



Consensus of the 8th Round Table

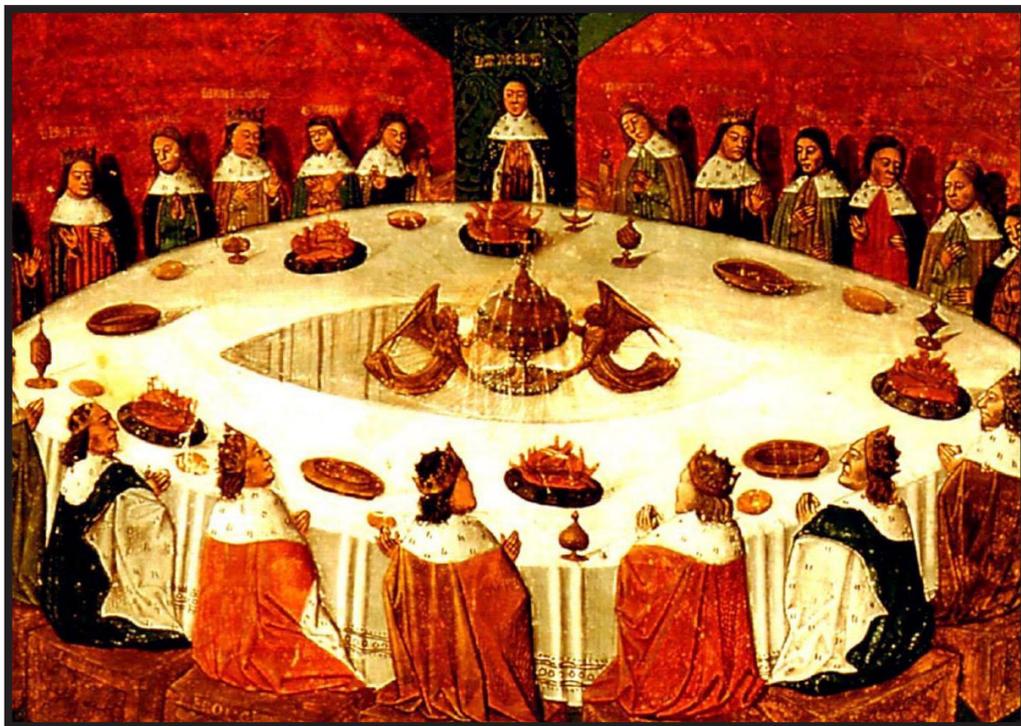
Tendon Disorders of the Foot & Ankle

Belfast, September 2018

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Aspects of Foot & Ankle Surgery

Tendon Disorders of the Foot & Ankle

Consensus of the 8th Round Table

Belfast, 5th to 7th September 2018

Course Convener:

Dishan Singh

Chairpersons:

Tim Clough

Nick Cullen

Andy Goldberg

Senthil Kumar

James Ritchie

Matt Welck



Hosted by:

OrthoSolutions Group

Distilled in this document are the thoughts and opinions, with consensus where possible, of 24 Orthopaedic Foot and Ankle Consultant Surgeons who gathered from across the United Kingdom and the Americas. Though eminence rather than true evidenced based medicine, this represents the concepts of over 200 years of combined experience. A basis of invited lectures introduced open and frank discussion from which consensus was sought. The statements herein only represent those of individuals and no claim is made that they are irrefutable. All the percentage figures quoted represent the proportion of the surgeons present who voted on the subject in discussion.

Preface

The Round Table concept is now established in British foot and ankle surgery. The first Round Table meeting was held in Padua in June 2011, followed by annual meetings in Paris, Barcelona, Budapest, Edinburgh, Munich and Cardiff. The **8th Round Table** in Belfast has once again not followed the usual orthopaedic meeting format where faculty members lecture to delegates. As always, the meeting is unique in that all participants have an equal input to review the literature and present their individual experience on a topic - with ample time for an informal discussion of the subject in a relaxed setting. We then attempt where possible to reach a consensus to guide us and the readers of this document.

This year, I have selected topics dealing with tendon disorders of the foot and ankle and the debate was indeed stimulating. Karan Malhotra and Shelain Patel were responsible for recording opinions and capturing the essence of the debates. Their valuable hard work is greatly appreciated and this booklet collates the literature review and the views of all those who participated.

This booklet does not represent Level I evidence derived from prospective randomised controlled trials but represents the compilation of the combined experience of 24 British and international orthopaedic surgeons. I would personally like to thank Professor John Wong, the president of the Irish Orthopaedic Foot and Ankle Society and his colleagues from Northern Ireland and the Republic of Ireland who contributed generously to both the organisation and the content of the meeting.

We also welcomed two transatlantic participants: João De Carvalho Neto of São Paulo in Brazil and Samuel Adams of Duke University, USA. Neto, the president of the South American Federation, in particular participated fully and made lively contributions to the meeting.

We have selected a short list of references in order to keep the booklet small and easily readable. I hope that you will find something of use and relevant to your own practice.

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Chair: Dishan Singh

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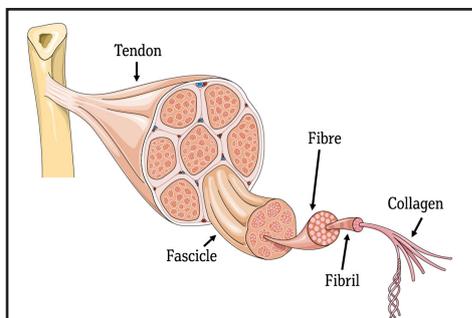
Session 1: Basic Sciences

1.1 - Anatomy of tendons

(John Wong)

Tendons are connective tissues which attach muscle to bone. They are composed predominantly of collagen, but also consist of tenocytes (a type of fibroblast), extra-cellular matrix, and elastin fibres. The collagen fibres are arranged in a quarter-staggered array which come together to form fibrils. These fibrils are bound together to form tendon fibres, which are organised into parallel fascicles. Tenocytes reside between the fascicles and contribute to production and maintenance of collagen fibres and extracellular matrix. Together these structures form a single tendon.

Tendons connect to bone through **fibrous** ('indirect') or **fibrocartilaginous** ('direct') enthesis. The fibrocartilaginous enthesis is more common and of greater interest to the foot and ankle surgeon. Fibrous insertion occurs to the periosteum on long bones to allow tendons to maintain their position whilst appositional growth occurs. Fibrocartilaginous insertion occurs directly onto the bone through four zones and Sharpey fibres travel across all four of these zones.

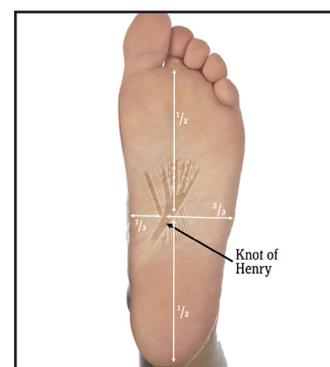
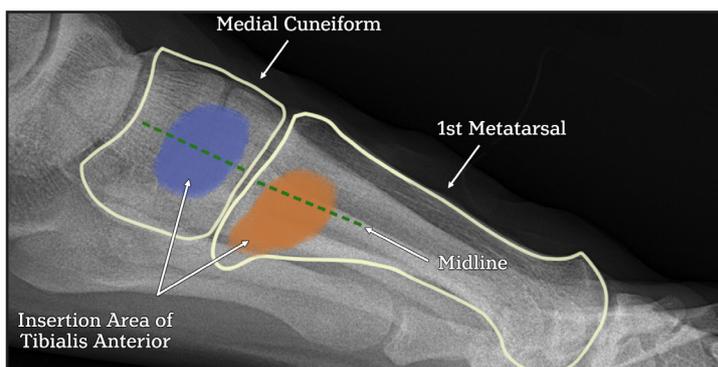


Zones of tendon insertion into bone:

- » **Zone 1:** Fibrous Tissue
- » **Zone 2:** Unmineralised fibrocartilage
- » **Zone 3:** Mineralised fibrocartilage
- » **Zone 4:** Bone

In the foot and ankle tendons may be thought of as those arising from proximal muscles and crossing the ankle, and tendons from muscles arising in the foot. Most tendons are surrounded by a loose connective tissue termed the paratenon which is usually vascular and abundant in cells (e.g. the Achilles tendon). However, some tendons may be relatively avascular and are surrounded by a synovial sheath instead of the paratenon. This allows tendons to glide more easily and reduces friction. Most tendons which cross the ankle joint are surrounded by a synovial sheath, including the peroneal tendons, the long flexors and extensors, and the tibialis anterior and posterior tendons.

It is important for the surgeon to appreciate the anatomy, course and insertion of tendons to avoid damage or irritation during operative interventions. The anatomy has a bearing on choice of approach and position of implants. The tibialis anterior tendon, for example, inserts onto the medial cuneiform in the mid-portion, but is inserted more plantar on the base of the first metatarsal. Therefore, when performing a Lapidus procedure, plantar plating should be performed more proximally, and medial plating more distally to avoid irritation of the tendon.



The various retinacula around the ankle serve to prevent bow stringing of tendons, and should be considered when performing tendon transfers as tendons can be transposed either superficial or deep to the retinacula. Each method has its own advantages and disadvantages.

Biomechanical Factor	Transfer Superficial to Retinaculum	Transfer Deep to Retinaculum
Excursion	Lesser	Greater
Moment Arm	Greater	Lesser
Other	Easier Gliding	Packing Effect

The flexor hallucis and digitorum longus have connections at the Knot of Henry in the plantar aspect of the foot. The flexor digitorum longus may require harvesting at the knot, or (as discussed in **Session 6.3**) tethering at the knot may result in a check-rein phenomenon which may need to be released. In these cases the knot of Henry may be located using surface anatomy landmarks, which allows a minimally invasive approach.

Knowledge of the location of the plantaris tendon for harvesting or excision is also required, as it is often easier to locate proximally on the lateral side of the leg between gastrocnemius and soleus. Finally, applied knowledge of the four muscle layers of the foot is required. When approaching the foot from the medial side, the abductor hallucis has been termed the '**door to the cage**' as identification and retraction of this muscle and tendon allows access to the rest of the foot muscles.

Summary:

- A good foundation of the anatomy and structure of tendons is required to enable understanding of the pathology of tendons
- An understanding of the applied anatomy is required to plan surgical approaches and techniques

References:

Apostolakos J, Durant TJ, Dwyer CR *et al.* **The enthesis: a review of the tendon-to-bone insertion.** *Muscles Ligaments Tendons J* 2014;4(3):333-42.

Jarusriwanna A, Chuckpaiwong B. **Appropriate Area for Operative Procedures Near Tibialis Anterior Tendon Insertion: A Cadaveric Study.** *Foot Ankle Int* 2018;39-3:349-54.

Panchbhavi VK, Yang J, Vallurupalli S. **Minimally invasive method of harvesting the flexor digitorum longus tendon: a cadaver study.** *Foot Ankle Int* 2008;29-1:42-8.

Sarrafian S. **Anatomy of the foot and ankle: descriptive, topographic, functional.** 2nd ed. Philadelphia: Lippincott, 1993.

1.2 - Biomechanics of muscles & tendons

(Constantinos Loizou)

Muscles initiate, decelerate and resist movement. Tendons transmit forces created by muscle to bone, but have additional roles as described below.

Roles of the tendon:

- » Transmits the force created by the muscle to bone
- » Stores and releases elastic strain energy during locomotion
- » Decreases impedance mismatch between muscle and bone (preventing injury)

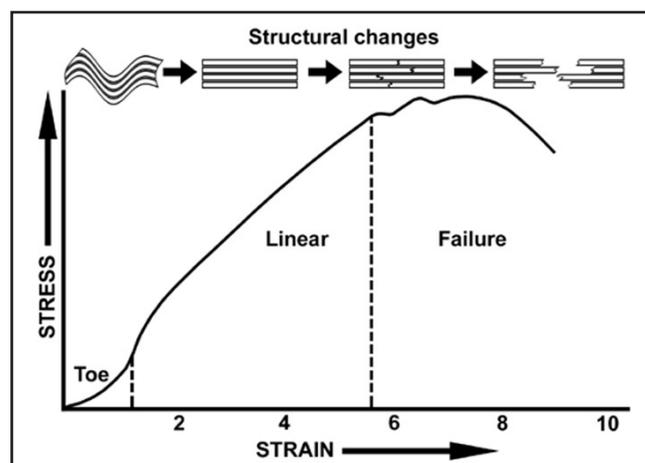
Tendons may be classified with regards to their functional role as positional or energy storing.

Positional Tendons	Energy Storing Tendons
Often extensor tendons (e.g. Tibialis anterior)	Often flexor tendons (e.g. Achilles tendon)
Experience low stresses	Experience high stresses
More intricate movements	Act as springs

When loaded, tendons exhibit a deformation pattern characteristic of their structure and this may be divided into three regions. The toe region, where collagen crimps are gradually removed by elongation, is a region of high compliance where muscle forces are low and contractile variations are damped resulting in smooth and finely controlled motion. Tendons remain in the toe region for up to the first 25% of maximum voluntary contraction.

The next region is the linear region, where strain is proportional to stress. This is a region of greater stiffness. It is in this region that high load tasks are performed and the damping effect is diminished resulting in more efficient force transfer.

The yield / failure region is the strain at which there are various degrees of fibre failure and finally complete tendon failure. The maximum strain the Achilles tendon can withstand is approximately 8%, whilst the peak strain achieved during normal maximum voluntary contraction is around 5.4%.



Tendons also demonstrate *viscoelastic properties* where their load-deformation relationships are rate and history dependent. Evidence from animal and human tendon experiments have shown that at higher strain rates there is greater tendon stiffness and higher load and strain to failure.

Tendons exhibit **hysteresis** which is the loss of energy between the loading and unloading cycles, and which varies between 5-30%. There is some evidence from porcine tendons that flexor tendons have less hysteresis and are more energy efficient than extensor tendons, in keeping with their functional role.

Creep is increased deformation to a stable state under a constant load. This may be significant when it comes to athletic activity and ensuring tendons behave in a repeatable way. Hawkins *et al.* found that during an eight-minute isometric ankle plantarflexion effort at 25% of maximum voluntary contraction (warm-up) the Achilles tendon reached a steady state of around 3% strain at five minutes. **Stress relaxation** is the observed decrease in stress in response to the same amount of strain. It seems to be in the region of 40-60%, and occurs predominantly through sliding between collagen fibres with greater reorganisation in flexor tendons as compared to extensor tendons.

There are also regional variations in tendon mechanics. At any given stress, the strain in the muscle-tendon region may be in excess of five times greater than the mid-tendon or bone-tendon strains. Such regional differences seem to be lost following denervation and might explain the increased incidence of muscle injury following reloading after periods of inactivity.

There is a lot of debate in the literature with regards to the optimum way of measuring such tissue properties (*in vivo* or *in vitro*, the form of tissue storage, the testing environments, tissue attachments and use of imaging for length and transducers for stress).

Summary:

- Tendons function to transmit forces from muscle to bone, but also store energy and decrease the impedance mismatch between muscle and bone
- Tendons have important viscoelastic properties which alter the way they behave under load over time
- Different regions of the tendon experience different strains under load, but this effect may be lost with inactivity, predisposing to injury

References:

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Wren TA, Yerby SA, Beaupre GS *et al.* **Mechanical properties of the human achilles tendon.** *Clin Biomech (Bristol, Avon)* 2001;16(3):245-51.

1.3 - Pathology of tendon disorders

(Patricia Allen)

As discussed previously, tendons are fibrous connective tissues consisting of predominantly Type I collagen (up to 85% dry weight). Additionally, tendons consist of tenocytes, proteoglycans and other non-collagenous proteins. The tenocytes, whilst scarce in mature tendon, are responsible for synthesis, organisation, degradation and replacement of the extra-cellular matrix. This ensures that the tendon responds to a variety of extrinsic factors, including mechanical load, exercise, and immobilisation.

In a healthy tendon the architecture and function are maintained by a balance between degradation and synthesis, and loss of this balance results in disorganisation of the extracellular matrix and ultimately to pathology. The primary cause for this is thought to be tendon overload through repetitive and excessive loading and unloading. The biomechanical factors described in **Session 1.2** play a role, as do intrinsic factors such as genetic make-up, age, gender, limb alignment and co-morbidities. Over the years a number of models for tendon pathology have been described.

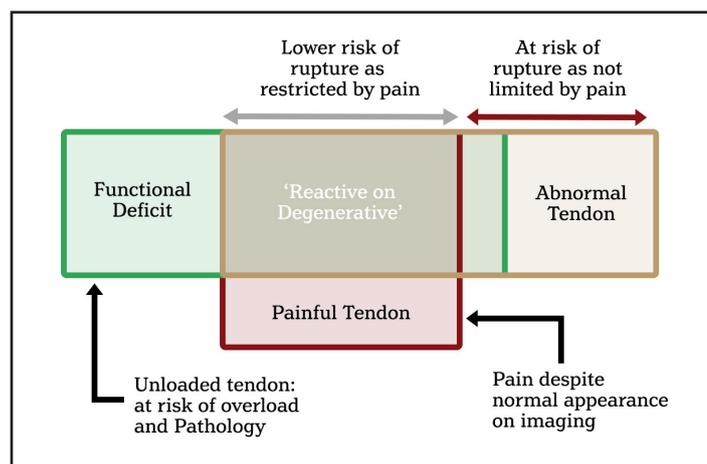
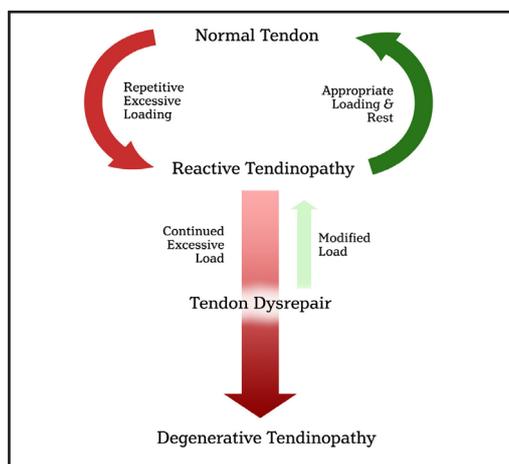
Models of tendon pathology:

- » Inflammatory Model
- » Degenerative Model
- » Failed Healing Model
- » Continuum Model

Continuum model of tendon pathology:

- » **Stage 1:** Reactive Tendinopathy
- » **Stage 2:** Tendon dysrepair (failed healing)
- » **Stage 3:** Degenerative Tendinopathy

The inflammatory model was the first described, but as studies found few inflammatory cells in diseased tendon this theory fell out of favour. The degenerative model was discarded as there was no evidence of this seen in the early stages of disease. The failed healing model was proposed to explain the neo-vascularity seen in tendon pathology, but could not explain all stages of tendon disease. The continuum model was therefore proposed to explain the disease process and why the early stages of tendinopathy are reversible, whereas the later stages are not.



Reactive tendinopathy is often seen in the younger patient and may be as a result of acute overload or direct trauma. There may be a non-inflammatory, proliferative response, where inflammatory mediators may be seen (IL-1 β , IL-6, COX-2). These mediators are released by tenocytes rather than inflammatory cells and may represent cell signalling pathways directed toward repair. The tendon is thickened and stiffer and may be seen on MRI as a fusiform swelling with no signal change. This tendon can return to normal if loading is returned to normal. As there are inflammatory mediators present, anti-inflammatories may help with pain.

If loading does not change or a period of rest is not instituted, failed attempts at healing result in matrix disorganisation and breakdown. This results in **tendon dysrepair** and may be seen in younger patients with chronic overuse. MRI will reveal swelling, increased vascularity and increased signal changes. Some of these changes are reversible with appropriate exercise programs which stimulate matrix repair.

In the final stage the changes to the matrix becomes irreversible which predisposes to rupture. This is termed **degenerative tendinopathy** and is seen with chronic overuse and advancing age. Imaging reveals swelling, increased vascularity and hypoechoic regions with areas of increased intra-tendinous signal change.

It is important to note that these processes may affect only part of the tendon. Pain can occur at any of the above stages as areas of relatively normal tendon surrounding areas of more advanced degeneration may become reactive and painful. This is termed **reactive-on-degenerative tendinopathy**.

Summary:

- Tendon pathology is related to changes in the extracellular matrix which leads to dysfunction and pain over time
- The continuum theory has been proposed to explain the progression of changes seen and can guide prognosis and treatment

Consensus / Discussion:

» **In an athlete presenting with Achilles tendinopathy secondary to overuse, does the pathology start in the tendon or the paratenon?**

Tendon first	14 (58%)
Paratenon first	0 (0%)
Not necessarily related	4 (17%)
Unsure	6 (25%)

References:

Cook JL, Purdam CR. **Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy.** *Br J Sports Med* [2009;43-6:409-16.](#)

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Khan KM, Cook JL, Bonar F *et al.* **Histopathology of common tendinopathies. Update and implications for clinical management.** *Sports Med* [1999;27-6:393-408.](#)

Kvist M, Jozsa L, Jarvinen MJ *et al.* **Chronic Achilles paratenonitis in athletes: a histological and histochemical study.** *Pathology* [1987;19-1:1-11.](#)

1.4 - Terminology of tendon disorders

(Anand Pillai)

As discussed in **Session 1.1** tendons are formed by fibres, which form fascicles and which in turn form the tendon. The individual fascicles are surrounded by loose connective tissue called the endotenon, and the tendon itself it is surrounded by an epitenon which carries a vascular, lymphatic and nerve supply. In tendons with a paratenon, the paratenon and epitenon are together called the peritenon.

The terminology of tendons and tendon pathology has changed numerous times throughout the years. **Tendinopathy** is commonly used as an umbrella term encompassing a variety of different tendon disorders which were traditionally defined based on anatomy or histology.

Definitions based on anatomy:

- » **Paratendinitis:** Inflammation of tendons surrounded by a paratenon (e.g. Achilles tendon)
- » **Tenosynovitis:** Inflammation of tendons within a synovial sheath (e.g. flexor tendons)
- » **Peritendinitis:** General term encompassing both paratendonitis and tenosynovitis.

- » **Insertional:** Pathology located at the point of insertion on the bone
- » **Non-insertional:** Pathology located proximal to the point of insertion on the bone

Definitions based on histology:

- » **Peritendinitis:** Inflammation of peritendinous sheath without tendon pathology
- » **Tendonosis:** Tendon degeneration without histological inflammation
- » *These may both co-exist in the same tendon*

However, tendon pathology is more complicated than this as discussed in **Session 1.3**, and inflammation and degeneration are not mutually exclusive. Therefore, attempts at a combined macroscopic and histologic classification were made by Clancy in 1990.

Pathological Diagnosis	Macroscopic Pathology	Histology Findings
Tendonosis	Intratendinous degeneration commonly due to ageing, microtrauma & vascular compromise	Disorganisation, mucoid ground substance, prominent cells ± neo-vascularisation / calcification
Tendinitis	Symptomatic degeneration of the tendon + vascular disruption & inflammatory repair response	As above, but evidence of partial tears with fibroblastic proliferation, haemorrhage and granulation
Paratenonitis	Inflammation of the paratenon / synovial sheath only	Mucoid degeneration in areolar tissue with mononuclear infiltrate
Paratenonitis + Tendonosis	Paratenonitis + Tendonosis	Combination of above findings for tendonosis and paratenonitis

Advances in the understanding of tendon pathology and the development of the continuum theory introduced further terminology as described in **Session 1.3**. This serves to add to the confusion surrounding terminology and as yet there is no system of terminology that unifies the most current theories.

Pain associated with Achilles tendon pathology has similarly undergone a number of shifts in terminology, and van Dijk *et al.* have attempted to rationalise this. However, their system introduces further terminology.

Term	Location	Symptoms	Clinical Findings	Histology
Mid-portion Tendinopathy	2-7 cm from insertion	Pain, swelling, reduced function	Diffuse / local swelling	Degeneration without inflammation (failed healing)
Para-Tendinopathy (Acute)	Mid-portion	Oedema + hyperaemia	Swelling + crepitus	Inflammatory infiltration + exudate
Para-Tendinopathy (Chronic)	Mid-portion	Exercise induced pain	Swelling + crepitus	Thickened paratenon + adhesions
Insertional Tendinopathy	Tendon insertion	Pain + solid swelling	Painful tendon insertion	Ossification of enthesial fibrocartilage
Retro-Calcaneal Bursitis	Insertion + distal	Pain + swelling	Painful swelling to either side	Synovial hypertrophy + inflammation
Superficial Bursitis	Distal	Swelling + limping with shoes	Discolouration + visible swelling	Acquired adventitious bursa + inflammation

Terminology used to describe a variety of Achilles tendon pathologies (van Dijk et al. 2011)

Summary:

- A large pool of confusing and inconsistent nomenclature exists and this has limited progress and understanding
- A uniform and clear terminology is necessary

Consensus / Discussion:

- » **A consensus was sought on the preferred spelling of 'tendonosis' versus 'tendinosis'**

Tendonosis	21 (87%)
Tendinosis	3 (13%)

References:

- Astrom M, Rausing A. **Chronic Achilles tendinopathy. A survey of surgical and histopathologic findings.** *Clin Orthop Relat Res* 1995;316:151-64.
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- Maffulli N, Khan KM, Puddu G. **Overuse tendon conditions: time to change a confusing terminology.** *Arthroscopy* 1998;14-8:840-3.
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1.5 - Imaging of tendon disorders

(João De Carvalho Neto)

Medical imaging plays an integral role in the diagnosis and management of tendon disorders in orthopaedic practice. Although history and clinical examination are key, up to 25% of injuries may be missed on physical examination. This is particularly true when there are complex, multiple or partial injuries.

Imaging therefore has a vital role to play and is best performed / interpreted by a dedicated musculo-skeletal radiologist working closely with the orthopaedic surgeon. Commonly available and used imaging modalities include *plain radiographs (XRs)*, *ultrasound imaging (USS)*, and *nuclear magnetic resonance imaging (MRI)*.

Role of imaging in tendon disorders:

- » Confirmation of diagnosis
- » To detect pathology not picked up on history and examination
- » To confirm the location and extent of pathology (planning of surgery)
- » Dynamic studies to guide management (e.g. assessing the gap in acute Achilles tendon ruptures)
- » Detection of calcification / foreign bodies
- » Medico-legal

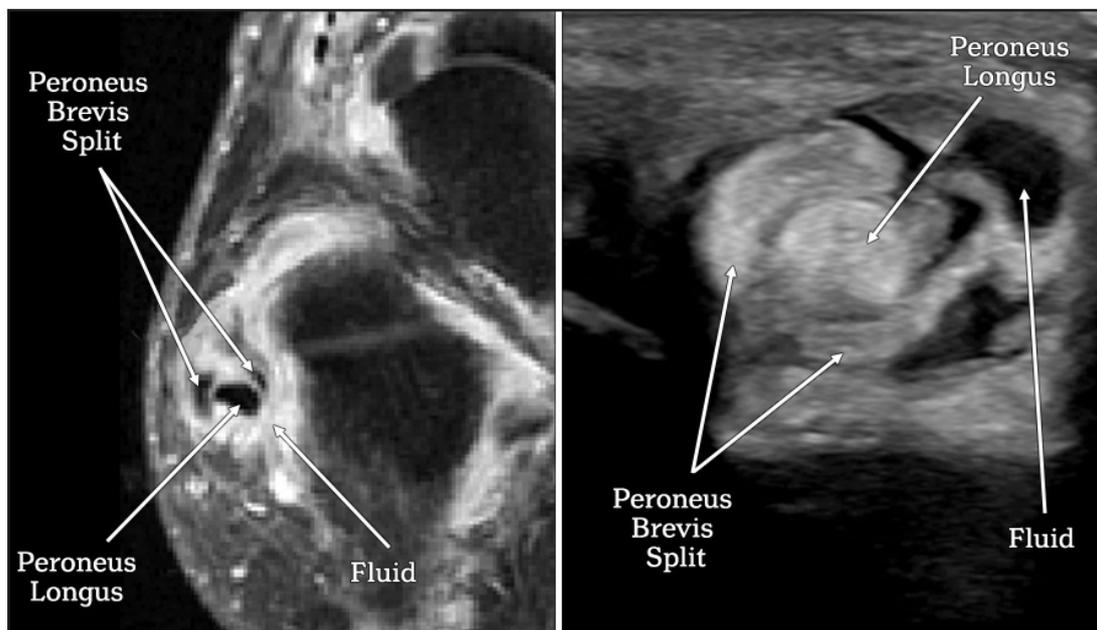
XRs are useful to examine bony alignment and to detect bony avulsions, calcification in tendons, and foreign bodies. They are also useful in the evaluation of accessory bones which may contribute to pathology (e.g. os peroneum or accessory navicular). Although they do not give much information about the tendons themselves directly, some indirect information may be gleaned from soft tissues shadows and the overall bony alignment.

USS is a useful investigation which can determine the shape and echogenicity of the tendon, assess splits in the fibres and gaps between tendon edges in injury. Dynamic scanning is possible and it a cheap and safe investigation which can be used in patients with contraindications to MRI. As discussed in **Session 3.3**, **Session 3.4** and **Session 3.5**, this can provide important prognostic information which can impact treatment. It can also provide better resolution than an MRI in foot and ankle pathology. However, it is highly operator dependant and may be inadequate in detecting partial tendon injuries.

MRI is superior in the detection of abnormal areas of tendon. Normal tendon has a low signal (dark) on both T1 and T2 sequences, but T2 is the better sequence for evaluation of pathology as fluid has a higher (bright) signal on T2-weighted images. In the setting of complete tendon ruptures, discontinuity of the tendon will be apparent and loss of the low signal will be seen at the tendon margins (i.e. margins will appear brighter). In tendinopathies, focal or fusiform thickening with diffuse signal increase in T2-weighted sequences may be seen. MRI images are also less operator dependant and easier to interpret than USS and therefore it is useful for measuring the retraction of tendon ends. Haemorrhage and oedema appear as areas of higher signal intensity on T2 sequences. Partial tears within the tendon substance and inflammation of the tendon sheath also demonstrate high signal intensity on T2 sequences.

It is, however, important that the correct investigations / sequences are performed. This is particularly true, for example, when using MRI to investigate the peroneal tendons. Standard MRI slices are performed at 90° to the ankle, but slices at 45° to this plane are better for assessing the peroneus longus and brevis. Note should also be made of the '*magic angle*' where tendons orientated at 55° to the magnetic field demonstrate increased signal on T2 sequences. The mechanisms for this are not completely understood but it occurs in tendons with tightly bound parallel collagen fibres. This is discussed further in **Session 2.1**.

Finally, MRI may be performed with contrast (gadolinium). Gadolinium increases the signal where there is an increase of blood flow and this is particularly useful when we suspect infection, changes in vascularity, inflammatory diseases, or after surgery. However gadolinium may be contraindicated in patients with renal impairment.



Different methods of imaging a peroneus brevis split. The surrounding oedema is readily apparent on the T2-weighted MRI sequence taken at 45° to the plane of the ankle (left). The ultrasound image (right) has higher resolution and allows dynamic scanning.

Summary:

- A variety of imaging modalities may be used in the assessment and management of tendon disorders
- It is important to choose the correct form of imaging for the particular pathology but more than one form of imaging may be required

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Horn DB, Meyers S, Astor W. **True Pathologic Abnormality versus Artifact Foot Position and Magic Angle Artifact in the Peroneal Tendons with 3T Imaging.** *J Am Podiatr Med Assoc* 2015;105(5):443-50.

Stoller D. **Magnetic Resonance Imaging in Orthopaedics and Sports Medicine.** 3rd ed. Philadelphia: Lippincott, 2006.

Session 2: Peroneal Tendon Disorders

2.1 - Tendinopathy & tears of the peroneal tendons

(Nick Cullen)

There are three main pathologies which affect the peroneal tendons: **tendonosis**, **tears**, and **subluxation / dislocation**. All three can co-exist although tendonosis is more common in the peroneus longus whilst split tears are more common in the peroneus brevis. The prevalence of tears has been reported as between 11% and 37% in cadaveric specimens. Subluxation and dislocation are discussed in **Session 2.2**.

Peroneal tendinopathy is a clinical syndrome characterised by thickened peroneal tendons with chronic pain. It was initially termed '**tendinitis**' but, as discussed in **Session 1.3** and **Session 1.4**, recent evidence suggests a degenerative rather than inflammatory process, and so the term '**tendonosis**' is preferred.

Factors predisposing to peroneal tendon pathology:

- » Trauma
- » Ankle instability
- » Hindfoot varus
- » Overstuffing of retro-malleolar groove, e.g. peroneus quartus / low lying brevis muscle belly
- » Inflammatory arthritides
- » Fibular anatomy, e.g. shallow fibular groove, sharp lateral ridge
- » Hypertrophied peroneal tubercle

Dombek *et al.* reported on their series of 40 patients who underwent surgery for peroneal pathology. The most common cause was an ankle sprain or other traumatic injury (58%). The nature of the pathologies found at surgery were: peroneus brevis tears (88%), peroneus longus tears (13%), combined peroneus brevis and longus tears (37%), low-lying peroneus muscle belly (33%), lateral ankle ligamentous disruptions (33%), and peroneal subluxation (20%).

Various theories exist to explain the location of peroneal tendonosis since peroneus brevis pathology is more common in the region around the distal 3 cm of the fibula whilst peroneus longus pathology is found at the levels of the superior peroneal retinaculum (9%), inferior peroneal retinaculum / peroneal tubercle (36%), and cuboid notch (89%). The commonest theory is that tendinopathy occurs at the points where the tendons pivot and are relatively avascular.

The peroneal tendons have non-linear trajectories and although they are bound by retinacula and have synovial sheaths to decrease the friction occurring during motion, the tendons pivot around corners and are subject to increased stress. Petersen *et al.* proposed three avascular zones exist (fibular groove, peroneal trochlea of the calcaneum, and cuboid notch) which prevent satisfactory healing and thus may allow tendinopathy to develop. However, this remains controversial since other groups have reported the peroneal tendons remain vascularised through their course.

USS has higher accuracy than MRI for assessment of peroneal tendon pathology which in part is related to the '**magic angle**' effect discussed in **Session 1.5**. It is particularly seen in the peroneal tendons as they change direction at the distal fibula and therefore the magnetic field may cross parts of the tendons at 55°.

Although the majority of patients may be managed conservatively for tears and tendonosis, surgery may be indicated when this fails. The treatment of tendonosis involves correction of the underlying abnormality (e.g. excision of peroneus quartus if this is causing irritation) whilst tears will be treated

by both, correcting the predisposing factor and performing either a debridement ± tubularisation, tenodesis or allograft. ESSKA and AOFAS recently released an international consensus on treatment of peroneal tears (below).



Summary:

- A triad of pathologies can affect the peroneal tendons which can occur in isolation or combination: tendonosis, tears and instability
- Tears and tendonosis may be predisposed by the anatomy of the hindfoot, ligamentous insufficiency and compression from adjacent structures
- Surgery may be indicated when conservative measures fail and choice of surgery can be guided by following an agreed treatment algorithm

Consensus / Discussion:

- » **What is your preferred operative treatment for a patient with a split tear of the peroneus brevis in the setting of a varus hindfoot? Patient is a younger athlete (< 35 years) with a traumatic injury.**

Repair tendon only	13 (54%)
Correction of deformity & repair of tendon	5 (21%)
Undecided	6 (25%)

- » **What is your preferred operative treatment for a patient with a split tear of the peroneus brevis in the setting of a varus hindfoot? Patient is older (> 35 years) with a degenerative lesion.**

Repair tendon only	5 (21%)
Correction of deformity & repair of tendon	15 (62%)
Undecided	4 (17%)

References:

Dombek MF, Lamm BM, Saltrick K *et al.* **Peroneal tendon tears: a retrospective review.** *J Foot Ankle Surg* 003;42(5):250-8.

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2.2 - Peroneal tendon subluxation

(Vivek Dhukaram)

Peroneal tendon instability may be distinguished as two entities: **subluxation / dislocation out of the retro-malleolar groove** (~ 0.5% of ankle injuries), and **intra-sheath subluxation** (less common). This session focusses predominantly on true peroneal tendon subluxation.

Factors predisposing to peroneal tendon subluxation / dislocation:

- » Superior peroneal retinaculum injury
- » Shallow retro-malleolar groove (*controversial*)
- » Crowding within the peroneal tunnel e.g. peroneus quartus / low lying brevis muscle belly
- » Generalised ligamentous laxity
- » Calcaneal fractures

Patients may present with '**snapping**' of the tendons which can lead to tears (particularly of the peroneus brevis) and which are painful. Examination seeks to reproduce the snapping effect. This can be achieved with either circumduction of the ankle or placing the patient prone with their knee flexed to 90° and performing an actively resisted dorsiflexion and eversion manoeuvre of the ankle.

A '**fleck sign**' on the AP ankle radiograph is pathognomonic of avulsion of the superior peroneal retinaculum but only diagnoses Type III injuries (below). Dynamic USS has a positive predictive value of up to 100% but is operator dependent. MRI enables visualisation of groove morphology, associated tendon tears and ligament injuries, allows grading of the injury, and facilitates preoperative planning.

Classification of peroneal tendon dislocation (Eckert & Davis, Type IV added by Oden):

- » **Type I:** Superior peroneal retinaculum elevated from the fibula
- » **Type II:** Superior peroneal retinaculum and fibrocartilage rim elevated from the fibula
- » **Type III:** Superior peroneal retinaculum and cortical fragment rim elevated from the fibula
- » **Type IV:** Superior peroneal retinaculum elevated from the calcaneum

Immobilisation in a short leg cast with foot in neutral to slight inversion has been described but high rates of recurrence are reported due to incomplete healing of the superior peroneal retinaculum. Various surgical techniques have been described but ultimately it is paramount to correct the underlying pathology.

Surgical Techniques used to treat peroneal subluxation (may include a combination):

- » Anatomical repair of the retinaculum
- » Groove deepening (*most common adjunctive procedure*)
- » Local tissue transfer to reinforce superior peroneal retinaculum (e.g. Achilles tendon)
- » Bone block procedures
- » Removing structures which lead to overstuffing (e.g. peroneus quartus)
- » Re-routing the peroneal tendons under the calcaneofibular ligament (*treatment of choice in young patients as it does not interfere with physeal growth*)

Data from limited case series have reported that anatomic repair with or without groove deepening has good outcomes and low complication rates. The other described surgical procedures also have a low risk

of recurrence but the complication rates are higher.

Intra-sheath subluxation represents a particular subgroup of pathology in which ankle dorsiflexion and eversion causes the tendons to switch their relative position with a reproducible painful click. Raikin *et al.* reported a case series of 14 patients presenting with symptoms of peroneal tendon instability, but with an intact superior peroneal retinaculum and tendons which were located within the groove. There was a high female preponderance and 13 of 14 had a convex groove. This injury was classified into **Type A (no tendon tear)** and **Type B (associated peroneus brevis tear)**. All patients had retinacular reefing with groove deepening and USS evaluation revealed healed tendons without persistent subluxation in 13 out of 14 patients.

Summary:

- Peroneal tendon instability may follow injury to the superior peroneal retinaculum
- A shallow peroneal groove may contribute to tendon subluxation but this is controversial
- Conservative management for peroneal tendon instability has a high failure rate
- Anatomic repair of the superior peroneal retinaculum is associated with good results and few complications, whereas other surgical procedures report higher complications

Consensus / Discussion:

» **In the operative management of chronic peroneal subluxation, how many surgeons perform groove deepening?**

Routinely perform groove deepening	10 (42%)
Never perform groove deepening	0 (0%)
Assess groove at time of surgery and then decide	14 (58%)

References:

Eckert WR, Davis EA, Jr. **Acute rupture of the peroneal retinaculum.** *J Bone Joint Surg Am* 1976;58(5):670-2.

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2.3 - Os peroneum

(Senthil Kumar)

The os peroneum is a sesamoid bone found in the peroneus longus tendon in 5-14% of the population. It is bilateral in 60% of patients, bipartite in 30% and more common in males than females (22% versus 17%). It articulates with the cuboid and calcaneum and is distinguished from an os vesalianum by its location. The os peroneum serves no specific function in bipedal walkers and is likely a developmental remnant given it is found in nearly all quadrupedal walkers such as primates where the prehensile hallux sits in a position similar to the human thumb and so is involved in grasping actions.

Painful Os Peroneum Syndrome (POPS) - described by Sobel *et al.* as 5 distinct entities:

- » Acute os peroneum fracture or a diastasis of a multipartite os peroneum
(Both may result in a discontinuity of the peroneus longus tendon)
- » Chronic os peroneum fracture or diastasis of a multipartite os peroneum with callus formation
(Both may result in a stenosing peroneus longus tenosynovitis)
- » Attrition / partial rupture of the peroneus longus tendon, proximal / distal to the os peroneum
- » Rupture of the peroneus longus tendon + discontinuity proximal / distal to the os peroneum
- » Presence of a gigantic peroneal tubercle on the lateral aspect of the calcaneum which entraps the peroneus longus tendon and / or the os peroneum during tendon excursion

Clinical history and examination can reveal thickening and tenderness of the peroneus longus and brevis with pain at the os peroneum during heel rise. Other signs include: near normal strength of peroneus longus and brevis tendons, a prominent or enlarged peroneal tubercle, sural nerve dysaesthesia, Tinel's sign at the lateral calcaneum, and painful resisted plantarflexion of the first metatarsal.

Plain radiographs will often detect an os peroneum although USS or MRI may be needed to identify the exact underlying pathology.

Sobel *et al.* found that in an acute fracture without separation, one month of casting will likely yield favourable results. If a wide separation is noted, then operative management is reasonable. The literature supports excision of the os peroneum and end to end peroneus longus repair as more likely to yield favourable results than attempting to fix the os peroneum. However the evidence is limited to a number of case reports and small series.

Summary:

- The os peroneum is a rare cause of lateral foot pain
- Injuries can be either acute or chronic
- Both acute and chronic injuries can often treated non-operatively

References:

Sobel M, Pavlov H, Geppert MJ *et al.* **Painful os peroneum syndrome: a spectrum of conditions responsible for plantar lateral foot pain.** *Foot Ankle Int* 1994;15(3):112-24.

Session 3: Achilles Tendon Ruptures (Part 1)

3.1 - Diagnosis: clinical or imaging?

(Mike Karski)

The clinical signs for detection of Achilles tendon rupture were first described as a triad by Franklin Simmonds in 1957. Thompson described the calf squeeze component of the test again five years later in 1962. There is often much confusion in terminology regarding whether the test result be termed '*negative*' or '*positive*'. However, because the test is designed to detect the presence of a tear, a **positive test confirms a tear** and a **negative test indicates that no tear is present**.

Simmonds' clinical triad for diagnosis of acute Achilles tendon rupture:

- » **Calf squeeze test (also 'Thompson test')**: with the patient prone the calf is squeezed and plantarflexion of the foot is observed. With a ruptured tendon no plantarflexion will be observed (positive test)
- » **Angle of declination (also 'Matles test')**: with the patient prone and knees flexed to 90° the resting angle of the foot is observed. With a ruptured tendon the injured side will rest in a more dorsiflexed position.
- » **Palpable gap**: a palpable gap will be felt at the level of injury

The advantage of the Simmonds' clinical triad is that it may be readily performed in the awake patient even in the setting of acute injury. Other tests have been described, such as the Copeland test and the O'Brien test, but these require anaesthesia to be performed and thus their clinical usefulness is limited.

Maffulli determined the sensitivity and specificity for the various components of the Simmonds' triad. The American academy of orthopaedic surgeons issued guidance in 2010 for diagnosis of Achilles tendon ruptures and suggested that a classical history and two positive clinical signs were sufficient to make the diagnosis. They were unable to recommend routine use of imaging.

Test Component	Sensitivity	Specificity
Calf Squeeze	96%	93%
Angle of Declination	88%	85%
Palpable Gap	73%	89%
Combined	100%	-

From Maffulli 1998 & Garras et al. 2012

AAOS Guidelines (2010):

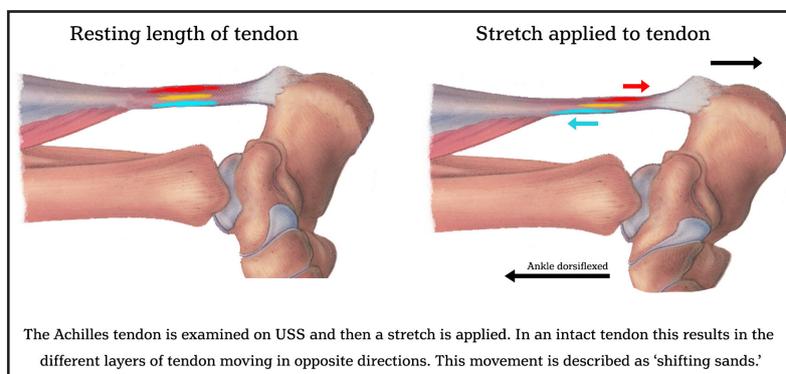
Rupture diagnosed with history and 2 of 4 criteria:

- » Positive calf squeeze test
- » Palpable gap present
- » Increased dorsiflexion on gentle manipulation
- » Decreased ankle plantarflexion strength

Imaging may be in the form of USS or MRI. As the technology and resolution of scanners has improved and radiologists have become more experienced in imaging tendon disorders, the sensitivity and specificity has improved. Margetic *et al.* have reported sensitivity with USS as up to 100%. However, the studies looking at sensitivity and specificity with USS only compared the findings to patients undergoing surgery, and therefore the results of these studies may suffer from bias.

Dynamic USS allows measurement of the gaps between the tendon edges with the foot plantarflexed which may have a bearing on treatment (discussed in further sessions). However, concern has been raised about where the gaps are measured from (i.e. from the areas of normal tendon to normal tendon, or from strand to strand) as this does not appear to be consistent. **It was the consensus of the assembled group that the gap reported should reflect the distance between the bulk of tendon ends and that the scan should be ideally performed within a week of injury.**

Real-time Achilles ultrasound (RAUT) may also be a useful tool. In this investigation a calf squeeze test or dorsiflexion stretch is performed whilst conducting the scan and in the presence of an intact tendon the Achilles tendon demonstrates two compartments with excursions in opposite directions. This has been termed the 'shifting sands' sign.



MRI scanning has also been investigated. Garras *et al.* looked at 132 patients who had surgery to their Achilles tendon – they found 100% sensitivity for Simmonds' triad and 91% sensitivity for MRI (the other 9% of scans were reported as partial ruptures, or 'unable to exclude tear'). ***It was the general consensus of the assembled consultant body that a 'partial rupture' on imaging is likely to indicate complete rupture.*** An MRI scan is time consuming, expensive and less sensitive than clinical testing. Therefore it cannot be routinely recommended for diagnosis in the acute setting (although it may have a role in the chronic setting – **Session 4.2**)

Summary:

- Clinical signs are more sensitive than imaging – Simmonds' clinical triad has a combined sensitivity of up to 100%
- Consider imaging with USS / MRI if diagnosis is unclear from history and examination or there is a chronic injury
- Imaging may also play a role in confirmation of diagnosis and measuring the dynamic gap

Consensus / Discussion:

- » **How many consultants routinely use imaging to diagnose Achilles tendon ruptures?**

Yes	0 (0%)
No	24 (100%)
- » **If you do obtain an ultrasound scan after clinical diagnosis, what is your indication?**

To measure the gap between tendon ends in plantarflexion	15 (63%)
To determine / confirm the location of the tear	2 (8%)
To confirm the diagnosis	1 (4%)
Do not routinely obtain ultrasound scan	6 (25%)
- » **How many consultants feel that it is essential to document the Simmonds' clinical triad when diagnosing Achilles tendon rupture clinically?**

Yes	23 (96%)
No	1 (4%)

References:

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3.2 - Thromboprophylaxis & Achilles tendon ruptures

(Robert Clayton)

Patients with Achilles tendon ruptures are immobilised and this puts them at increased risk of venous thromboembolism (VTE). Thromboprophylaxis may be mechanical or chemical, but due to the nature of treatment in cast or boot, mechanical prophylaxis is often challenging. There are a number of options available for chemical thromboprophylaxis, including low molecular weight heparin (LMWH), aspirin, warfarin, and novel oral anticoagulants (NOACs). Apart from the choice of treatment, the duration of treatment also needs to be considered.

There is abundant literature looking at the risk of VTE following Achilles tendon rupture, and whilst one study found the rate of symptomatic deep vein thrombosis (DVT) to be 23.5% (Makhdom *et al.*) the rest of the literature reports much lower rates without thromboprophylaxis. It has been estimated that the number needed to treat to prevent one pulmonary embolism (PE) is 475 patients (Heyes *et al.*).

Paper	VTE rate in operated patients	VTE rate in non-operated patients
Saragas & Ferrao 2011	6.80%	-
Patel <i>et al.</i> 2012	0.63%	0.86%
Heyes <i>et al.</i> 2015	-	1.37%

Although the risk of VTE may seem low at first glance, it is significantly higher than the risk of VTE following other interventions commonly performed by foot and ankle surgeons. Jameson *et al.* have reported these risks for hallux valgus surgery (VTE risk 0.03%), ankle fracture fixation (VTE risk 0.29%), hindfoot fusions (VTE risk 0.13%), and ankle replacements (VTE risk 0.06%).

The National Institute for Health and Care Excellence (NICE) issued guidance on VTE prophylaxis in 2010, which was updated in 2015 and most recently in 2018. A key component of their recommendations is that all patients are **risk-assessed**. Patients being treated for Achilles tendon ruptures are automatically at increased risk due to an extended period of '**significantly reduced mobility**'. Patients may additionally be at risk due to age, BMI and use of oestrogen-containing contraceptives.

The 2018 guidance from NICE regarding patients with lower limb immobilisation is treatment with LMWH for the duration in cast, or the first 42 days. They further suggest that aspirin may be as effective as LMWH, but despite the recommendation of aspirin for chemical prophylaxis in lower limb arthroplasty, they conclude there is insufficient evidence to recommend its use in this setting.

2018 NICE Guidance on VTE prophylaxis for patients with lower limb immobilisation:

- 1.11.1 Consider pharmacological VTE prophylaxis with LMWH or fondaparinux sodium for people with lower limb immobilisation whose risk of VTE outweighs their risk of bleeding. Consider stopping prophylaxis if lower limb immobilisation continues beyond 42 days. [2018]

There are no other specific guidelines which address this issue. The BOFAS scientific committee has stated that patients with Achilles tendon ruptures are at higher risk and that this should be discussed with the patient.

Trials on the efficacy of LMWH in preventing VTE after Achilles tendon rupture are either poorly designed or have failed to show a significant reduction in VTE, yet still conclude that LMWH should be used. There are no studies looking at use of other chemical agents in this setting.

Summary:

- Patients with Achilles tendon rupture are at increased risk of VTE
- The currently recommended treatment is LMWH
- For all patients there should be documentation of risk-assessment being undertaken
- For all patients there should be documentation of a discussion regarding thromboprophylaxis

Consensus / Discussion:

» Following Achilles tendon rupture, how many consultants routinely assess the risk of venous thromboembolism?

Yes	24 (100%)
No	0 (0%)

» What is your preferred method of thromboprophylaxis following Achilles tendon rupture?

Low molecular weight heparin (LMWH)	22 (92%)
Aspirin	0 (0%)
Novel oral anticoagulant (NOAC)	2 (8%)
Warfarin	0 (0%)
Do not routinely use Chemical thromboprophylaxis	0 (0%)

References:

BOFAS. **Position Statement on VTE.** <https://www.bofas.org.uk/Portals/0/BOFAS%20VTE%20position%20statementd.pdf> (date last accessed 06/09/2018).

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Makhdom AM, Cota A, Saran N *et al.* **Incidence of symptomatic deep venous thrombosis after Achilles tendon rupture.** *J Foot Ankle Surg* 2013;52-5:584-7.

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Patel A, Ogawa B, Charlton T *et al.* **Incidence of deep vein thrombosis and pulmonary embolism after Achilles tendon rupture.** *Clin Orthop Relat Res* 2012;470-1:270-4.

Saragas NP, Ferrao PN. **The incidence of venous thromboembolism in patients undergoing surgery for acute Achilles tendon ruptures.** *Foot Ankle Surg* 2011;17-4:263-5.

3.3 - Non-operative management is best

(Phil Vaughan)

Approximately 11,000 Achilles tendon ruptures are seen in the UK every year and in the majority of cases the tendon is abnormal before it ruptures. Injuries can occur in younger patients during sporting activity, and in older patients during normal activities. A survey of BOFAS members in 2013 had 181 responders and indicated that the majority of consultants either routinely operated upon Achilles tendon ruptures, or routinely did not operate, with a smaller proportion operating approximately half the time.

Regardless of treatment method the desired goals are: a good functional outcome whilst minimising complications. Functional outcome may be measured **qualitatively** or **quantitatively**.

Qualitative Outcome Measures:

- » Achilles tendon rupture score (ATRS)
- » Euro-Qol 5-dimension score (EQ-5D)
- » Return to pre-injury level of activity

Quantitative Outcome Measures:

- » Re-rupture rate
- » Weakness of plantarflexion strength
- » VTE rate
- » Surgery related complications (nerve / wound)

Non-operative management may be preferred as in majority of cases the risks of surgery will outweigh the benefits. Hsu *et al.* demonstrated no difference in wound complication rate between percutaneous and open repair and numerous other studies have found that the relative risk ratio of complications with operative treatment compared to non-operative treatment is 3.9 to 4.9, and the risk of surgical complication may be as high as 10 to 20%.

Potential benefits of surgery:

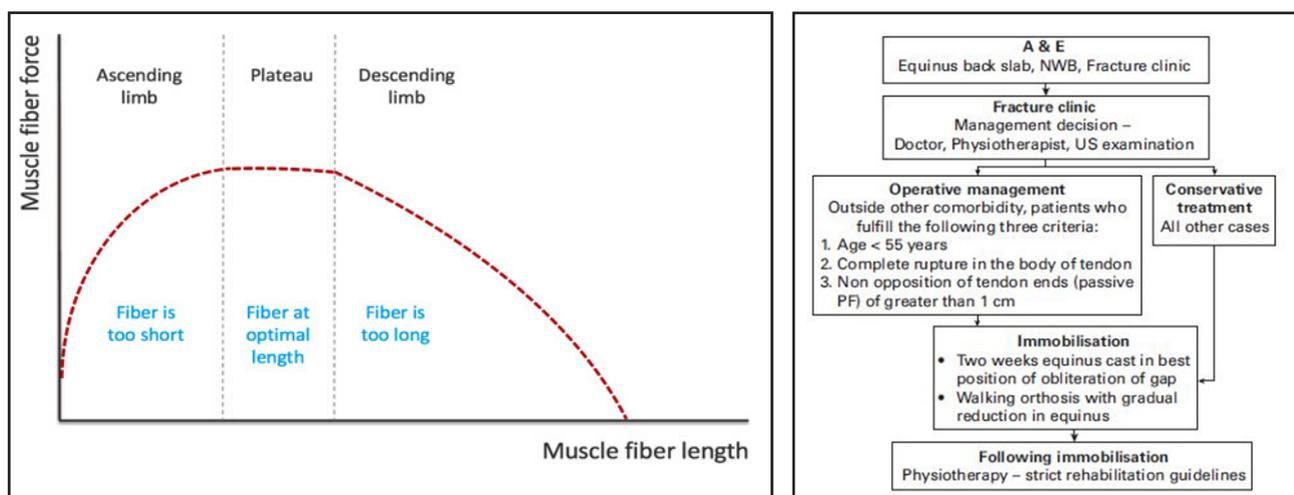
- » Lower re-rupture rates
- » Better functional outcome
- » Better biomechanical outcome

Although historically the **re-rupture rate** has been quoted as significantly greater with non-operative management, recent studies employing early functional rehabilitation have found this is no longer the case. Indeed, the latest series appear to demonstrate the differences in re-rupture rates seen are not statistically significant and there is a less than 2% difference overall (Glazebrook *et al.* 2012). However, majority of the literature has focussed on functional rehabilitation in operated patients, and there is less evidence for the role in non-operatively managed patients. The UK STAR study has been set up to address this particular question and is discussed further in **Session 4.1**. The aforementioned notwithstanding, **the most recent evidence suggests that in the setting of functional rehabilitation, the re-rupture rate is not significantly greater with non-operative management.**

When assessing **functional outcome**, a number of studies and meta-analyses have concluded that **clinical outcome scores, such as the ATRS, are no different in patients treated with and without an operation.** They also found no difference in time to return to sport but noted that patients treated operatively returned to work at an average of 19 days earlier. However, when interpreting any clinical outcome score one must question whether the scores are sensitive enough to pick up small differences which may have a significant impact on patient experience. Rosso *et al.* have demonstrated that there is no correlation between long term biomechanical outcome and ATRS. Furthermore, there is as yet no data on functional outcome scores for various subgroups of higher demand patients.

The **biomechanical outcomes** may be assessed by measuring push-off strength. If the tendon heals elongated, the force generated by the muscle-tendon unit will be reduced. Rosso *et al.* found that regardless of treatment method, at three years there was noted to be a degree of lengthening of the Achilles tendon and a degree of soleus muscle atrophy in patients who had an Achilles tendon rupture. Other studies have found that push-off strength may be lower in non-operatively managed patients but that this mainly affected the jumping or sprinting athlete where high speed contractions are regularly required and therefore suboptimal fibre length has a greater impact on performance.

More recently there has been interest in the degree of gap between tendon ends. The increased gap between tendon ends has been linked to over-long healing of the Achilles tendon. Lawrence *et al.* showed that there appears to be a threshold value of 10 mm, beyond which there is a deficit in strength; however, this did not correlate with functional outcome. It should be borne in mind that, surgery is not the only way to achieve closure of the gap and an appropriate boot / cast which apposes the tendon fibres may be sufficient to prevent over-lengthening. Dynamic USS may have a role in assessing this.



Clearly there are patients in whom surgery will be required, either due to delayed presentation, patient functional demands or patient choice. Similarly, there will be patients in whom surgery is contraindicated. However, for the majority of patients a good functional outcome can be achieved with non-operative management. An example of this is the SMART protocol published by Hutchinson *et al.* (above) where they achieved a re-rupture rate of 1% across all patients.

Summary:

- Non-operative management of acute Achilles tendon ruptures is associated with significantly fewer complications
- With functional rehabilitation programmes, the re-rupture rates are equivalent to operative management
- Functional outcomes are equivalent with either treatment method
- Providing there is a < 10 mm gap between tendon ends on plantarflexion, the biomechanical outcome is equivalent with either treatment method

References:

Achten J, Parsons NR, Kearney RL *et al.* **Cast versus functional brace in the rehabilitation of patients treated non-operatively for a rupture of the Achilles tendon: protocol for the UK study of tendo achilles rehabilitation (UK STAR) multi-centre randomised trial.** *BMJ Open* 2017;7-10:e019628.

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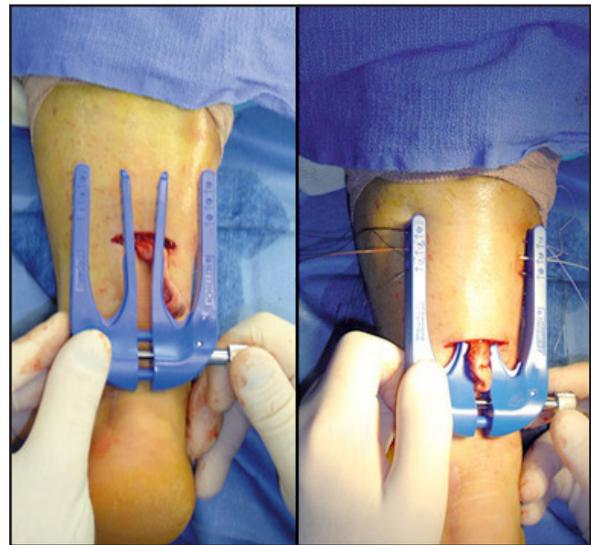
3.4 - Percutaneous / minimally-invasive repair

(Lee Parker)

The debate between operative and non-operative intervention for Achilles tendon rupture is ongoing, but the goals of treatment are the same. As discussed in **Session 3.3** studies have demonstrated that there is no significant difference in return to activity or re-rupture rate in operatively and non-operatively managed patients. On the other hand, the risks from surgery may be significant. Nevertheless, there are instances where surgery may be required, either due to delay in presentation, persistent gap, or patient choice. In these cases, strategies should be employed which will reduce the risk of complications: percutaneous or minimally invasive repair is one such strategy.

Goals of surgery in Achilles tendon rupture:

- » Achieve a healed, non-elongated tendon:
 - Prevent re-rupture
 - Maintain strength and function
- » Minimise immobilisation:
 - Reduces muscle atrophy
 - Reduces ankle stiffness
 - Reduces time off work / driving / sports
- » Do no harm:
 - Avoid infection
 - Avoid wound breakdown
 - Avoid nerve injury



Ma & Griffith described minimally invasive repair in 1977 through six stab incisions. They found a lower incidence of infection, but could not adequately tension the tendon and there was a high incidence of sural nerve injury. To combat these problems various devices have been created for minimally invasive repair. Examples of this are the Achillon (Integra®) and the PARS (Arthrex®) systems which are designed to keep all the suture loops inside the paratenon to minimise the risk of nerve injury (pictured above).

Although these systems did reduce the risks, the knots could cause local irritation and so knot-less techniques were developed. These new procedures involve use of a biotenesis screw inserted into the calcaneum. An example of this is the knot-less Speedbridge system used with the PARS jig (Arthrex®). A drawback of this technique is that the screw can result in heel pain which can persist for up to 6 months. A small case series by the developing centre included 28 patients and reported no re-ruptures, nerve injuries or wound complications using this technique.

Various other studies have also demonstrated that although the re-rupture rate between open and minimally invasive procedures is similar, infection rate and rate of other complications is lower in the minimally invasive group. McMahon *et al.* report better subjective outcome with minimally invasive repair.

Complication / Outcome	Minimally invasive repair (n = 426)	Open Achilles repair (n = 451)
Full return to sport	82.14%	74.24%
Re-rupture	2.44%	2.64%
Sural nerve injury	2.55%	1.43%
All other complications	7.51%	24.17%

Results of Achilles tendon repair techniques from the study by Akcekij et al. 2017

Although minimally invasive surgery is classically described through a transverse incision, it was the opinion of a number of consultants present that better exposure of the tendon ends may be achieved through a minimal, but longitudinal incision.

Summary:

- Minimally invasive repair has a lower risk of wound complications than open surgery
- The re-rupture rates, nerve injury rates and return to function is comparable to open surgery

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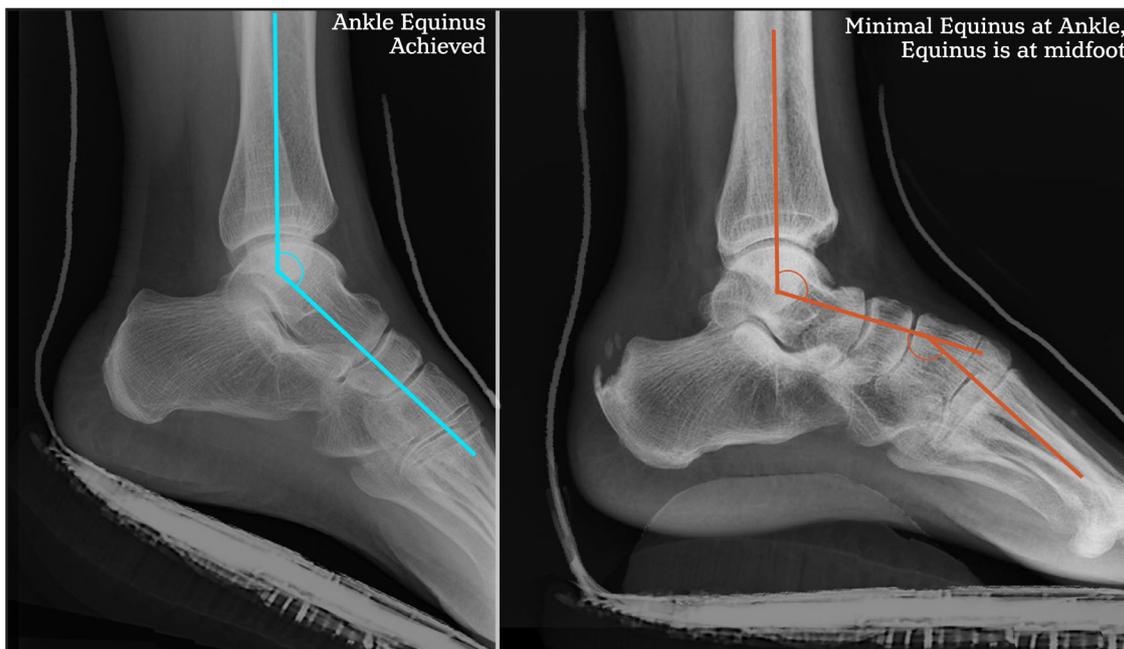
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3.5 - Formal open repair is better

(Tim Clough)

To determine whether open repair of acute Achilles tendon injuries is better we need to determine whether surgery is better than non-operative management, and need to determine whether open repair is better than percutaneous repair.

As discussed in **Session 3.3**, Hutchinson *et al.* have demonstrated excellent results can be obtained with non-operative management in patients with a gap of < 10 mm using a dedicated management program. The ATRS scores using this program are equivalent to the scores with operative intervention at nine months. However, there are a few caveats, which include use of specific VACoped® boots that ensure that plantarflexion occurs at the ankle joint rather than the midfoot. This protocol may be difficult to replicate in every clinical setting.



Example positions of ankle versus midfoot equinus in different boots. It is important the appropriate boot is used for optimal results.

Furthermore, traditional markers for outcome include re-rupture rate, wound problems and patient reported outcome scores. As discussed in **Session 3.3** and **Session 3.4** there is now little difference in these factors between treatment regimens, but outcome scores may not be sensitive enough to fully capture patient deficit. Modern management must therefore also consider **weakness** and **return to sport**.

As discussed previously, a gap of > 10 mm between tendon ends may result in over-lengthening of the tendon which can result in weakness. Heikkinen *et al.* compared the muscle mass and length following patients treated operatively and non-operatively following Achilles tendon rupture. They found that although atrophy of the soleus and hypertrophy of the flexor hallucis longus occurred in both groups, the atrophy (8% more) and lengthening (19 mm more) that occurred in the non-operatively managed groups was greater. They also found that the push-off strength correlated with soleus atrophy and hence the push-off strength of the ankle was lower in those patients undergoing non-operative management.

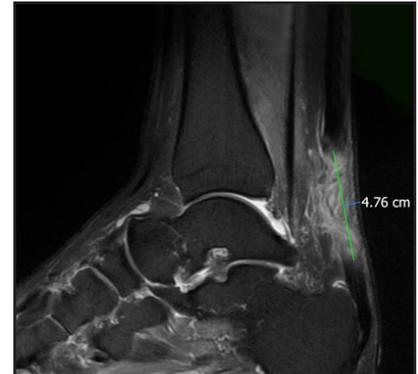
Other studies by Lantto *et al.* and Olsson *et al.* have demonstrated that patients undergoing open repair had faster and more complete strength recovery, and better ability to hop and jump. Furthermore, regardless of treatment type, 30 to 40% of elite athletes cannot return to jumping sports after injury to the Achilles tendon.

It is clear therefore that there are patients in whom surgery is preferable to non-operative management, i.e. those with an increased gap and those who wish to return to sports involving jumping. However, as discussed in **Session 3.4**, minimally invasive surgery can achieve similar results to open surgery, with a lower wound complication rate and potentially faster recovery.

Despite this most surgeons continue to perform open repair as the preferred operative intervention. This is particularly true in the significantly retracted tendon. In these cases, steps can be taken to mitigate against wound complications, including meticulous tissue handling and the use of absorbable sutures so as not to leave behind foreign material in the long term.

Reasons for open Achilles tendon repair:

- » Familiarity with the procedure
- » Lesser learning curve
- » Visualisation of the sural nerve possible
- » Ability to better visualise tendon ends, improving apposition
- » Ability to perform adjunctive reconstruction procedures in cases with significant tendon retraction



Summary:

- Most acute Achilles tendon ruptures can be managed non-operatively
- However, for best results an appropriate boot / cast is required and a dedicated rehabilitation programme should be followed
- Surgery has a role to play where there is a gap in tendon ends and for those participating in elite sporting activity
- Good results can be obtained with both open and minimally invasive techniques, but ultimately good visualisation and apposition of tendon ends is key

Consensus / Discussion:

- » **How many surgeons prep both legs when performing Achilles tendon repair to help with judging tension of repair?**

Yes	8 (33%)
No	16 (67%)

- » **Given an appropriate patient, how many surgeons would routinely offer surgery to a patient with an Achilles tendon rupture and a 10 mm gap on ultrasound scan?**

Yes	10 (42%)
No	14 (58%)

- » **Given an appropriate patient, how many surgeons would routinely offer surgery to a patient with an Achilles tendon rupture and a 20 mm gap on ultrasound scan?**

Yes	23 (96%)
No	1 (4%)

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Session 4: Achilles Tendon Ruptures (Part 2)

4.1 - Serial casting *versus* functional rehabilitation

(Mark Rogers)

The optimal management of Achilles tendon ruptures remains controversial. Whether an acute rupture is operatively repaired or not, the surgeon has to advise the patient on a programme of rehabilitation but there is no universally accepted method of treatment.

Commonly used protocols for management of Achilles tendon ruptures:

- » **Serial casting:** employs a series of casts which gradually bring the foot from equinus to plantigrade over several weeks with delayed weight-bearing.
- » **Functional rehabilitation:** allows early but protected range of movement and weight-bearing for which a variety of splints and boots are commercially available (*multiple protocols described*)

Proponents of **functional rehabilitation** programmes suggest early tendon loading is advantageous as long as the load of the healing tendon is controlled so as to avoid re-rupture. Mechanical loading of a tendon during healing promotes a biological response, encouraging the inflammatory cascade, stimulating a more orderly arrangement of collagen fibres, and promoting vascularity of the repair. The tendon may thus heal and be able to withstand mechanical load faster and with less muscle atrophy.

The clinical benefit of a functional rehabilitation programme would therefore be an expected earlier return to functional activity and a reduced re-rupture rate. Although the re-rupture rate of non-operatively managed patients appears to have reduced since the more widespread adoption of functional rehabilitation, few studies have compared outcomes of **serial casting *versus* functional rehabilitation in non-operatively managed patients**.

In 1992 Saleh *et al.* undertook a randomised study of 40 patients who were managed either with cast immobilisation for eight weeks, or cast immobilisation for three weeks, followed by controlled early mobilisation in a Sheffield splint for between six and eight weeks. Patients treated with the splint regained mobility significantly more quickly, returned to normal activity sooner and preferred the splint to the plaster cast. Recovery of the power of plantar flexion was similar in the two treatment groups, and no patient had excessive lengthening of the tendon. One re-rupture occurred in each group.

Other studies have since looked at casting *versus* functional bracing in non-operatively managed patients, and found a benefit of functional bracing. However, the numbers in these studies are small and the protocols of rehabilitation vary widely. It is therefore difficult to know which protocol has the best results. It is hoped that the outcomes of the UK STAR study will be able to answer this question more definitively.

By contrast, there have been multiple studies investigating the **rehabilitation protocols after surgical repair** of the Achilles tendon. McCormack & Bovard published a meta-analysis on this topic in 2015. They looked at ten randomised studies and found many patients returned to prior employment and sporting activity in both cast immobilisation and functional rehabilitation groups. Five of the six trials measuring the time interval showed a faster return to prior sporting level in the functional rehabilitation group. Subjective patient outcomes were significantly better with functional rehabilitation groups and major complications did not differ between the two groups. Dynamometry and anthropometry measurements favoured functional rehabilitation at 6–12 weeks after surgery although these differences were negligible after 6 months.

Summary:

- Functional rehabilitation has been shown as superior to serial casting in operatively managed acute Achilles tendon ruptures
- There is a suggestion that functional rehabilitation is also superior in non-operatively managed patients, but the studies are small and use varied protocols
- The UK STAR study may help answer the question of whether functional rehabilitation is superior to serial casting in patients with an Achilles tendon rupture managed non-operatively

Consensus / Discussion:

- » **Following operative repair of an acute Achilles tendon rupture, how many consultants would opt for early functional rehabilitation versus casting?**

Functional Rehabilitation	24 (100%)
Serial Casting	0 (0%)

- » **In the non-operative management of an acute Achilles tendon rupture, how many consultants would opt for early functional rehabilitation versus casting?**

Yes	22 (92%)
No	2 (8%)

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4.2 - Treating neglected Achilles ruptures or re-rupture

(Dessie Gibson)

There is no consensus in the literature defining the time from initial trauma to diagnosis of a **neglected rupture** of the Achilles tendon. However, it is generally accepted that a rupture may be considered neglected when it is recognised more than six to eight weeks after the primary event. A **re-rupture** occurs once healing has occurred and may be diagnosed acutely when signs and symptoms are obvious, but can be easily missed since the pain and swelling may be assumed to be part of a patient's recovery.

Aetiology of neglected ruptures:

- » Delay in diagnosis due to patients being unaware of the significance of the injury
- » Delay in diagnosis due to clinician misdiagnosis (e.g. ankle sprain)

Aetiology of re-ruptures:

- » Poor patient compliance
- » Over aggressive rehabilitation
- » Insufficient strength of surgical repair
- » Development of complication (e.g. infection)

Patients presenting with neglected or re-ruptured Achilles tendons will have reduced strength in plantarflexion, which they may describe as a weakness or loss of control / power in push-off activity or going upstairs. Clinical examination will reveal calf atrophy, a positive calf-squeeze test, increased angle of declination (this sign persists even in delayed presentations), and a gap at the site of defect sometimes called the '**hatchet sign**'.



Example of a large, obvious defect in the Achilles tendon following a neglected rupture, giving a similar appearance to an inverted hatchet ('**hatchet sign**')

Non-surgical treatment is reserved for patients with severe medical co-morbidities and low functional demand. However, in most cases, **surgical intervention** is required. After suitable imaging (below), patients should be adequately consented and informed of the possible procedures which may be required. Surgical planning should consider methods of tendon augmentation if required. Prone positioning of the patient and draping of both legs is recommended to allow for comparison to the contralateral side when judging tension in the reconstruction.

USS in imaging neglected / re- ruptures:

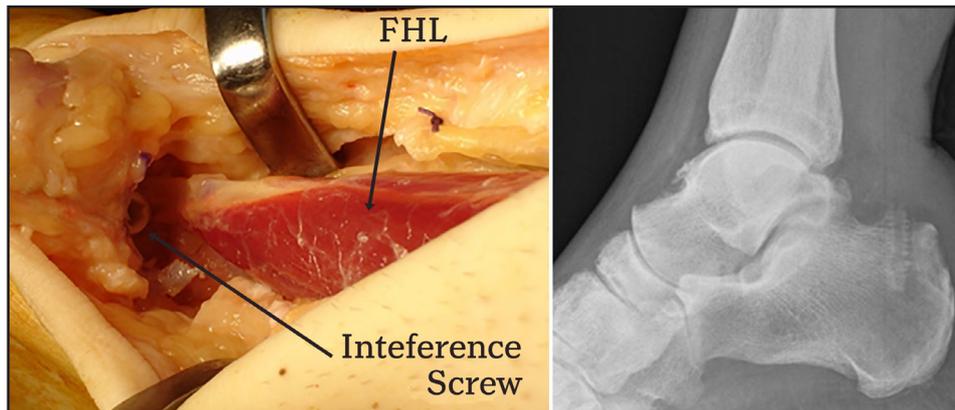
- » User dependent
- » May identify false negatives due to scar tissue between tendon ends
- » *Not routinely recommended*

MRI in imaging neglected / re- ruptures:

- » Confirmation of diagnosis (medicolegal)
- » Site and length of ruptured segment (facilitates surgical planning)
- » Integrity of tendons for reconstruction
- » *Recommended investigation*

The surgical strategy employed depends on the **time from rupture** to surgery, and the **length of the gap** between tendon edges after debridement. The latter may not be readily apparent pre-operatively. When

dealing with **defects < 2 cm within 3 months**, primary open repair ± augmentation (e.g. turn-down flap, plantaris autograft or allograft) may suffice. However, for **gaps between 2-5 cm**, a direct repair is unsuitable so a V-Y plasty is recommended with either augmentation or a tendon transfer. When performing a V-Y plasty, the limbs of each arm should be 1.5 to 2 times the length of the defect to allow it to be brought down sufficiently to cover the gap. **Gaps > 5 cm** usually require a tendon transfer. The most commonly sacrificed tendon is of the flexor hallucis longus (FHL) since it has cross connections with the flexor digitorum longus (FDL) tendon at the Knot of Henry which preserves some functional hallux interphalangeal joint flexion. Furthermore the FHL muscle belly has been demonstrated to hypertrophy by more than 50% after tendon transfer and may improve plantar flexion strength to within 16% of the uninjured side.



Intraoperative photograph and post-operative radiograph of an FHL tendon transfer using a bio-absorbable screw

Other donor tendons and techniques, apart from the FHL, have also been described. Vega *et al.* have reported their outcomes with an **all-endoscopic transfer of the FHL tendon**. They treated 22 patients with a mean gap of 6.3 cm and found significant improvement in AOFAS scores at a mean of 30 months. They report no major complications and all patients returned to their daily activities without difficulties. No patients reported complaints or symptomatic deficits of great toe flexion strength.

de Cesar Netto *et al.* have described using the **FDL tendon** as an alternative to the FHL. Foot and ankle surgeons frequently perform lesser toe tenotomies and so it could be argued it is a more expendable donor. Although outcomes scores were overall improved in their cohort of 15 feet, significant differences remained in heel rise ability and they did not feel the strength of FDL would be sufficient to maintain the function of the gastrocnemius-soleus complex and so performed adjunctive procedures.

Maffuli *et al.* compared the outcomes of treating patients with small gaps in the Achilles tendon with either ipsilateral **peroneus brevis** or FHL transfers. They found that whilst overall outcomes were similar, a difference existed in sporting activity. Patients undergoing brevis transfer had a slightly slower return to sports compared to the other groups. However, 13 out of 14 patients in the brevis group returned to high impact sports, compared to 9 out of 12 in the FHL group. They therefore suggested that peroneus brevis may be a better donor for patients participating in high impact sports.

Despite the abundance of papers discussing acute Achilles tendon ruptures, there is a relative paucity on the management of **re-ruptures**. Risk factors for re-rupture include male gender, younger age (< 30 years) and initial gap more than 10 mm on USS (as discussed in **Session 3.3**). The management of re-ruptures has not been established, and as such it is reasonable to treat a re-rupture in the same way as one would manage an acute rupture, i.e. discussing the merits and disadvantages of non-operative and operative management and engaging in a shared decision making process with the patient.

Summary:

- Neglected ruptures and re-ruptures are challenging pathologies presenting with reduced strength in plantarflexion
- MRI is the preferred method of imaging
- Non-operative management of neglected ruptures is reserved for high risk patients
- Surgical technique is influenced by the chronicity of the problem and the gap between the tendon ends

Consensus / Discussion:

- » **In an appropriate patient, how many consultants would routinely advise surgical management of a re-rupture of an Achilles tendon with a 1 cm gap on imaging?**

Yes	23 (96%)
No	1 (4%)

- » **In the surgical management of a re-rupture of an Achilles tendon with a gap of 3 to 4 cm, what is your preferred technique in an otherwise healthy tendon?**

Turndown / V-Y Plasty	8 (33%)
FHL transfer	7 (29%)
FDL Transfer	0 (0%)
Allograft / Autograft	0 (0%)
Undecided / Other	9 (38%)

References:

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4.3 - Treating an over-long or short Achilles after rupture

(Steve Bendall)

An over-long Achilles tendon can be clinically diagnosed using the Achilles tendon resting angle (angle of declination), with the patient prone and the knee flexed. It can arise from both, operative and non-operative methods of treatment, or as a result of a missed injury.

Causes after non-operative management:

- » Incorrect foot positioning (equinus at mid-foot rather than ankle)
- » Poor patient compliance (removing splints prior to instructions)
- » Significant gap between tendon ends (> 10 mm)

Causes after operative management:

- » Inadequate suture or knot strength (allowing gapping to occur)
- » Poor quality tendon (insufficient hold on sutures)
- » Operative techniques
- » Mobilisation regimen

As illustrated and discussed in **Session 3.5**, Ellison *et al.* analysed the lateral radiographs of patients treated in either a walking boot with wedges, or an adjustable external equinus-corrected brace. They found the adjusted brace produced equinus similar to that with an equinus cast. By contrast, the boot with wedges produced less equinus, and majority of the equinus with this device was through the mid-foot rather than the ankle, which could lead to a lengthened Achilles tendon.

Multiple studies have investigated the role of sutures on **gapping**. The load to failure of the repair can be increased by using locking and grasping suture techniques, increasing the number of core sutures and performing an epitendinous repair. These factors may in turn reduce gapping whilst the tendon is loaded. Recently the role of elasticity in healing tendons has also been explored. Karatekin *et al.* found that after repair of ruptured Achilles tendons there was a decrease in the elasticity compared to the non-injured side. It cannot, however, be determined whether there was a pre-existing decrease in elasticity which precipitated the injury. In porcine models, higher forces are needed to induce clinically relevant gapping when the elastic capacity of a tendon-repair construct is increased. This suggests that poor quality tendon which is likely degenerate and inelastic may be more susceptible to gapping.

As discussed in **Session 3.4**, minimally invasive surgery has been advocated due to the low complication rates and improved cosmetic appearance without compromising function. However a small incision may obscure visualisation of the tendon ends, potentially resulting in gapping. This would be dependent upon the size of the incision (more likely with a small incision), the direction of the incision (more likely with a transverse incision), and the extent of tendon retraction.

Kangas *et al.* reported lengthening of the Achilles tendon correlated with a worse Achilles tendon rupture score (ATRS) although interestingly there was no association with reduced calf strength. This finding has been supported by Carmont *et al.* who compared the angle of declination with the ATRS after surgical repair. Moderate correlation was found between these two parameters suggesting tendon elongation may influence outcome in the general population. However, there are likely to be other important factors and the effects of an over-long Achilles tendon in an elite athlete remains unknown.

If an over-long Achilles tendon is symptomatic, then end to end shortening, Z-shortening and even endoscopic shortening have been described in case reports and case series. In some cases reconstruction of the tendon may be required. However, there is as yet insufficient evidence to recommend one treatment over another.

There is no data on the shortened Achilles tendon after rupture, although the effects and treatment of a tight Achilles tendon in other situations are well documented.

Summary:

- There has been little focus on the effect of tendon length after rupture
- Greater emphasis has been placed upon on the method of treatment and around reducing re-ruptures
- A better understanding of the impact of final tendon length on individual patient function and satisfaction needs to be established

Consensus / Discussion:

- » **If performing an FHL transfer for reconstruction of the Achilles tendon after rupture, either due over-long healing, or re-rupture, what is your preferred method?**
- | | |
|-----------------|----------|
| Minimal harvest | 19 (79%) |
| Long harvest | 5 (21%) |

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Session 5: Tibialis Anterior & Posterior

5.1 - Stage 1 tib. post. tendinopathy: Conservative treatment (Krishna Vemulapalli)

Stage 1 tibialis posterior tendon dysfunction is characterised by pain and swelling along the course of the tendon, but single leg heel rises are still possible, the medial arch of the foot has not collapsed, and the subtalar joint remains flexible.

There is a lack of literature regarding optimal non-operative management of this condition but it is often managed in the same way as other tendinopathies. Davenport *et al.* hypothesised an association between activity, symptoms, and tissue degeneration which resulted in tendon degeneration. The advancing tissue pathology results in pain and whilst rest may provide temporary relief, the tendon structural integrity could remain compromised. Restarting activity may cause further tendon degeneration with episodes of progressively worsening pain that require increasingly longer rest periods. Eventually, degeneration could result in the mechanical failure of the tendon. On the **continuum model** described in **Session 1.3**, this would correspond to **reactive tendinopathy**, progressing to **reactive-on-degenerative** over time.

Davenport *et al.* also described a stepwise model to treat tendinopathy where they educated patients about their disease process, unloaded the tendon to allow the acute episode to settle, and progressively reloaded the tendon in a controlled manner to allow healing and strengthening without further deterioration. They then discussed strategies to prevent recurrence. They termed their model EdUReP.

The EdUReP model of conservative therapy for tendinopathies (Davenport *et al.*):

- » **Education:** Enabling independent self management
- » **Unloading:** Reversing disease progression at the level of tissue pathology
- » **Reloading:** Returning patients to their previous level of activity
- » **Prevention:** Stopping disease recurrence

A number of observational studies on conservative management have been analysed in a systematic review by Bowring & Chockalingam. Whilst they suggested conservative management is helpful in reducing symptoms, they found the evidence was limited, of poor quality, and failed to establish a causal relationship between intervention and outcome. They were also unable to recommend an optimal conservative treatment regimen.

Kulig *et al.* compared three treatment regimens for early tibialis posterior tendon dysfunction in a randomised controlled trial. Their control group was treated with orthotics and stretching. However, the other two groups had progressive resistive exercises which were either concentric or eccentric in addition to orthoses and stretching. All patients benefited from orthoses and stretching. However, both concentric and eccentric progressive resistive exercises further reduced pain and improved perceptions of function with outcomes in the eccentric exercise group being the best overall.

Summary:

- Conservative management may be successful in Stage 1 tibialis posterior tendinopathy
- A period of rest followed by controlled reloading and eccentric exercises appears to be the most effective treatment, but this remains an overlooked area of research

Consensus / Discussion:

- » **In the non-operative management of Stage 1 tibialis posterior tendinopathy, how many consultants would consider image-guided intra-sheath injection of corticosteroid?**

In the presence of tendonosis	1 (4%)
With inflammation and effusion in the sheath but with a normal tendon	18 (75%)

It was generally agreed that a period of time in a boot or cast following injection is advisable

- » **In the non-operative management of Stage 1 tibialis posterior tendinopathy, how many consultants would consider the following interventions:**

High volume injection of the tendon sheath + local anaesthetic	1 (4%)
Immobilisation with a boot / cast	14 (58%)
Physiotherapy	24 (100%)
Orthotics	24 (100%)

Although it was generally agreed that orthotics should be corrective and include a medial post, it was accepted that the exact nature of the orthotic would vary from case to case

References:

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5.2 - Stage 1 tib. post. tendinopathy: Debridement

(Alistair Wilson)

Over the last two decades, a change has been observed in the role of surgery for early tibialis posterior tendinopathy. Whereas it was previously not uncommon to perform debridement of the tendon / tendon sheath in patients with rheumatoid arthritis affected by florid synovitis and at risk of rupture, the advent of disease modifying and biological agents has dramatically reduced this problem. When surgery is required, the options are open surgery or tendoscopy.

Open debridement:

- » Easier to perform
- » Allows full visualisation
- » Allows co-existing tears to be repaired
- » Increased risk of wound complications

Tendoscopy:

- » Cosmetically better
- » Diagnostic (*greater sensitivity than MRI*)
- » Allows debridement only
- » Reduced risk of wound complications

Teasdale & Johnson reported their outcomes of open tenosynovectomy and debridement in nineteen patients. At a mean follow-up of 30 months, 74% reported complete relief of pain, 16% reported minor pain, 5% had moderate pain, and 5% had continued severe pain. Complications included two superficial wound infections and one wound dehiscence at three weeks following surgery. However, all complications occurred in the first 5 patients who had steroids injected around the tendon before wound closure and so they omitted this in the remaining fourteen patients and found no further wound complications.

van Dijk *et al.* popularised tendoscopic treatment as an alternative to open surgery and the literature has subsequently spawned multiple case series. Bernasconi *et al.* recently reviewed the literature and found that tendoscopy yielded an 82% success rate at short to mid-term follow-up. The need to convert patients to open procedures was observed but only when longitudinal split tears were present that required repair or tubularisation rather than simple debridement.

For tendoscopic procedures the patient is often supine, although a '**figure of 4**' position may be used. Two portals are commonly used: the primary portal is made directly over the tibialis posterior tendon 3-4 cm proximal to the posterior edge of the medial malleolus. After introducing a 2.7 mm scope and visualising the tendon, the light-source may be used to identify the location of the secondary portal which is 2-3 cm distal to posterior edge of the medial malleolus. After the procedure is completed, sutures rather than adhesive strips are recommended to avoid creating a synovial fistula. Post-operative care will depend upon the extent of surgery performed but simple debridement can be managed with non-weight bearing activity for two weeks before escalating activity.

Summary:

- Debridement still has role in early tendinopathy although it is practiced less than before due to the improvement in medical management of inflammatory arthropathy
- Both open and tendoscopic debridement yield favourable results
- Tendoscopic surgery facilitates debridement alone so patients should be warned about the risk of open surgery if tears are encountered

References:

Bernasconi A, Sadile F, Smeraglia F *et al.* **Tendoscopy of Achilles, peroneal and tibialis posterior tendons: An evidence-based update.** *Foot Ankle Surg* 2017;Epub.

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5.3 - Tibialis anterior disorders

(Matt Welck)

The majority of tibialis anterior tendon disorders may be categorised as **tendinopathies** or **ruptures** (acute or chronic). For **tendinopathies**, treatment is usually non-operative and involves resting the tendon in dorsiflexion using a foot drop splint or ankle-foot orthosis. Recalcitrant cases can be managed surgically with debridement and tubularisation. Grundy *et al.* recommend that if debridement involves more than 50% of the tendon, an extensor hallucis longus (EHL) tendon transfer to the medial cuneiform should be performed. However, patients should be counselled that this will result in hallux interphalangeal extensor lag.

Tendinopathies:

- » 2 distinct patient groups affected:
 - *Overweight, elderly females (medial, burning foot pain, worse at night)*
 - *Athletes (activity related anterior ankle pain)*
- » Swelling and tenderness along course of tendon with pain on resisted dorsiflexion
- » Preserved strength with no foot drop
- » Tibialis anterior passive stretch has specificity of 90% and sensitivity of 95%
 - *Passive plantarflexion, eversion, abduction and pronation of the foot: stretches tendon and provokes pain*
- » MRI and USS are both effective imaging modalities

Rupture is rare and usually secondary to acute / chronic strain or chronic microtrauma. The most common aetiology is forced plantarflexion of foot and ankle. Other causes for rupture include: laceration, attrition over an exostosis, neurological disorders causing foot drop, gouty tophi / inflammatory arthropathy affecting the tendon sheath, diabetes, and steroid injections. Radiographs investigate the presence of exostosis, USS allows for dynamic assessment, and MRI can be used to measure the tendon gap.

Acute presentation of ruptures:

- » Acute episode of trauma
- » Pain, swelling, palpable gap
- » Foot drop gait
- » Reduced dorsiflexion strength

Chronic presentation of ruptures:

- » Associated with systemic conditions / exostosis
- » Insidious onset / delayed presentation (~ 10 weeks)
- » Painful foot drop
- » Extensor substitution present to compensate

The decision regarding operative or non-operative management of tibialis anterior ruptures is based on age, function and medical co-morbidities. **Non-operative management** can lead to mild planus, persistent ache, foot drop, and difficulty walking on uneven surfaces. **Surgery** should improve function but may not restore it fully. Since the deficits with non-operative management may be mild, it may be an appropriate treatment option in low demand, elderly patients.

Non-operative management of ruptures:

- » Physiotherapy
- » Activity modification
- » Ankle-Foot orthosis (*Prevents contractures and can reduce extensor workload, but is often poorly tolerated*)

Operative management of ruptures:

- » Direct Repair
- » Tendon-slide lengthening
- » Tendon transfer
- » Free tendon autograft / allograft

Operative treatment is considered in active, healthy patients who have failed orthotic treatment and are at risk of developing contractures. **Direct repair** requires adequate tendon length, integrity and mobility. A suture providing adequate pull out strength should be used for mid-substance ruptures whilst bone anchors or biotenodesis screws in the navicular or cuneiforms can be employed for distal ruptures. **Tendon-slide lengthening** is suitable for defects between 2 and 4 cm but enough healthy tendon must be available after debridement. The proximal end of the tendon is split to the mid-portion of the tibia with half the width harvested and transferred distally.

Tendon transfers are indicated for defects larger than 4 cm or when the tendon is too diseased to accommodate a slide. Options for transfer include EHL (most commonly used), extensor digitorum longus, peroneus brevis, and tibialis posterior. In an EHL transfer, the EHL is detached at the first metatarsal and tenodesed proximally to the proximal stump of tibialis anterior. The remaining EHL is then sutured to the distal stump of the tibialis anterior tendon, whilst the distal stump of the EHL which remains attached to the hallux is tenodesed to the extensor hallucis brevis. The superior extensor retinaculum must be closed to prevent bowstringing. Closure of the inferior retinaculum is not universally advocated since leaving it open may help tendon gliding. A tight Achilles tendon will also need to be addressed to protect the repair. **Free tendon grafts** may be used instead of tendon transfers, but there is no data to indicate whether a tendon transfer, autograft or allograft offers the best outcome.

Summary:

- Tibialis anterior tendinopathy and ruptures are uncommon
- Treatment for tendinopathy primarily involves resting the tendon with surgery reserved for the few cases where this is unsuccessful
- Treatment for tibialis anterior tendon ruptures is based upon age, function and co-morbidities since conservative treatment in select populations results in satisfactory outcomes

Consensus / Discussion:

» **How many consultants routinely use imaging in the diagnosis of, or to confirm the diagnosis of rupture of the tibialis anterior tendon?**

Yes	24 (100%)
No	0 (0%)

References:

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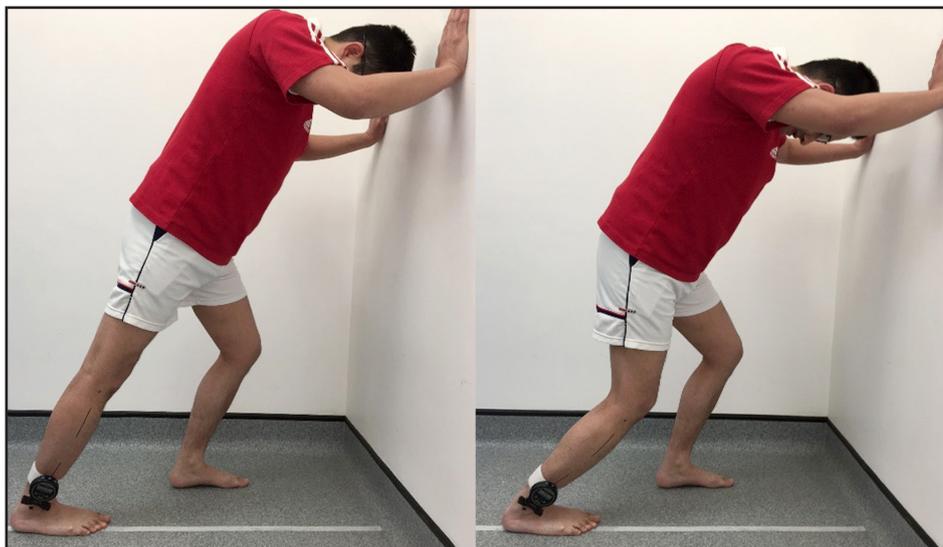
Session 6: Miscellaneous Tendon Disorders

6.1 - Isolated gastrocnemius tightness

(Dishan Singh)

The gastrocnemius-soleus complex plantarflexes the tibiotalar joint. The **gastrocnemius** crosses the knee and becomes tight when the knee is extended, whilst the **soleus** does not cross the knee and so tightness in this muscle is independent of the position of the knee. This difference forms the basis of the **Silfverskiöld test**, where in the presence of isolated gastrocnemius tightness an equinus deformity at the tibiotalar joint may be seen with the knee extended, but improves when the knee is flexed.

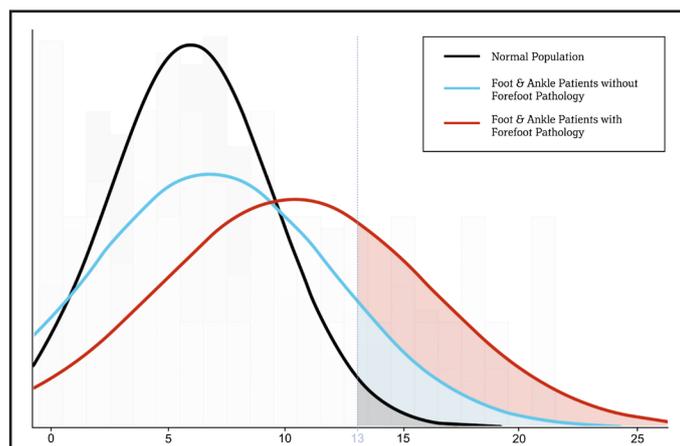
Although the Silfverskiöld test is the most widely known test for assessing gastrocnemius tightness, it must be performed in a standardised manner with the hindfoot corrected and a consistent force applied to the foot. The inevitable variability with attempting to control these factors means that inter-rater reliability has been reported to be as low as 0.230. The lunge test is an alternative; it is a weight-bearing test and thus reproduces physiological load, and it has a much higher inter- and intra-observer reliability (0.820 to 0.970). However, values from the lunge test may be up to 5° greater than with the Silfverskiöld test and therefore it is important to note which method of testing has been used.



Weight-bearing lunge test performed with a digital inclinometer. A maximal dorsiflexion stretch is applied with the knee extended and then flexed to > 20°. Gastrocnemius tightness is measured as the difference between the 2 values.

Whilst isolated gastrocnemius tightness certainly exists, its clinical manifestations are a matter of much controversy. Clinical studies show limitation of ankle dorsiflexion during the swing phase of gait secondary to gastrocnemius tightness leads to increased forefoot pressures, but dynamic optoelectronic studies suggest that this may be compensated for by knee flexion.

DiGiovanni *et al.* reported that within the adult population, isolated gastrocnemius tightness affected 29% of patients with forefoot and / or midfoot symptoms compared with 15% of a control population, although these rates varied depending upon the values set for defining tightness. More recently, Chan *et al.* and Malhotra *et al.* have carried out work using the weight-bearing lunge test (above). They found that asymptomatic members of the normal population without foot and ankle pathology have a mean gastrocnemius tightness of 6°, and up to 13° may be considered as within the normal population range. They also found that most patients with foot and ankle pathology do not have a significantly increased gastrocnemius tightness, but that it is present in over a third of patients with forefoot pathology.



Histograms of gastrocnemius tightness in various population subgroups: $> 13^\circ$ is abnormal (Malhotra *et al.* 2018)

Treatment for isolated gastrocnemius tightness begins with non-operative measures which includes **static stretching** and **proprioceptive neuromuscular facilitation** which have been demonstrated to increase ankle dorsiflexion by 5.2° and 4.3° respectively. However, ballistic stretching is less effective and can do harm (Medeiros & Martini). However it is unclear if these changes are clinically important.

Methods of gastrocnemius lengthening:

- » Vulpius
- » Strayer
- » Endoscopic
- » Proximal-medial gastrocnemius release

Complications of operative intervention:

- » Nerve injury (sural / saphenous)
- » Venous thromboembolism
- » Wound healing / infection
- » Prolonged weakness

A number of **operative techniques** have been described but no studies demonstrate the superiority of one technique over another. The risk of sural nerve injury is higher in endoscopic recession (up to 20%). Weakness also occurs following gastrocnemius recession although it does improve somewhat with time: gastrocnemius recession has been shown to impair the strength of the ankle plantarflexion by 40% at six weeks and 10% at 24 weeks compared to the contralateral side (Schmal *et al.*).

Whilst isolated gastrocnemius tightness is linked to forefoot overload and pathology, there has been only one study investigating whether it is needed as an adjunct to surgery. Lai *et al.* retrospectively reviewed patients who had undergone either a scarf osteotomy alone or in conjunction with endoscopic gastrocnemius recession. Whilst the outcomes appeared similar across groups at 24 months, the recession was only performed in patients with a positive Silfverskiöld test; thus it remains unknown if the outcomes would have been inferior had the recession not been performed.

Summary:

- Gastrocnemius tightness is more common in patients with forefoot pathology
- Both operative and non-operative treatments are effective
- No one particular operative technique has been proven to be advantageous over the others
- Surgical treatment is associated with weakness in plantarflexion which improves over time

Consensus / Discussion:

- » **How many gastrocnemius lengthening procedures do you do a year?**

0	0 (0%)
0-5	5 (21%)
6-10	11 (46%)
11-20	8 (33%)
> 20	0 (0%)

- » **What is your indication for gastrocnemius lengthening?**

Forefoot overload	24 (100%)
Plantar fasciitis	20 (83%)
Achilles tendinopathy	7 (29%)
More proximal pathology	0 (0%)

- » **What is your preferred procedure for gastrocnemius lengthening?**

Stayer / Vulpius	14 (58%)
Endoscopic / Mini-open incision	0 (0%)
Proximal Medial Gastrocnemius Release	11 (42%)

- » **Would you perform a gastrocnemius lengthening for a high level athlete (runner)?**

Yes	1 (4%)
No	23 (96%)

- » **Who routinely uses chemical thromboprophylaxis after gastrocnemius lengthening?**

Yes	5 (21%)
No	19 (79%)

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- Schmal H, Walther M, Hirschmuller A *et al.* **Gastrocnemius recession leads to medial shift of gait line, impairment of muscle strength and improved dorsal extension in forefoot overload syndrome.** *Foot Ankle Surg* 2018;24(4):309-13.

6.2 - Flexor & extensor injuries

(Gary Colleary)

There is a paucity of literature regarding flexor and extensor tendon injuries of the foot. Most reports are case series with variability in treatment protocols. The commonest cause for injury is a **traumatic laceration** (glass involved in 70-80% of cases), although **spontaneous ruptures** and **avulsions** occur less commonly.

Basic first aid forms the basis of initial management. A thorough inspection of the wound should be performed and injuries to adjacent structures documented. When the ends of a tendon have retracted, they may not be visible. It is paramount not to miss an injury for this reason, so if suspicion is raised due to functional loss, then it is reasonable to extend the wound to confirm tendon integrity. Management is based upon a patient's pre-morbid function, the extent of injury and the actual tendon which has been injured. If surgical repair is performed, then the same principles which are used in the hand apply, namely: using a **suture configuration** with a high pull out strength, increasing the **number of core sutures**, using an **epitendinous suture**, preventing bowstringing by **repairing the retinaculum**, and initiating rehabilitation programmes that allow **early controlled range of motion**.

Zones of tendon injury of the Flexor Hallucis Longus (as described by Lui):

- » **Zone 1:** Musculotendinous junction to the fibro-osseous orifice of the posterior talar process
- » **Zone 2:** Orifice to the Knot of Henry
- » **Zone 3:** Knot of Henry to the phalangeal insertion of the tendon

The **flexor hallucis longus (FHL)** is the primary plantarflexor of the hallux so laceration results in a cock-up deformity. Using the classification described above, injuries in **Zone 3** retract only marginally after laceration. Surgery for injuries in Zone 3 involves either direct end to end repair or FHL to flexor digitorum longus (FDL) tenodesis. Zone 3 injuries are also more likely to be symptomatic since they occur distal to the FDL and FHL commissures found at the Knot of Henry and therefore there is likely to be complete loss of flexor function. Injuries in Zone 3 are sometimes subdivided into those **proximal and distal to the sesamoids**. Injuries distal to the sesamoid result in the most scarring and adhesions.

Incisions under the first metatarsal head are best avoided since they can cause painful scars in the weight-bearing area of the foot; a plantar-medial approach is therefore recommended if undertaking repair. End to end repairs are preferred but if there is insufficient tendon then options include either **FHL lengthening**, **flexor hallucis brevis (FHB) tenodesis** or using the FDL tendon of the second toe as graft for tenodesis (if the laceration is proximal to sesamoids). A survey by Yancey in 1977 revealed that more than 80% of foot and ankle surgeons felt repairing a Zone 3 FHL tendon injury was important. It is estimated that 65–70% of patients achieve acceptable results with respect to improvement in strength of hallux plantarflexion, although motion at the interphalangeal joint is frequently lost. Interestingly Frenette & Jackson reported a case series of 10 young athletes with FHL lacerations. Four patients had non-operative management and they had no functional deficit at final follow-up.

The **FDL** is the primary plantarflexor of the lateral four toes and the tendon is vulnerable to deep penetrating injury at the base of the toes or around the medial malleolus. There are few reports published on FDL tendon repair and many surgeons feel it is an expendable tendon. By contrast, Wicks *et al.* reported six out of eight children had a satisfactory result with primary repair, and recommended early exploration and surgical repair of selected tendons to avoid future disability. However the lack of further meaningful information on this topic means primary repair would not ordinarily be advocated unless it was felt that the benefits of surgical management outweighed the risks.

The **extensor hallucis longus (EHL)** extends the hallux and everts the foot. Tendon injuries distal to the extensor expansion are suitable for conservative management but operative management is otherwise recommended. Retraction becomes a problem if the laceration occurs at the level of retinaculum. Good to excellent reports are universally described for surgical management of this injury with the majority of patients regaining active hallux dorsiflexion. **Options for tendon transfer were discussed and it was the consensus of the majority of surgeons present to transfer the extensor digitorum longus (EDL) tendon from the second toe.**

The **EDL** extends the metatarsophalangeal and interphalangeal joints of the lesser toes. The tendon is a superficial structure which splits into four tendons at the level of the inferior extensor retinaculum. The extensor digitorum brevis (EDB) tendon approaches the extensor apparatus from the lateral side for each toe. Injury to the common tendon can lead to weakness in foot dorsiflexion and eversion whilst injury of an individual toe tendon can result in a claw toe if not repaired. Spontaneous rupture has been reported in association with rheumatoid arthritis, diabetes, trauma, tophaceous gout, osteophytes and steroid injections. Only a few case reports describe this pathology and surgical repair appears to offer high rates of satisfaction.

Summary:

- Tendon injuries can be spontaneous or due to lacerations
- Injuries to the EHL and FHL tendons are a cause of morbidity which can be improved by early surgical management
- Injuries to the EDL and FDL tendon are less common, but repairing an injured EDL tendon will likely yield good outcomes

Consensus / Discussion:

- » **How many consultants have seen an FHL injury after Akin osteotomy?**

Yes	3 (13%)
No	21 (87%)
- » **Of those who have encountered this injury, how many have repaired the FHL**

Yes	1 (33%)
No	2 (67%)

References:

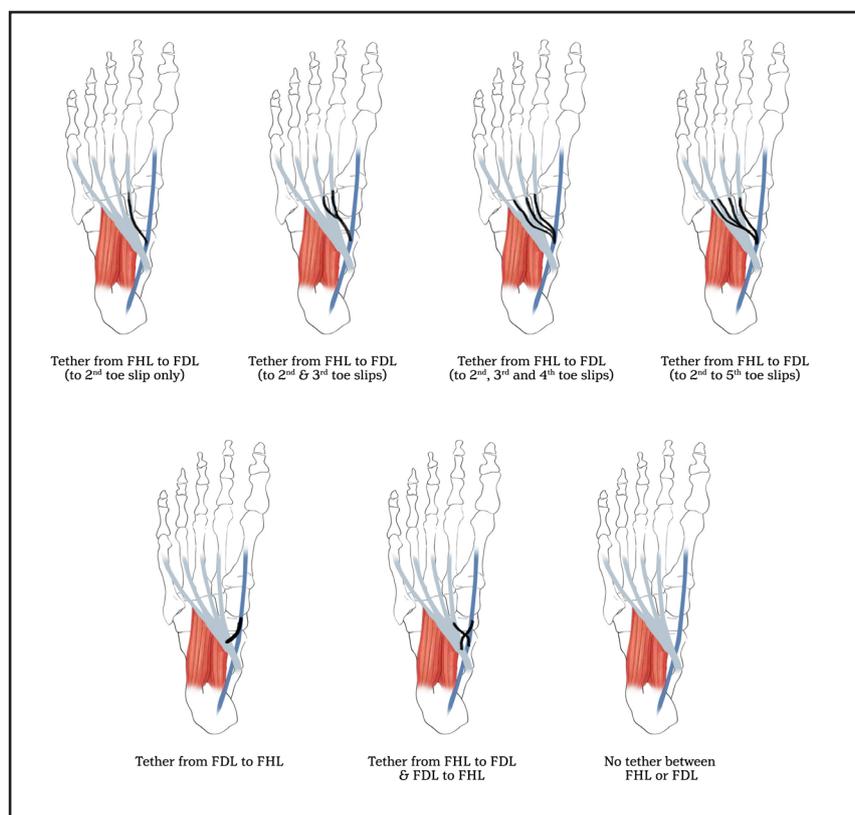
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6.3 - The flexor quadriga effect in the foot: can we ignore it?

(James Ritchie)

The origin of the term '*quadriga*' comes from Roman times where it referred to a chariot drawn by four horses. The skill of the charioteer was in balancing the tension in all four reins to control the direction of the chariot. In the hand, a quadriga effect is observed when one slip of the flexor digitorum profundus (FDP) tendon is either shortened or tethered. The remaining FDP slips therefore become functionally lengthened as their flexion excursion is reduced, resulting in a weak grasp.

The effect of tethering on a tendon's excursion can also be seen in the foot. Indeed, the situation may be more complex since there are frequently connections between the tendons of the FDL, FHL and quadratus plantae with up to seven different patterns described (below). Approximately 97% of the population have a connection between the FDL and FHL so it is reasonable to expect that altering the excursion distance of one will inhibit movement of the others. However this phenomenon receives little attention in the literature which suggests it may be uncommon, unrecognised or largely asymptomatic.



Variability in the connections between FHL & FDL at the Knot of Henry (Beger et al. 2018)

A quadriga-type effect can be produced when the first ray is shortened (e.g. after surgery). In this situation the FHL tendon is relatively lengthened and because of the connections to the FDL tendon, it cannot function independently or effectively, which may lead to metatarsalgia and sesamoiditis. In this scenario, passive flexion of the lesser toes (which allows for increased FDL excursion) should re-function the FHL and is thus a useful clinical test to see if the quadriga effect is present.

Symptoms from a quadriga-type involvement of the FHL have been variably reported but may include pain along the tendon, triggering (*hallux saltans*), stiffness, and pain during push-off. If patients are symptomatic, and conservative methods (such as stretching and physiotherapy) are unsuccessful, release of the tethers at the Knot of Henry should improve symptoms. The anatomical landmarks to perform this through a minimally invasive technique are described in **Session 1.1**.

Lui & Chow described a minimally invasive release of the fibrous connection between the FHL and FDL in a patient with pain related to the hallux on tiptoeing and push-off eight months after a road traffic accident. He had difficulty initiating active motion of his hallux when his lesser toes were held still and ultrasound showed creasing of the FHL tendon. By 18 months his symptoms had largely resolved.

In the 2011 Round Table Meeting a series of nine cases with a similar phenomenon was presented. All patients had open releases of the adhesions between the FDL and FHL. Full function was achieved in seven out of nine patients although one patient sustained a nerve injury.

It is important to note that the effects of the tethering between the FHL and FDL tendons may work in the foot and ankle surgeon's favour. The FDL and FHL are commonly harvested for various reconstructive procedures and the expected morbidity may be reduced as the Knot of Henry allows continued flexion of the toe / toes through the remaining tendons. This often obviates the need for a tenodesis. Various studies have attempted to assess the biomechanical consequences of harvesting these tendons, but the numbers are small and often inconclusive. Furthermore in most cases there was no functional difference seen.

Summary:

- A quadriga-type effect can occur in the foot but it is a rarely symptomatic
- However, if symptomatic, it should not be ignored as it is treatable
- Often the cause is de-functioning of the FHL through tethering at the Knot of Henry
- Release of the adhesions between the FHL and FDL may improve symptoms

References:

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Session 7: Plantaris in Mid-portion Achilles Pain

7.1 - Debate: I debride or excise it

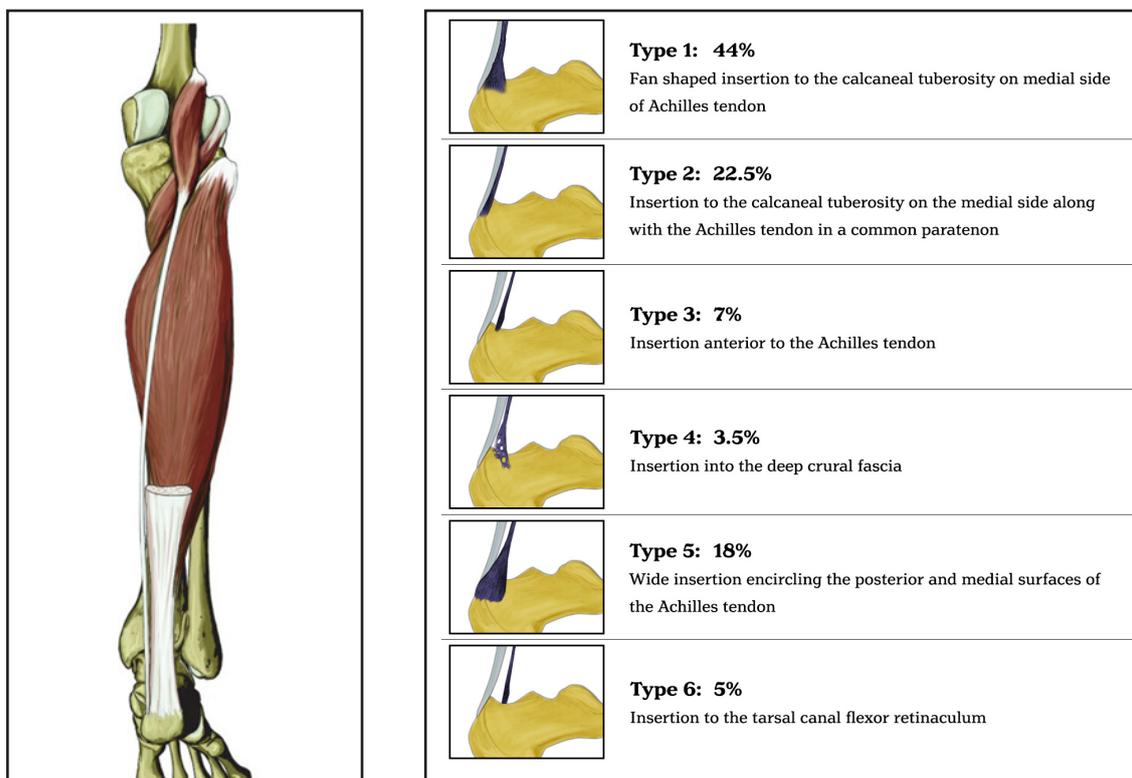
(Andy Goldberg)

There have been a number of non-operative treatments described for non-insertional Achilles tendinopathy including neuromuscular rehabilitation, shockwave therapy, low level laser therapy, high volume injections, nitroglycerine patches, whole blood, platelet rich plasma and stem cell treatment. If conservative treatment fails, surgery may be considered and may take the form of debridement and scraping of the Achilles tendon to debride abnormal tendon and promote healing. However, a proportion of patients will fail operative intervention and have persistent pain and it has been hypothesised that the plantaris tendon may play a role in the pathology in this subgroup of patients.

Proposed mechanisms for plantaris involvement in Achilles pain:

- » **Interference theory:** the plantaris tendon is in close approximation to the Achilles tendon which causes shearing, attrition and inflammation in the Achilles tendon during contraction
- » **Stiffness theory:** the plantaris tendon is stiffer than the Achilles tendon and may therefore take an increased proportion of the load causing the Achilles tendon to atrophy

The plantaris muscle is a component of the superficial posterior compartment of the leg and originates in the popliteal fossa (lateral supracondylar ridge of the femur, adjacent to the lateral head of the gastrocnemius). The muscle belly is approximately 50 to 100 mm long and it is tendinous throughout the rest of its course. It runs between the gastrocnemius and soleus laterally, exiting from the medial side of the Achilles tendon in 85% of cases. In the other 15% of cases the tendon exits anterior to the Achilles tendon. In primates, the plantaris aids in grasping, but it is vestigial in humans and absent in 11 to 19% of the population. The plantaris has a number of variations in its insertion as illustrated below.



The course of the plantaris tendon and variations of its insertion (Olewnik et al. 2018)

Alfredson has reported a series of 519 tendons where patients underwent Achilles tendon debridement from a lateral approach initially and from a medial approach later in the study period. Overall he found that 5% of patients had recurrence and half of these patients were found to have invagination of the plantaris into the Achilles tendon at time of re-operation. In the latter half of his study he routinely debrided the plantaris tendon (in 86% of cases). He therefore surmised that the plantaris may play a role in Achilles tendinopathy, although the recurrence rate in this subgroup of patients is not reported.

A further series by Calder *et al.* reported excision of the plantaris in athletes at time of Achilles scraping. They included 32 patients with medial Achilles tendinopathy and found that 29 patients (90%) improved and 30 returned to sport (mean time of 10 weeks). They concluded that the plantaris may be responsible for symptoms in some athletes and that excision is safe and does not prevent early return to sport.

Summary:

- The plantaris may be a cause for pain in a small proportion of patients (~ 5%)
- These patients may be identified as those with minimal changes in their Achilles tendon, predominantly medial pain, and ultrasound proven tendinopathy of the plantaris
- This subgroup of patients may benefit from debridement / excision of the plantaris

Consensus / Discussion:

- » **How many consultants currently excise the plantaris when treating Achilles tendinopathy operatively?**
- | | |
|-----|----------|
| Yes | 5 (21%) |
| No | 19 (79%) |

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7.2 - Debate: It is a mythical diagnosis

(Sam Adams)

The various proposed mechanisms for the contribution of the plantaris tendon to mid-portion Achilles tendon pain has been discussed in **Session 7.1**. However, in order for this to be true, the plantaris tendon must be actively contributing to the pathology.

Possible mechanisms by which the plantaris must contribute to Achilles pathology:

- » **Physical contribution:** Via direct pressure or abutment
- » **Chemical contribution:** Via inflammatory cytokines

Studies by Alfredson and Bedi *et al.* have suggested that the plantaris has a role in Achilles pain as when they re-operated on patients for failed Achilles scraping, they noted the plantaris was closely related to or invaginated into the Achilles tendon. However, cadaveric studies have shown this can be a normal finding in 85% of patients. Therefore, the vast majority of patients with these findings will be asymptomatic. Furthermore, patients taken back to theatre in these series also had further ventral Achilles tendon scraping in addition to plantaris excision and therefore we cannot ascertain whether the clinical improvement observed was due to the procedure on the Achilles tendon or the plantaris tendon. There is therefore insufficient evidence to support a physical mechanism for Achilles pain via the plantaris tendon.

In order to provoke a chemical cause for Achilles pathology, the smaller plantaris tendon would have to initiate a large cytokine response. In this instance we would expect the plantaris to be diseased. However, in a study by Calder *et al.* 13 out of 16 (81%) excised plantaris tendons were histologically normal. Thus it cannot be proven that the plantaris was chemically driving the process.

In a number of studies patients who had just scraping of the Achilles tendon without plantaris excision did as well as patients who had plantaris excision and there are similar incidences of recurrence in both groups. There is therefore inadequate evidence to support the assertion that the plantaris tendon has any significant contribution to Achilles pathology, nor is there any evidence to support improved outcomes with its excision.

Summary:

- No scientific evidence to support the involvement of the plantaris tendon in Achilles pain
- Studies demonstrating improvement all performed ventral Achilles scraping in addition to plantaris excision which is a significant confounding factor

Consensus / Discussion:

- » **How many consultants believe that the plantaris plays a role in mid-portion Achilles tendon pain?**

Yes	4 (17%)
No	20 (83%)

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