

Superb Micro-Vascular Imaging – A new tool for the sports physician

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In the past decade there has been an explosion in the use of diagnostic ultrasound by sports medicine practitioners, predominantly physicians/surgeons but also the allied professions such as physiotherapists. The ultrasound scanner has become a useful (and sometimes invaluable) aid to the team physician when providing daily care to his/her athletes at the clinic, sporting venues and when travelling.

Grey-scale ultrasound provides anatomical and structural information that can also be assessed under dynamic functional stress and gives immediate information that can influence diagnostic decisions, shape training and rehabilitation programmes and provide visual feedback and education to the athlete patient. Additional functionality such as colour and power Doppler enables the visualisation of vascularity and objective measurement thereof within and around the joints and soft tissues that form the vast majority of presentations to a sports/musculo-skeletal physician. Superb Micro-Vascular Imaging (SMI) is the latest addition to the armoury available to the sports physician/radiologist with access to Toshiba's diagnostic ultrasound hardware.

Clinical relevance

Why is visualisation of vascularity important when dealing with sports medicine cases? There has been a shift of thought regarding the presence of vascularity in or around soft tissues, joints or bony entheses in recent years; maybe the excitement of being able to detect neovessels following the addition of colour and power Doppler functionality on the early portable ultrasound scanners around 15 years ago led the sports medicine practitioner to an impression that this was a 'bad' pathological entity. Moreover there was a tendency to associate such vascularity with painful conditions or injuries and an assumption that the associated neural proliferation was the cause of pain and therefore a temptation to obliterate the neovessels by various treatments. This was particularly true in cases of tendinopathy; however further research uncovered multiple potential pain generators including chemical mediation and psychological

factors that play a significant part in the appreciation of tendon pain irrespective of the degree of neovascularity. Vascularity in tendons increases after exercise so the timing of the scan is important and as the neovessels are easily compressed, transducer pressure and positioning of the joint the tendon crosses can heavily influence the appearances. The author's view from experience of scanning many athletes is that neovascularity in an injured soft tissue is a good thing as it suggests that a repair/regeneration process is in progress; there is much more concern about a non-painful weight-bearing tendon where an inert hypoechoic lesion is detected on routine screening as this implies a lack of healing response and potential loss of tensile load-bearing capacity which translates to a higher risk of rupture. In joints however neovascularity tends to be associated with an unwanted chronic inflammatory process (synovitis) which may be a result of systemic disease, post-surgical or reactive to joint instability or impingement.

Detection of neovascularity by ultrasound modalities must therefore be interpreted in context of the following:

Diagnosis

Ultrasound scanning is usually a confirmatory adjunct when diagnosing an athletic injury suspected from clinical history, clinical examination and sport performance findings. However sometimes the presence of subtle neovascularity can clinch a diagnosis that is not completely evident from the history or examination alone; this is often in the subacute phase where a healing response is already in progress as the athlete has continued training or competing with a

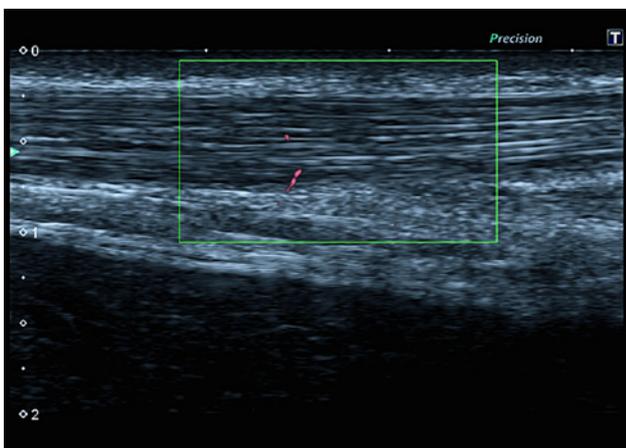


Figure 1: cSMI of Achilles tendon showing subtle neovascularisation in subacute tendinosis

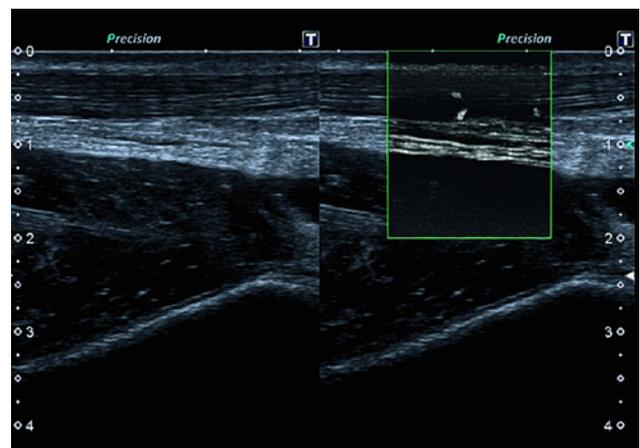


Figure 2: Grey-scale and mSMI comparison of subtle Achilles tendinosis

niggling injury leading to subjective or objective reduction in performance. Examples that spring to mind include a small intramuscular tear that might prevent an athlete from sprinting at absolute top speed but causes no impairment in all other respects or a very subtle Achilles tendinosis that only causes pain on a change of surface/pitch firmness.

Staging

Tendinosis has well recognised stages of progression and the presence or otherwise of neovascularity is a defining factor confirming that it has progressed from the acute reactive phase into the proliferative phase; this has important implications for clinical management in terms of exercise load management and the use of anti-inflammatory medication (the latter may be useful in the early reactive phase but detrimental to collagen formation in the proliferative phase).

Neovascularity following structural muscle injury indicates an attempt to regenerate muscle tissue which is a preferable outcome for an athlete when compared to seroma formation or fibrosis; many treatments used by sports physicians treating muscle injuries specifically aim to stimulate production of Vascular Endothelial Growth Factor (VEGF) whilst also inhibiting Transforming Growth Factor (TGF) in order to promote regeneration over repair. This can sometimes accelerate recovery and return to athletic activities but more importantly restores better functionality and reduces risk of re-injury.

Healing response

The majority of athletic muscle injuries are functional in nature i.e. with no evidence of macroscopic structural disruption on ultrasound or MRI even if oedema may be present from lymphatic or perimuscular 'congestion'. In cases where there is fibre or bundle disruption to an extent that can be detected within the resolution capacity of imaging modalities the presence of neovascularity indicates a favourable healing response. If left to natural means vascularity encircling a muscle tear is usually visible at around 14 days post-trauma.

Effectiveness of treatment/early rehabilitation

Medical treatments that aim to promote neovascularity in muscle injury such as High Power Laser Therapy, Autologous Plasma injection, Platelet-Rich Plasma injection or Actovegin can accelerate the production of neovessel formation so monitoring via ultrasound is a useful way of assessing the patient's response to such treatments; neovascularity can be observed around the 7 – 10 day stage if these treatments are effective.

Determination of readiness to load tissues

Similarly, regression of the neovascularity and replacement by new muscle, tendon or ligament fibres indicates the onset of the remodelling phase and readiness to load the injured tissue in a more functional and challenging manner specific to the demands of the sport.

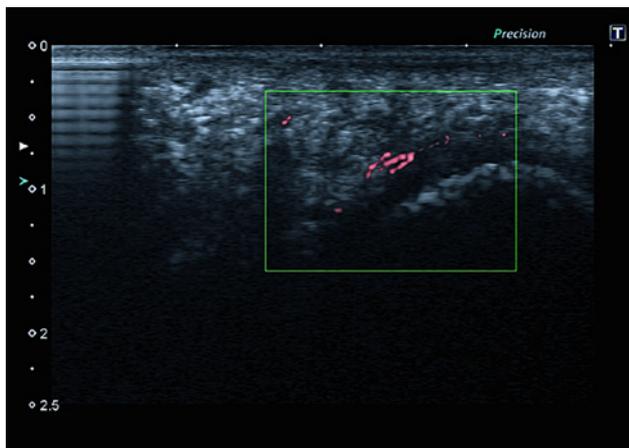


Figure 3: cSMI of periosteal neovascularity in tibial sesamoiditis



Figure 4: cSMI of peritendinous/periosteal neovascularity in healing navicular tuberosity fracture

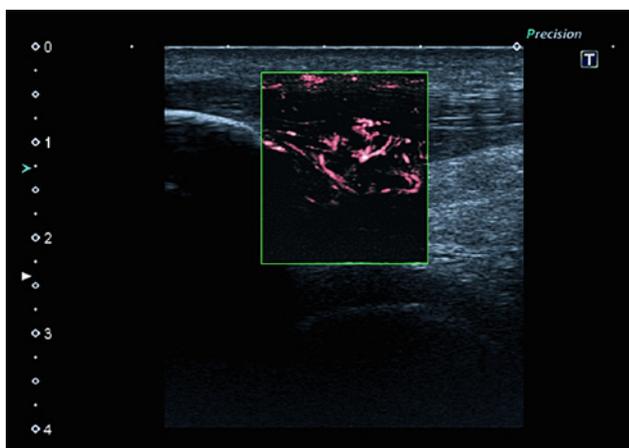


Figure 5: mSMI Hold image of patellar tendon with advanced proliferative proximal tendinosis

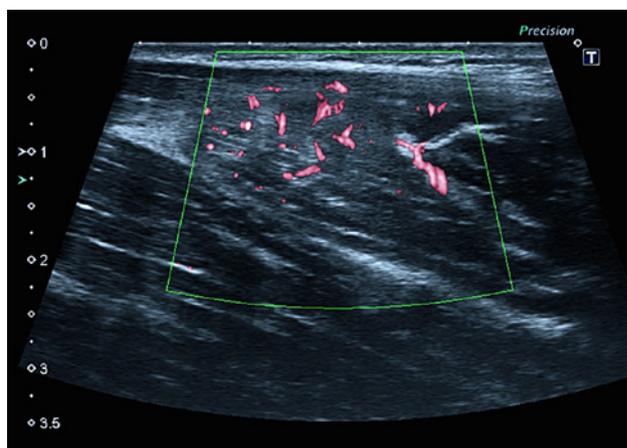


Figure 6: cSMI of healing proximal myotendinous tear in adductor longus muscle

Ongoing monitoring

Tendinopathy is often a chronic relapsing and remitting process in athletes in line with the mantra 'once a tendinopath always a tendinopath', however it can be managed and does not necessarily lead to an inability to compete at the athlete's maximal performance level. This of course requires judicious training regimes and optimal preparation and recovery strategies but monitoring of the tendon structure and vascularity can play an important part in raising

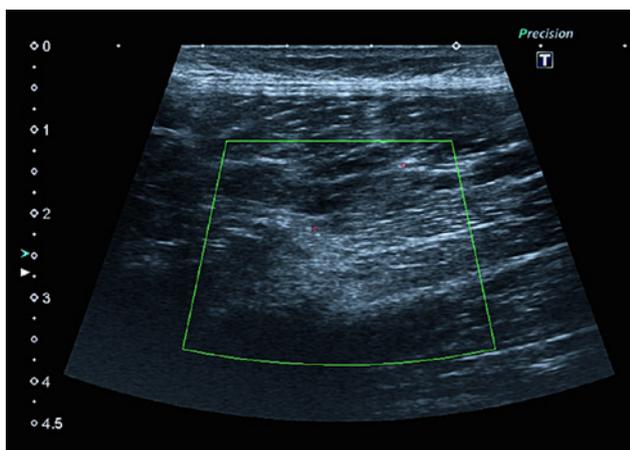


Figure 7: cSMI of near-complete regression of neovascularity in a healing soleus muscle tear

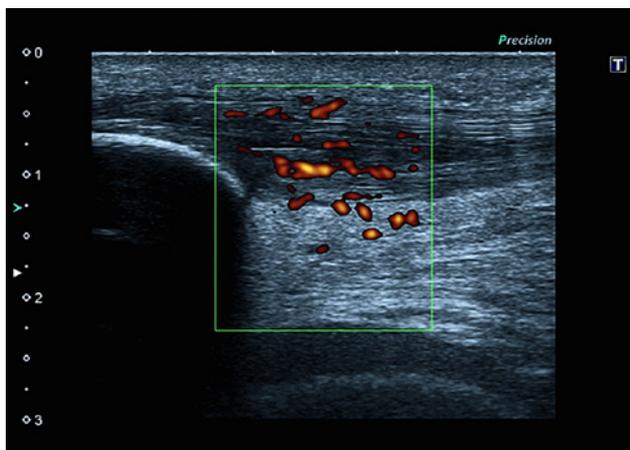


Figure 8: Power Doppler image of proximal patellar tendinosis

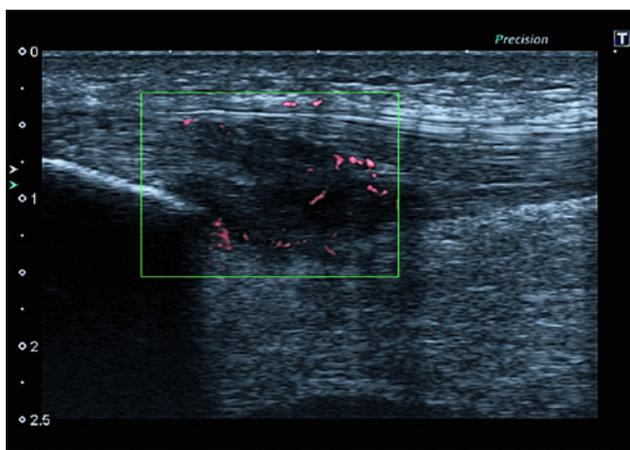


Figure 9: cSMI of same patellar tendon highlighting the underlying hypoechoic structural defect

confidence in the decision making by the athlete and his/her coaches, trainers and therapists. This is perhaps the greatest benefit of ultrasound scanning in general as a modality in the hands of a sports physician as it becomes an extension of the normal clinical and functional assessment process and being very visual, facilitates education and awareness of the athlete and his/her support team with regard to the structure and physiology of musculoskeletal tissues.

Comparison of Doppler and Superb Micro-Vascular Imaging (SMI) Power Doppler has generally been preferred to colour Doppler as the sports physician is less interested in direction of vascular flow and more interested in the detection of small low flow neovessels and the pattern thereof in injured tissues. Power Doppler leads to unwanted 'noise' in the image and a very steady hand is needed when scanning to avoid artefact when looking for subtle neovascularity e.g. when assessing healing in a minor muscular tear.

Superb Micro-Vascular Imaging provides a much clearer and defined outline of the vascular pattern with less movement-related artefact and the facility to employ the 'Hold' function allows the vascular tree to be constructed over several seconds whilst the operator holds the transducer in a static position. The added attraction of both monochrome (mSMI) and colour (cSMI) options makes this a more powerful visual tool when discussing findings with the athlete. Building a library of sequential scans is a useful record of progress particularly when managing a chronic injury such as tendinosis.

Future developments

With the advent of sports science the modern athlete and coach rely heavily on objective data and statistics in order to complement their subjective opinions and assessments; the addition of quantification of microvascular blood flow could be a useful development for the sports physician to further enhance the advantages that Superb Micro-Vascular Imaging has over power and colour Doppler. Athletes respond to numbers and the addition of a quantifiable assessment of blood flow in healing tissues would add another level to the decision-making during rehabilitation or when managing a chronic injury through a training programme. In the meantime correlation of the image appearances available via SMI against objective training loads and injury presentations will provide a more evidence-based approach to injury management. //



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