MANAGEMENT OF TENDINOPATHIES WITH ULTRASOUND TISSUE CHARACTERISATION

Achilles and patella tendon pain is very common, but the precise nature of the complaint is difficult to diagnose and treat. The new imaging modality of ultrasound tissue characterisation (UTC) produces high resolution scans of the tendon, providing an in-depth analysis of the health of the tendon tissue. In the future this technology will become indispensable for preventing tendon overload, diagnosing tendon conditions and monitoring rehabilitation.

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TENDONS AND TENDINOPATHY

Tendons connect muscle to bone and are able to withstand very high tensile loads. Tendon complaints are very common in recreational and elite sportsmen and women, particularly the Achilles tendon. Epidemiology data on recreational runners indicates 5–34% will develop Achilles tendon pain, and in elite runners and elite sportsmen and women, tendon pain is responsible for significant time off training and competition. Achilles tendon pain provides a challenge to any health professional.

Tendinopathy is characterised by matrix disintegration as a consequence of overstraining, ageing, degeneration and/or partial ruptures. The differential diagnosis of Achilles tendon complaints is paramount to implementing the most effective treatment plan (Table 1).

> "ULTRASOUND TISSUE CHARACTERISATION (UTC™) PROVIDES A MORE DETAILED IMAGING PROFILE OF THE TENDON"

IMAGING MODALITIES

Currently, ultrasound is the imaging modality of choice for the assessment of tendons as it has far superior spatial resolution to MRI and can assess for neovessels in and around the tendon. However, clinical improvement is not correlated with changes in imaging status or the amount of neovascularity (1). Also, ultrasound is dependent on the skills of the operator and produces a 2D image of a 3D structure, which introduces further limitations in assessing the structural integrity of the tendon.

ULTRASOUND TISSUE CHARACTERISATION

A new novel imaging modality ultrasound tissue characterisation (UTC™) provides a more detailed imaging profile of the tendon (Fig. 1). UTC imaging produces a multi-planar and 3D coronal view to assess in detail the structural integrity of the tendon (2).

TABLE 1: POSSIBLE DIFFERENTIAL DIAGNOSES FOR DIFFERENT REGIONS OF THE TENDON (J. ANTFLICK, 2014)

Mid portion	Distal tendon	Medial tendon	Lateral tendon
Achilles degeneration/ tendinosis	Insertional Achilles tendinopathy	Plantaris rupture	Sural neuropathy
Achilles dysrepair	Enthesitis	Plantaris partial tear	
Achilles intrasubstance partial tear	Insertional tendinopathic degenerative change	Plantaris tendinopathy	
Central/spinal sensitisation Achilles tendinopathy	Insertional calcification	Plantaris friction syndrome	
Achilles rupture	Retrocalcaneal bursitis		
Achilles paratenonitis			

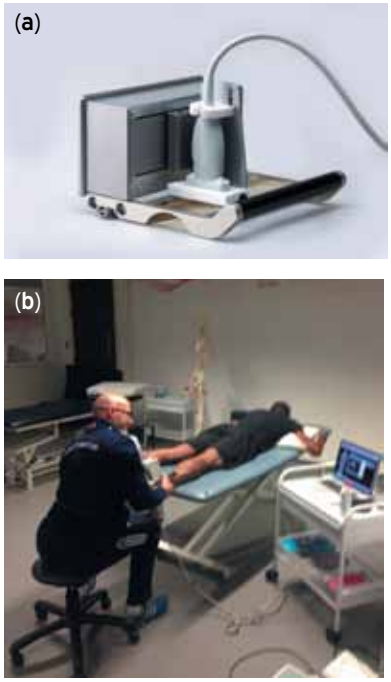

Figure 1: The Ultrasound Tissue Characterisation (UTC™) Tracker device provides a more detailed image of the tendon. The UTC Tracker (supplied by utcimaging) (a) is specifically designed to image tendons (b). [(a) Courtesy of utcimaging.com; (b) credit: J. Antflick, Tendon Performance, 2013]

The UTC probe travels automatically over the tendon's long axis, collecting transverse images at even distances of 0.2mm over a length of 12–20cm. UTC produces a transverse, coronal and longitudinal image and a 3D coronal view. The tendon structure is classified into four discrete echo types:

- Echo-type I (green), generated by reflections at intact and aligned tendon bundles (coloured green in processed images)
- Echo-type II (blue), generated by reflections at discontinuous or waving tendon bundles (coloured blue in processed images)
- Echo-type III (red), generated by interfering echoes from mainly fibrillar components (coloured red in processed images)
- Echo-type IV (black), generated by mainly cellular components and fluid in amorphous tissue.

These different echo types provide objective information on the integrity of the tendon matrix from the distal insertion to musculotendinous junction. The scans are analysed to assess for focal areas of echo change and to establish the overall health of the tendon (Fig. 2).

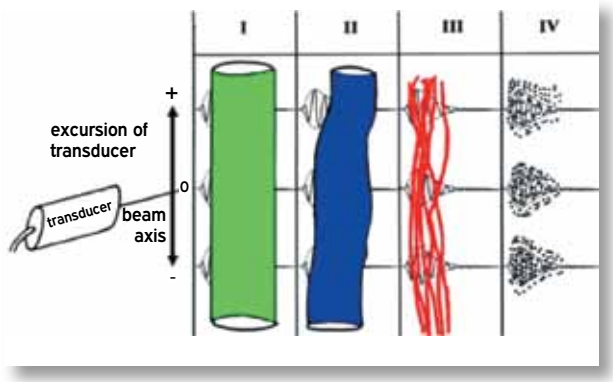

Figure 2: The image created from the UTC scan indicates healthy or progressively more damaged tissue by a colour classification system:
I. Green: intact and aligned bundles and fasciculi, diameter: 0.38mm
II. Blue: discontinuous wavy bundles and fascicule, diameter: 0.38mm
III. Red: mainly smaller fibres ('fibrillar'), diameter: <<0.38mm
IV. Black: mainly amorphous tissue containing cells and/or fluid, diameter <<<0.38mm.
(H. van Schie, utcimaging)

EXAMPLES OF UTC IMAGES

The UTC Tracker produces images that give a clear indication to the health of the tendon. Figure 3 shows an image of a relatively normal healthy tendon. The scan data can also be presented in different types of graphical images. Figure 4 is a graph of the relative amounts of echo-types (and therefore tissue types) along the length of the tendon. Figure 5 is a bar chart, which gives a clear picture of the relative amounts of the healthy and damaged types of tissue as indicated by the different echo-types. The values for a normal healthy Achilles or patella tendon would typically be: green, 80% or greater; blue, 15%; and red and black together, 5%. Figures 6 and 7 show the recovery of a surgically repaired tendon following complete rupture and the healing that takes place over time.

UTC plays an important role in monitoring athletes' tendon health during each phase of the rehabilitation process and for managing in-season tendon pain. Managing tendinopathy in season is particularly challenging as training and competition loads are high and often there is not sufficient time for a full recovery. Tendon pain is provoked by excessive loading; the greater the load, the more pain is experienced (3). UTC is currently being used in British Athletics and Australian Rules Football in symptomatic and asymptomatic tendons to study the effect of load on the tendon matrix.

The UTC data combined with clinical markers assess the tendons tolerance to load, such as 24-hour pain response, morning stiffness,

> "UTC IMAGES ARE COLOURED ACCORDING TO ECHO TYPE, WHICH INDICATES THE HEALTH OF THE TISSUE"

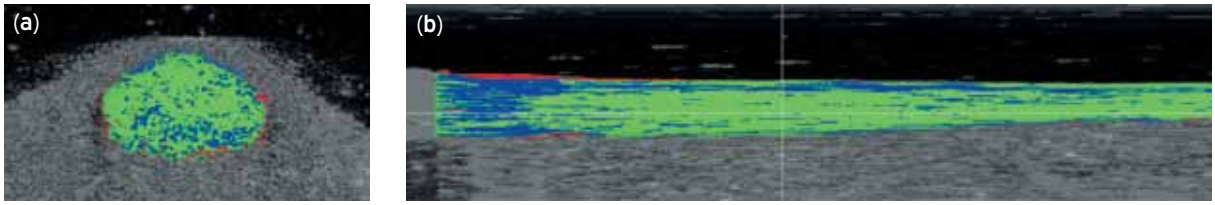

Figure 3: Scans of a normal Achilles tendon in the transverse plane (a) and the sagittal plane (b). (J. Antflick, Tendon Performance, 2013)

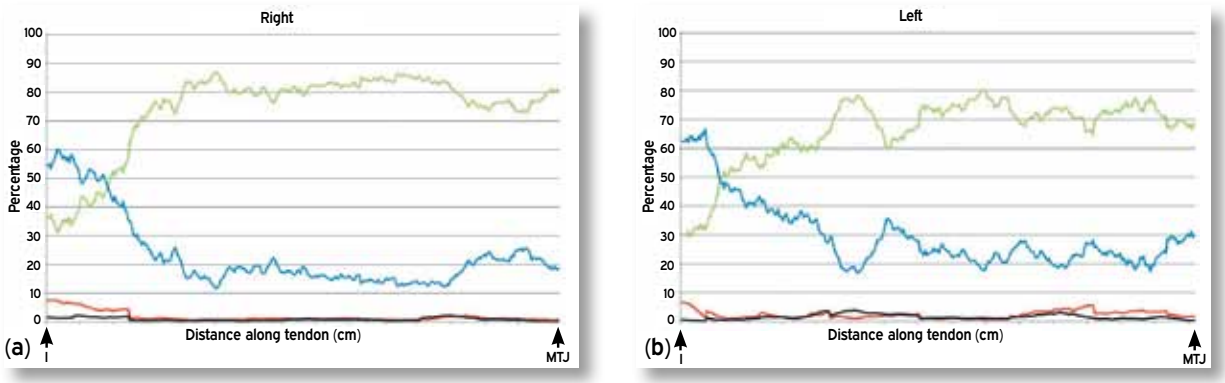

Figure 4: Graphical presentation of the ultrasound echo-types (indicating tissue health) along the length of typical healthy Achilles tendons from the insertion (I) to the musculotendinous junction (MTJ) of the right (a) and left (b) Achilles tendons.

pain on single-leg heel-raise and single leg hops. This information is used to adjust and modify tendon load to ensure the tensile loading capabilities of the tendon is not exceeded and the tendon remains pain free. This enables athletes, their clinicians and coaches to make informed and effective decisions about the capacity for training and performance. Research has demonstrated that UTC is valid, reliable and is sensitive at detecting a tissue response to load (4,5).

REHABILITATION

Complete removal of tendon load is catabolic for a tendon and only very short periods would be advocated in reactive tendons (6). It has been widely accepted that appropriately progressed loads to the tendon will maintain and/or remodel the tendon matrix (7). Over the last ten years there has been significant attention to eccentric exercises with some promising results in tendinopathy. However, the appropriateness for managing in-season tendon pain is questioned when combined with a high training and/or competition load (8,9). Isometric exercise is a useful

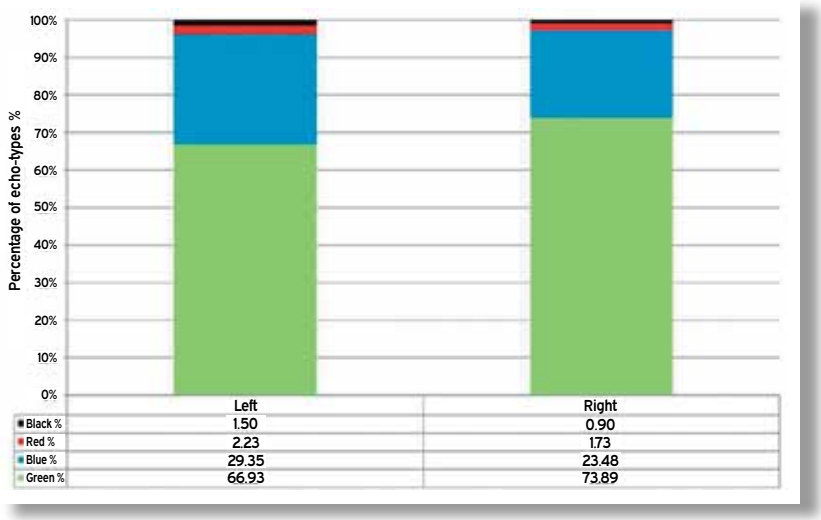

Figure 5: The different echo-types present in the ultrasound image can be quantified and displayed as a bar graph to give a clear representation of the percentages of the healthy and damaged tissues present in the tendon. (J. Antflick, Tendon Performance, 2013).

adjunct for reactive tendon complaints and can be used for pain modulation in-season while still maintaining some load stimulus. Cook & Purdham (10) suggest sustained holds for 40–60 seconds, repeating 4–5 times several times a day. Such exercise is thought to recruit descending inhibitory mechanisms, resulting in mechanical hypoalgesia and increased pressure pain threshold (11,12). UTC is also being used to monitor the response of the tendon matrix to medications, shockwave therapy and injectables. Watch this space!

There is limited evidence to suggest that isolated eccentric programmes offer superior clinical outcomes in comparison to combined loading programmes. The exact mechanisms underpinning clinical improvements seen with rehabilitation

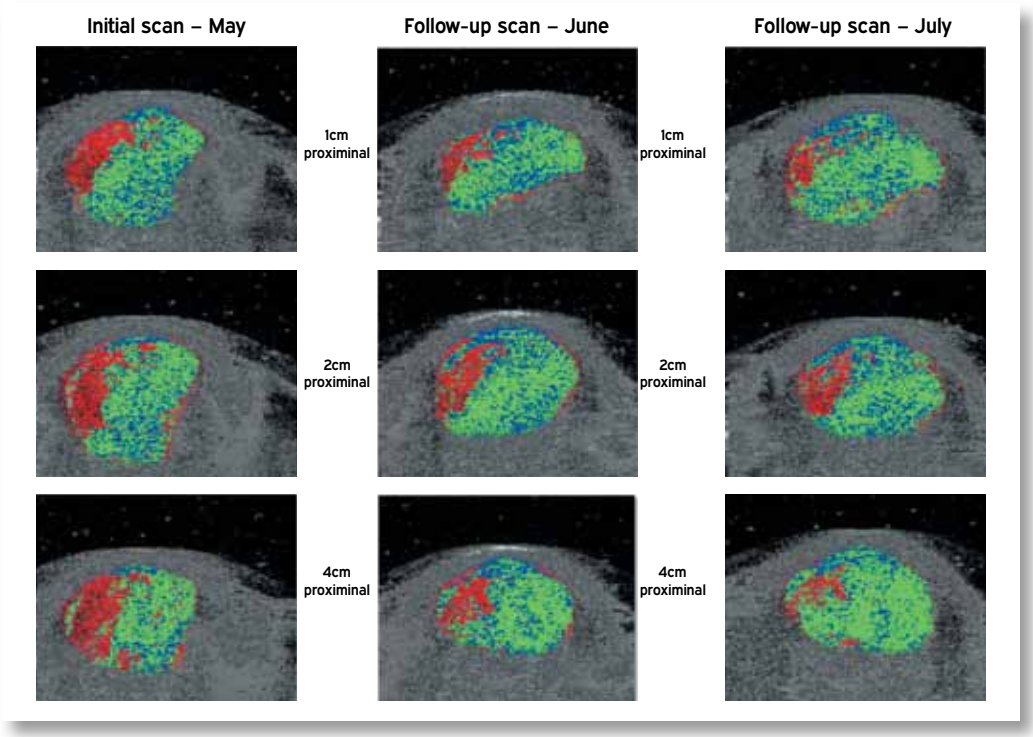

Figure 6: Scans showing injury and follow-up. Healing can be seen as the damaged (red) tissue becomes healthier (green). (J. Antflick, Tendon Performance, 2013)

programmes in pathological tendons are currently unknown. It would appear the key goal of an exercise programme is to increase the load tolerance and energy absorption of the tendon. Tendons are very slow to adapt and this process is likely to take several months (10).

ONE-STOP MULTIDISCIPLINARY TENDON CLINIC USING UTC IMAGING

Tendon Performance and Fortius Clinic have teamed up in London to provide a multidisciplinary one-stop shop for tendon-related issues designed for elite athletes and recreational sportsmen and sportswomen. The clinic utilises UTC imaging to provide detailed analysis of the tendon to ensure it results in the most effective management plan. The multidisciplinary team consists of leading foot and ankle consultants, specialist physiotherapists, sports doctors and interventional radiologists (Box 1, 2).

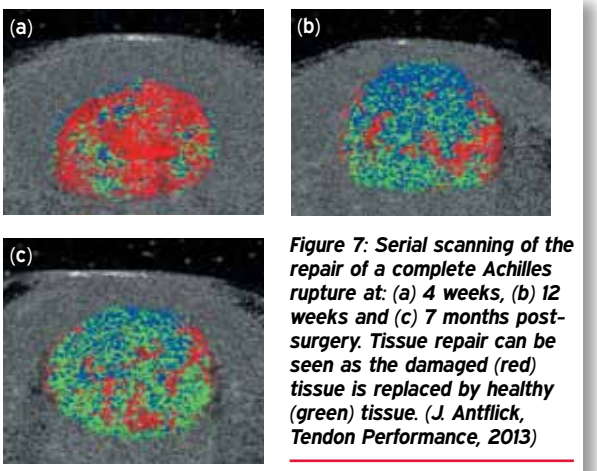

Figure 7: Serial scanning of the repair of a complete Achilles rupture at: (a) 4 weeks, (b) 12 weeks and (c) 7 months post-surgery. Tissue repair can be seen as the damaged (red) tissue is replaced by healthy (green) tissue. (J. Antflick, Tendon Performance, 2013)

TAKE-HOME POINTS

The following list provides key points for you to bear in mind when diagnosing and treating tendon injuries:

- Diagnosis is key: be specific and consider all differentials (Table 1)
- Carry out a detailed examination with a thorough history. For example, does the patient remember a specific incident when they felt the pain? This will help to rule in/out a tear.
- How long do they experience morning stiffness in the tendon?
- Palpate the tendon carefully and be specific – where is the pain? Is the pain on the mid portion, the enthesis or the medial or lateral side of the tendon?
- Before commencing a loading programme, consider the irritability of the tendon: eg. how long does it take for the pain to go away once they have aggravated it?
- Eccentric loading may be effective but consider other types of loading as well: eg. moderate and heavy isometric exercises.
- Soleus rehabilitation. Approximately 2/3 of the calf complex is soleus and it plays a very important role in the overall strength endurance of the calf – don't forget it!
- Beware loading into end-of-range

BOX 1: TENDON PERFORMANCE

Tendon Performance is a clinical consultancy, led by physiotherapists Jarrod Antflick and Chris Myers, specialising in musculoskeletal services for recreational sportsmen and women, and elite level human and equine athletes.

BOX 2: FORTIUS CLINIC

Fortius Clinic provides leading orthopaedic and sports injury treatment, specialising in integrated musculoskeletal care.

Our Consultant Foot and Ankle specialists are recognised as leaders in the field of foot and ankle disorders, with particular expertise in arthroscopic treatment. We also offer many non-surgical therapies including the latest evidence-based techniques optimising treatment for Achilles tendon disorders (extra-corporeal shockwave therapy) and Achilles tendon rupture.

Mr James Calder, Consultant Orthopaedic Foot and Ankle Surgeon and Dr Jeremiah Healy, Consultant Radiologist are closely involved with the tendinopathy clinic. Both have particular expertise in sports injury.

positions initially, especially if the tendon is irritable or you suspect the plantaris to be involved, ie. medial Achilles pain.
- Monitor overall load on the tendon. Stopping all tendon load, ie. complete rest, is unlikely to solve the problem but load modification is important.

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12. Kosek E, Lundberg L. Segmental and plurisegmental modulation of pressure pain thresholds during static muscle contractions in healthy individuals. **European Journal of Pain 2003;7:251–258**.

FURTHER RESOURCES

1. UTCimaging website. www.utcimaging.com
2. Follow Jarrod Antflick on twitter: tendonexperts@jarrodantflick
3. van Schie HTM, de Vos RJ, et al. Ultrasonographic tissue characterisation of human Achilles tendons: quantification of tendon structure through a novel non-invasive approach. **British Journal of Sports Medicine 2010;44(16):1153–1159**
4. Cook JL, Purdham CR. The challenge of managing tendinopathy in competing athletes. **British Journal of Sports Medicine 2014;48(7):506–509.**

- What are the different diagnoses that can be made for the different regions of the Achilles tendon?
- What kind of imaging technology does UTC use and what do the different colours on a UTC scan indicate?
- What are the key points to think about in an Achilles tendinopathy rehabilitation programme? Would you do things differently for in-season/off-season athletes?

KEY POINTS

- **Achilles tendon complaints are very common in recreational and elite sportsmen and women.**
- **Tendinopathy is characterised by matrix disintegration as a consequence of overstraining, ageing, degeneration and/or partial ruptures.**
- **The differential diagnosis of Achilles tendon complaints is paramount to implementing the most effective treatment plan.**
- **Ultrasound tissue characterisation (UTC™) provides a detailed image of the tendon, producing transverse, coronal and sagittal images as well as a 3D coronal view.**
- **UTC scans are coloured according to echo type, which reflects the current health of the tendon tissue.**
- **Successive UTC scans are useful for monitoring tendon health/rehabilitation.**
- **Eccentric exercises have been the focus of rehabilitation for the last 10 years, but is one loading strategy, there are many more depending on the diagnosis.**
- **Isometric exercises are useful for treating pre-season and in-season reactive tendinopathy.**

THE AUTHORS

JARROD ANTFLICK BAPP BHSC PGCERT

Jarrod is consultant physiotherapist with British Athletics sharing his time between clinical work (at Tendon Performance, Complete Physio and The Fortius Clinic in London, UK) and attending major championships. He is currently undertaking field research into the effect of tendinopathy on performance utilising UTC. Jarrod was a consulting physiotherapist for members of the US Track and Field Team in preparation for the London 2012 Olympics.

CHRIS MYERS BSC MSC PGCERT

Chris is a physiotherapist, osteopath and MSK sonographer. He runs a group of private clinics in London called Complete Physio. He has a special interest in tendons and is especially interested in how imaging findings relate to pain and prognosis. He uses UTC as part of his daily practice in the clinic and treats many elite and recreational athletes from a variety of sports.

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