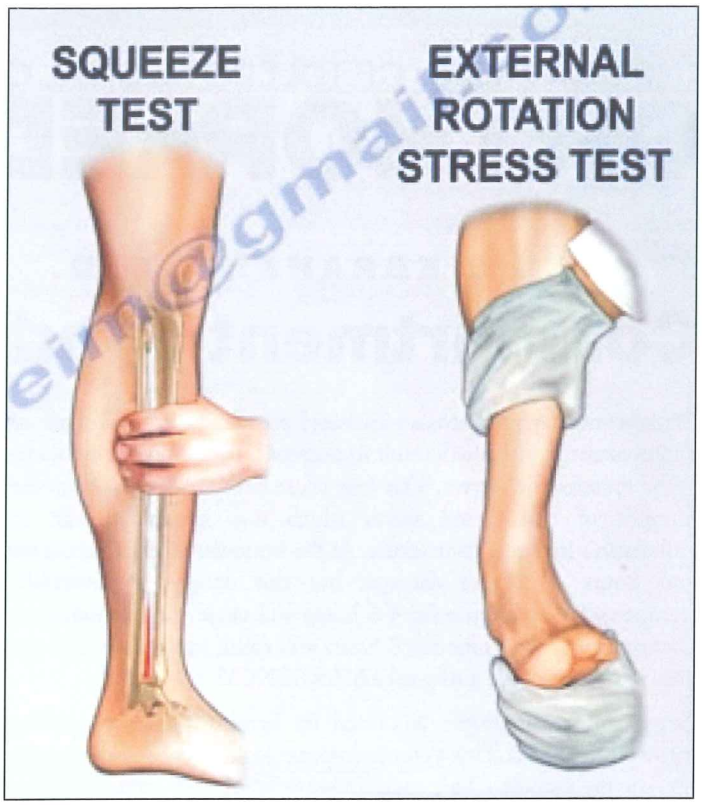
Ankle Ligament Injury, Test & Assessment

There are many structures present at the anterior aspect of the ankle. These structures are often susceptible to injury. Common injuries and conditions around the anterior ankle include: anterolateral impingement, arthritis of the ankle joint, osteochondritis dissecans of the talus, and tibialis anterior tendonitis.

Anterolateral impingement is painful limitation of full range of ankle motion due to soft tissue or osseous (bony) pathology. This soft tissue thickening is commonly seen in athletes with prior trauma that extends into the ankle joint. Tibial bone spur impinging on the talus can become a source of chronic ankle pain and limitation of ankle motion in athletes. An Osseous, or bony, spur on the anterior lip of the tibia contacting the talus during dorsiflexion. Arthritis of the ankle joint is commonly seen as the result of a prior injury or inflammation to the ankle joint. It can usually be diagnosed with an examination and x-ray. Osteochondritis dissecans of the talus are chip-type fractures that usually occur with severe ankle sprains. This condition causes pain, swelling, and stiffness of the ankle joint. X-rays, CT scans, or MRIs are commonly used for the diagnosis. Tibialis anterior tendonitis is an overuse condition that commonly occurs in runners. It usually accompanies anterior shin splints. If this tendon is strained, pain and tenderness will be felt upon active dorsiflexion or when the tendon is touched.

There are many structures present at the medial aspect of the ankle. These structures are often susceptible to injury. Common injuries and conditions around the medial ankle include: posterior tibial tendonitis or rupture, tarsal tunnel syndrome, flexor hallucis tendonitis, and rupture of the deltoid ligament.

Posterior tibial tendon problems can occur from over use activities, degeneration, and trauma. The posterior tibial tendon is one of the major supporting structures of the foot. The tendon helps to keep the arch of the foot in its normal position. When there is insufficiency or rupture of the tendon, the arch begins to sag and a flatfoot deformity can occur with associated right Achilles tendon. The posterior tibial tendon rupture occurs distal to the medial malleolus. This area is hypovascular. It presents itself clinically as painful swelling on the posteromedial aspect of the ankle. The patient may be unable to perform a single leg toe raise, have too many toes, have a flat foot, or have a fixed deformity of the hindfoot. Tarsal tunnel syndrome is a compression of the tibial nerve in the tarsal tunnel. The flexor retinaculum covers the nerve. Tarsal tunnel syndrome is similar to compression of the median nerve in the carpal tunnel. Tarsal tunnel syndrome can be caused by ganglia, accessory muscles, and soft tissue mass. Differential diagnosis include: herniated discs, stress fractures, and plantar fasciitis. Clinical findings of tarsal tunnel syndrome include: pain on the medial side of the foot and pain worse with dorsiflexion due to tension on the nerve. Paresthesia and numbness of the foot, as well as a positive Tinel's sign behind the medial malleolus are common indicators. An EMG study is usually not helpful. Flexor Hallucis Tendonitis refers to the pain, swelling, and weakness occurring posterior to the medial malleolus. Dorsiflexion of the big toe may be reduced when the



ankle is placed in dorsiflexion. Triggering and pain along the tendon sheath may also occur with toe flexion. This condition often presents itself in activities, such as ballet dancing, in which plantar flexion is necessary. The deltoid ligaments are the primary stabilizers of the ankle joint. The deltoid ligaments provide support to prevent the ankle from everting. An isolated eversion sprain with tear of the deltoid ligaments is a rare injury.

There are many structures present at the posterior aspect of the ankle. These structures are often susceptible to injury. Common injuries and conditions around the posterior ankle include: posterior ankle impingement (os trigonum), flexor hallucis longus tenosynovitis, Achilles tendonitis, and Achilles tendon rupture.

Posterior ankle impingement is posterior talar impingement of the os trigonum or large process of the talus (stieda syndrome). There is also a nonunited piece of accessory bone seen posterior to the talus. This is a common injury for ballet dancers. Tenderness will be appreciated in the posterolateral aspect of the ankle posterior to the peroneal tendon, especially with passive plantar flexion. This condition may also be seen in association with flexor hallucis longus tenosynovitis. Flexor hallucis longus tenosynovitis is another condition associated with ballet dancing, in which extreme plantar flexion is necessary. Swelling and pain posterior to the medial malleolus will be discovered. Triggering will be found with toe flexion. Dorsiflexion of the big toe is less when the ankle is dorsiflexed.

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Achilles tendonitis is a condition which causes irritation and inflammation due to overuse. The patient will have pain, swelling, and tears within the tendon. Achilles tendonitis is usually treated with therapy and injections; rarely with surgery. The Achilles tendon can become prone to rupture with age, lack of use, or by aggressive exercises. Rupture is diagnosed by the Thompson test and MRI. Treatment for an Achilles tendon rupture may be conservative, however the rerupture rate is high. Surgery is done by approximation of the torn ends, however there is a risk of infection, skin, and wound complications with surgery.

There are many structures present on the lateral side of the ankle. These structures are often susceptible to injury. Diagnosis of these injuries can be confusing and many may be missed. A diagnosis of a sprained ankle may be wrong! Common injuries around the lateral ankle include: a sprained ankle, high ankle sprain, peroneal tendon subluxation, rupture of the peroneus longus tendon, peroneal tendonitis, anterior process of the calcaneus fracture, lateral process of the talus fracture, and Achilles tendonitis.

Anatomical Snuff Box

The anatomical snuff box is a small, triangular depression located on the dorsoradial aspect of the wrist. People used this place for placing and then sniffing the powered tobacco or "snuff". This is how the "snuff box" received its name. It is triangular in shape and the base is proximal. The apex of the snuff box is pointing towards the thumb. The anatomic snuff box is seen better when the thumb is extended. It can also be seen well by placing the palm flat on the table and then lift the thumb off of the table. This is another way to clearly see the anatomical snuff box. There are three tendons which form the anatomical snuff box: the abductor pollicics longus, extensor pollicis brevis, and extensor pollicis longus.

Laterally, you can see the tendon of the abductor pollicis longus and it is inserted into the base of the first metacarpal. The abductor pollicis longus originates from the radius and the ulna. The second tendon is the extensor pollicis brevis, which is inserted into the base of the proximal phalanx. The extensor pollicis brevis originates from the radius. BREVIS probably indicates that it is a short muscle, so it comes from the radius. The abductor pollicis longus and the extensor pollicis brevis both form the lateral border of the anatomical snuff box. The extensor pollicis longus forms the ulnar border of the anatomical snuff box. The extensor pollicis longus inserts into the base of the distal phalanx and as its name indicates, its "longus" so it has to be longer. The extensor pollicis longus inserts into the base of the distal phalanx and as its name indicates, its "longus" so it has to be longer. The extensor pollicis longus comes from the ulna and forms the ulnar side of the anatomical snuff box. The abductor pollicis longus and extensor pollicis brevis tendons are present in the first dorsal extensor compartment. The extensor pollicis longus is present in the third dorsal extensor compartment. All three muscles are supplied by the posterior interosseous nerve, which is a branch of the radial nerve.

The anatomical snuff box is comprised of the radial artery, which forms the deep palmar arch, the superficial radial nerve, and the cephalic vein. The floor of the snuff box is the scaphoid and trapezium. There are several conditions that are related to the anatomical snuff box. Fracture of the scaphoid bone is a common carpal bone injury. If a fracture is suspected, the physician should look for tenderness in the anatomic "snuffbox". You will consider a fracture and treat it as a fracture even if you don't see a fracture on the x-ray. With scaphoid fractures, the patient's wrist should be immobilized in a thumb spica and seen in 10-14 days for re-evaluation and x-rays. Immobilization should be started early because the nonunion rate will increase if there is a delay in diagnosis for more than 4 weeks. The EPL tendon is most commonly due to fractures of the distal radius. Rupture is more common in nondisplaced fractures compared to displaced fractures. The patient will be unable to lift the thumb up, especially when the palm is down on a flat surface. A tendon transfer of the extensor indicis proprius (EIP) tendon to the EPL tendon is used for treatment of an EPL rupture (the best option). The anatomical snuff box is also important to identify during De Quervain syndrome injections. De Quervain syndrome is stenosing tenosynovitis of the first dorsal compartment of the wrist. Tendons of the radial boundary of the anatomical snuff box are the tendons involved in De Quervain syndrome. These two tendons should be located and injected. They will be found on the radial aspect of the anatomical snuff box. The extensor pollicis longus (EPL) tendon is on the ulnar side of the anatomical snuff box, DO NOT INJECT!

Ankle Ligament Injury and Assessment

The ligaments of the ankle are complex. Injury to these ligaments are called ankle sprains. Sprain of the ankle is usually a low ankle sprain. Occassionally, it can be a high ankle sprain. Sprain of the ankle can be confused with other conditions that can happen around the ankle such as: osteochondral lesion, peroneal tendon subluxation, fracture of the lateral talar process, fracture of the anterior process of the calcaneus, and the high ankle sprain (syndesmotic injury). A few tests used to test for injury of these ligaments are the anterior drawer test, the squeeze test, the talar tilt test, and the external rotation stress test. If the patient cannot bear weight on the ankle, the patient should get an x-ray.

Injury of the deltoid ligament occurs at the medial side of the ankle and it is usually associated with ankle fractures. Sometimes injury of the deltoid ligament is occult and the patient will need external rotation stress x-rays to demonstrate injury of the deltoid ligament.

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Injury to the lateral side ligaments is referred to as a low ankle sprain. The anterior talofibular ligament is the weakest ligament on the lateral side.

The anterior drawer test is done to test the competency of the anterior talofibular ligament. Test is done in 20° of plantar flexion and compare it to the other side. A shift of an absolute value of 9 mm on the lateral x-ray or 5 mm compared to the other side is positive.

The calcaneofibular ligament is usually injured after the anterior talofibular ligament. The test used to diagnose injury of the calcaneofibular ligament is called the talar tilt test or the inversion test. Less than 5 degrees of tilt is usually normal. The final area of injury is called a high ankle sprain or injury to the syndesmosis. Contrary to a low ankle sprain, a high ankle sprain may require surgery. This is how injury to the synesmosis occurs. Always check the fibula proximally to avoid missing a Maisonneuve fracture. The Maisonneuve fracture will have a proximal fibular fracture, a syndesmotic injury, and a deltoid ligament injury. This will require surgery.

Tests used to diagnose high ankle sprains are the squeeze test and the external rotation stress test. During the squeeze test, the physician will squeeze the tibia and the fibula at the mid-calf. This will cause pain at the syndesmosis if a high ankle sprain is present. The external rotation stress test is the other test that is used to diagnose a high ankle sprain or an injury of the syndesmosis. When physicians perform the external rotation stress test, the ankle should be placed into a neutral position. Then, an external rotation stress should be applied, followed by a mortise view radiograph. There is a positive result for syndesmotic injury if the tibiofibular clear space is more than 5mm or if the medial clear space widening is more than 4 mm.

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Dr. Ebraheim, Amanda Critton and Lauren Corba do not have any relationships with industry to disclose.

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