From left to right: Manchester United first team players, Juan Mata, Scott McTominay and Marcus Rashford at the Canon Medical Centre at the Aon Training Complex

Multi-modality imaging in progressive sports medicine

Dr Steve McNally, Head of Football Medicine & Science at Manchester United Football Club explores the role of multi-modality imaging in sports medicine, its importance in unlocking an understanding of anatomical and physiological information, and how different diagnostic imaging solutions go towards protecting and rehabilitating elite athletes.

We often get asked what diagnostic imaging equipment best fits today's needs for sports science. Is there a particular system that gives the most accurate or broadest spectrum of information? How can player recruitment decisions, routine health surveillance, and the emerging needs of post-retirement health management be enhanced? What innovations in medical technology do people need to look out for to assist progressive sports science?

We recognise that we are in a fortunate position to have an ultra-modern medical imaging centre1 at Manchester United Football Club that includes a range of Canon Medical systems including MRI, CT and Ultrasound. This helps us to carefully manage the health of our most valuable assets, our players. This equipment is the same as what can be found at the frontline of many independent and NHS hospitals across the UK. However, this high level of access to multi-modality imaging may not be the same for other sporting organisations. But what we do share is the need to treat athletes as people, from community-based sports groups to amateur, national and other premier leagues, and the careful management of their long-term sporting aspirations.

The use of multi-modality imaging today

To date, many football club doctors utilise ultrasound as a point of care imaging platform. It is an extension of our clinical examination and used as part of a normal routine. For example, in 2016/17, 80% of our imaging procedures were for ultrasound screening and diagnostics. This included musculoskeletal (MSK) injury assessment, the monitoring of soft tissue injury healing, guided interventions and player education and echocardiography, looking at the anatomical and functional aspects of the heart for cardiac profiling and surveillance.

The use of MRI for pre-signing medicals and injury assessment diagnostic procedures followed at 16%; then CT (2%) for accurate diagnostics and guided interventions; and finally X-ray (1%), usually for fracture diagnosis. Clinical considerations such as indication, ionising vs non-ionising and cost effectiveness of what modality to use is always key in our decision pathways, though we do have to bear in mind a number of other unique factors such as asset value of the patient concerned.

Cascading imaging research and advancing techniques

We are learning a lot at Manchester United Football Club from having an ultra-advanced diagnostic imaging centre. Yet this research and knowledge are not ours alone. Knowledge has the potential to be cascaded into the wider sporting arena and public health community. In addition to the daily and routine health surveillance of our players to monitor and manage injury and rehabilitation, there are several research projects underway that will have far reaching benefits around the globe.

Innovation in medical imaging is moving at a great pace as health ecosystems in the UK and further afield look for solutions to overcome capacity pressures. We too benefit from these advancements. Recent developments in the innovation and access to fast acquisition, post-processing capabilities and clearer resolution via high-end 3T MRI means that the number of regular ultrasound imaging procedures is curving downwards.

MRI helps to identify very minute intra-articular joint injuries, muscle oedema changes or very small fibre tears which have the greatest of implications in elite sports. It is also highly useful for cardiac screening for proactive health surveillance and for exploratory work into diagnosing and monitoring for Chronic Traumatic Encephalopathy (CTE)2. In contrast, the use of ultrasound as a physiotherapist's tool is on the increase, for example, to monitor tissue healing. Is this the future for football ultrasound? Time will tell, but it does offer increased research possibilities in muscle morphology, fascicle length assessment and potential associations with injury and performance.

Quick and low dose CT innovations are also very valuable in sports medicine. Motion CT is possible where we can get the athlete moving, and with 4D imaging we can see any indications

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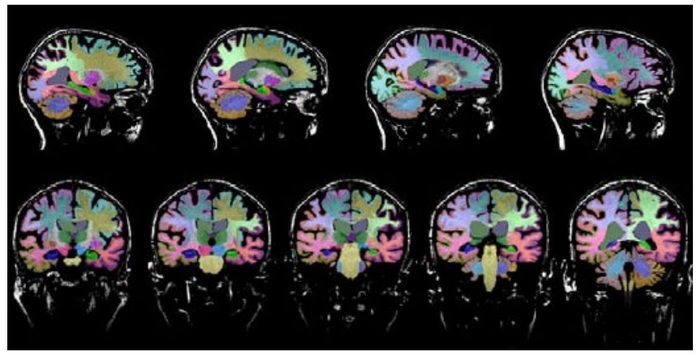

Fig.1 MRI has its place in sports health surveillance such as diagnosing and monitoring Chronic Traumatic Encephalopathy.

of instability, hypomobility, sublux-ations or maltracking in places such as the subtalar joint, the knee joint (patellofemoral), hip joints or acromio-clavicular joints.

3D and 2D imaging also facilitates measurements of joints and we can get useful dynamics to see how joints move and how the bones work together (Fig. 2). This combination of imaging information is particularly important in a sprain to see if the ligaments are holding it together or if surgery is required, or indeed, when there has been surgery to assess if it is all functionally stable before we put a player back out on the field.

Fig. 2 Dynamic CT shows joint motion that is important for assessing functional stability in strains.

Innovations in ultrasound are also creating benefits in the evolution of sports medicine. Superb Microvascular Imaging (SMI) is a recently developed vascular application that expands the range of visible blood flow and provides visualisation of low microvascular flow that has never before been seen in ultrasound. Compared to conventional Doppler technologies, the advantages of SMI are high frame rates, high resolution, high sensitivity and fewer motion artefacts. Muscle and tendon stiffness can also be examined in depth via compression and shear wave elastography technology on the latest diagnostic ultrasound systems (Fig 3 & 4).

Lastly, Virtual Reality (VR) and Artificial Intelligence (AI) will also have their parts to play moving forward as these innovations mature for application in sports medicine.

Fig 3. B-mode ultrasound image of the Achilles tendon

The future of yesterday's players

What more can we do? This is the question we are often asked. Further to the current attention on our youth and professional players, there is increasing focus on the retiring athlete and the issues experienced by our already retired club players, with questions raised about our duty of care.

Osteoarthritis, mental health and lifestyle choices are all topics in debate. Perhaps it may be that we will see exit health examinations using imaging systems in the future. This could include monitoring cardiac de-training effects, coronary atheroma screening, articular cartilage mapping, brain morphology and prostate screening.

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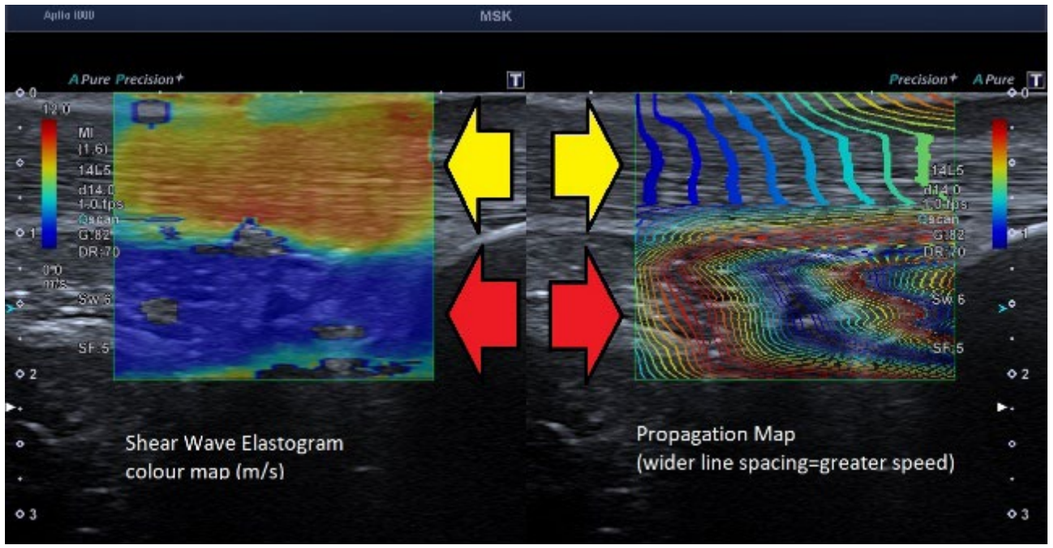

Fig 4. Ultrasound shear wave elastogram image of the Achilles tendon
Left side demonstrates colour mapping of the shear wave elastogram and the propagation map on the right. Wide spaces between the lines of the propagation map demonstrate a high velocity (fast propagation) shear wave (Yellow arrows). The red arrows depict tissues deep to the tendon (Kager fat pad), which have closer propagation lines and a corresponding lower velocity.