Toshiba Medical’s SportsMed Program
Delivering exceptional care to everyone.

Toshiba Medical Workshop: Saturday 13th May 13:00 – 14:30 at TRIBUNA
Role of Imaging in the Diagnosis of Injuries and Return to Play

Hear from the medical teams of Manchester United, FC Barcelona and Real Madrid, as they discuss the use and advantages of dedicated imaging centres in the diagnosis, treatment and clinical management of players.

From 13:00 to 14:30 Toshiba Medical’s workshop includes sessions on Ultrasound and MRI in Football Players, Pathways and Decision Process and there will be Q&A.

Chair: Ara Kasarian and Gil Rodas
Speakers: Luis Cerezal, Lluís Til, Xavier Alomar, Sandra Mecho, Ricard Pruna, Bryan English, Fabrizio Tencone, Jesus Olmo

Ultrasound and MRI Workshops at Toshiba Medical booth:
Learn from the experts, a hands-on opportunity.

<table>
<thead>
<tr>
<th>Saturday 13th May</th>
<th>Sunday 14th May</th>
<th>Monday 15th May</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 – 09:30</td>
<td>Upper Extremity Nerves</td>
<td>Ankle and Foot</td>
</tr>
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<td>Upper Extremity Nerves</td>
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<td>13:00 – 14:00</td>
<td>Workshop at TRIBUNA</td>
<td>Ankle and Foot</td>
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<td>13:30 – 14:30</td>
<td>Hip and Thigh</td>
<td>Hip and Thigh</td>
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</tbody>
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Fundamentals of MRI image acquisition & analysis

MSK MRI - advanced and emerging techniques to improve clinical practice.

Chair: Ara Kassarjian and Gil Rodas
Speakers: Luis Cerezal, Lluís Til, Xavier Alomar, Sandra Mecho, Ricard Pruna, Bryan English, Fabrizio Tencone, Jesus Olmo

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Coronal oblique PD FS image of a 17 year old footballer’s pelvis showing typical functional stress-related bone oedema in the pubic body bilaterally.

Ultrasound in Modern Sports Medicine

mSMI Hold image of patellar tendon with advanced proliferative proximal tendinosis

Musculoskeletal MRI in Football Medicine – essential, useful or too much information?

Ultrasound in Modern Sports Medicine

Hyaluronic Acid Protection of Cartilage

Superb Micro-Vascular Imaging – A new tool for the sports physician
Together, we complete the image.
Made for life

06
MRI User Meeting -
FC Barcelona, Spain

25
Clinical Experience with 4D Ortho Application

28
Medical testing at Lotto-Belisol: MoT for Professional Riders

36
Toshiba Medical’s SportsMed Program
13-15 May 2017, Camp Nou, FC Barcelona, Spain

25 Clinical Experience with 4D Ortho Application
TECHNOLOGY // COMPUTED TOMOGRAPHY // MUSCULOSKELETAL SYSTEM, POST PROCESSING // FROM VISIONS 25

28 MoT for Professional Riders
SPORTS MEDICINE // MEDICAL TESTING AT LOTTO-BELISOL // FROM VISIONS 24

32 Unique Imaging Combination Delivers a Winning Result On and Off the Pitch
SPORTS MEDICINE // MRI, CT AND ULTRASOUND // MANCHESTER UNITED // FROM VISIONS 22
Exploring MR Applications in Top Sport
Advanced Techniques in Musculoskeletal Imaging

Playing sports at the highest levels increases the chance of injuries, as the body is pushed to its limits, and sometimes beyond. High quality imaging can play a key role in managing the training and treatment of top athletes through optimization of training schedules and injury prevention, as well as revalidation after injury.

Specialists from all over Europe with an interest in top level sports were gathered to discuss this topic and were able to explore advanced MRI techniques in musculoskeletal imaging at Toshiba’s European MRI User meeting. The event was held in 2016 at the stadium of one of Europe’s top professional football clubs, FC Barcelona, in Barcelona, Spain. The meeting was organized by Toshiba in collaboration with the Clinica Creu Blanca Medical Center in Barcelona and Olea Medical – providers of advanced MRI and CT post-processing and visualization solutions.

Speakers at the event included a variety of researchers, radiologists and technicians, who shared results they have achieved in this field with Toshiba MRI systems and Olea Medical’s advanced software.

Decision-Making Based on Precise Results
Dr. Canal, Chief Medical Officer of FC Barcelona, pointed out the importance of advanced imaging techniques in his daily practice of managing treatment and training of top athletes. He explained the background of decision-making based on medical imaging. One of the physicians of the FC Barcelona Medical Team, Dr. Til, showed the results of MRI examinations on cartilage problems sometimes experienced by players.

Dr. Blasi from the University of Barcelona presented on the anatomy and histology of cartilage, muscles and tendons. To get the best views of these tissues, correct imaging protocols are crucial. Mrs. Ferrer, Radiographer at Clinica Creu Blanca Medical Center, and Mrs. Fernandes, from Toshiba Medical Systems in Spain, showed an extensive overview of optimal MRI techniques, pinpointing important issues with regard to optimizing 3D imaging.

Measuring the Impact of Top Sport
The effect of top sports on cartilage and the chondral charge was explained by Professor Gold from Stanford University, California, US. Dr. Bossy, from the Clinica Creu Blanca Medical Center, focused on muscle and tendon injuries and emphasized the importance of identifying the function of each muscle and tendon with regard to the total support structure. To explore the internal structure of peripheral nerves, Dr. Lefebvre, from Lille University Hospital, in France, showed high level diffusion images with tensor reconstruction.

Dr. Padrón, from the Clinical Centro, Madrid, in Spain, presented interesting cases on chondral and osteochondral injuries. The advanced diagnosis using quantitative imaging techniques showed that MRI is increasingly emerging from a qualitative technique towards quantifiable data that can easily be compared in follow-up examinations. From chondral pathology a small step was made into MR Hip imaging by Dr. Cerezal from Clinica Diagnostico Medico Cantabria, Santander, Mexico. Dr. Cerezal, who is an expert in hip pathology, shared a large variety of hip pathologies visualized with MRI.

Muscle and tendon injuries were also explored in the event. While Dr. Blasi from the University of Barcelona, explained the anatomy and histology of these important structures, Dr. Teixeira from the University of Nancy, in France, demonstrated how advanced imaging techniques can be used to observe all the features and characteristics of muscles and tendons.

Assessing Athletic Potential
Professor Derave from Ghent University, in Belgium, presented a novel Muscle Talent Scan Project. The ratio between different muscle types and their abundance is unique to the performance potential of an athlete in a specific sport. A 20 minute MRS scan can reveal the potential of an athlete. In addition, optimization of training schemes based on this knowledge could play a crucial role in injury prevention. Professor Gold Stanford University, California, US, also explored muscle velocity and the use of phase contrast to measure this.

Fusion Techniques
Dr. Til also demonstrated the technique of fusion MRI and Ultrasound modalities. Whereas problems are encountered in Ultrasound, due to limits to penetration depth caused by shading, the same is not incurred in MRI. However, MRI takes more time is less easily available. Through synchronized fusion of the images during live ultrasound scans, the operator can benefit from the best of both worlds, as demonstrated in a live demonstration.

Access to Advanced Knowledge
Through user meetings, Toshiba aims to provide its customers with direct access to specialists with experience in advanced techniques and applications of Toshiba’s technology that might be valuable in their own work. //
FC Barcelona unveils one of the most powerful magnetic resonance systems on the market

The FC Barcelona Medical Centre has, as a result of its agreement with Toshiba Medical Europe, some of the finest technology in the field of sports diagnosis. And now the facilities went one step further with the installation of a 3 Tesla nuclear magnetic resonance machine, the most powerful device produced by the Japanese medical technology firm. It will be used to diagnose muscle and bone injuries in athletes at greater speed and accuracy levels than ever.

The system will be operated by staff from Assistència Sanitària which, like Toshiba, is also an FC Barcelona sponsor, and will be used for the diagnosis, treatment and rehab of both professional and amateur athletes. Since the agreement with the football club was signed, Toshiba has already provided thirteen echography systems to the clubs medical services. Assistència Sanitària insurance policy holders will also be able to use the new machine, located in the Medical Centre at the Ciutat Esportiva Joan Gamper training ground.

Toshiba Medical’s New Ultrasound Advances Elite Sports Medicine at ‘Stade Toulousain’ Rugby Club in France

Toshiba Medical is sponsoring the ‘Stade Toulousain’ rugby union club from Toulouse in France – one of the best rugby clubs in the world - with a Toshiba Medical Aplio i800 ultrasound system.

With the state-of-the-art ultrasound system installed at the club’s training center, it will have new possibilities to diagnose and treat any musculotendinous or osteoarticular injuries that their players might incur.

The Aplio i800 ultrasound system will help to enhance injured players rehabilitation programs. Its advanced technological capabilities will help ensure that healing is complete before players return to the field.

The system is also attracting the interest of many global specialists, and positions the Stade Toulousain’ rugby union club as a global center of expertise in Elite Sport Medicine.

Toshiba Medical Supports Major Global Sports Events in France

Toshiba Medical sponsors a ‘Mobile Medical Center’ for several top level, global, sporting events including the Dakar Rally, Tour de France, African Cup of Nations and BMX European Cup.

Equipped with the Toshiba Medical CT ‘Activion 16’ and soon also with an Aplio Ultrasound system, the mobile medical center carried out more than 3,000 radiographs and more than 250 Ultrasound scans during events in 2016.
Last year Toshiba announced a strategic partnership with The Advanced Wellbeing Research Centre in Sheffield, United Kingdom. The partnership will see Toshiba providing state-of-the-art diagnostic imaging equipment and wearable biosensors as well as ongoing consultancy with regard to application innovation and development for AWRC applied research.

Much of the research expertise will come from research teams that helped the Great Britan Olympic Team achieve 24 medals in London 2012 and will integrate into the National Centre for Sport and Exercise Medicine that seeks to improve people’s lives through physical activity.

Toshiba will also supply World class diagnostic imaging equipment including its Aquilion ONE™ dynamic volume CT system, which will allow researchers to successfully collect images of athletes’ and patients’ entire organs in one rotation. The imaging equipment comes with dynamic volumetric acquisition protocols that can be used to review moving joint structures in 3D, as well as dynamic blood or air flow that will see Toshiba consultants partnering with AWRC researchers to develop applications and best practice guidelines regarding the early diagnosis, improved rehabilitation and preventative care for those that are exercising both at elite athlete level and for the local community and wider public.

Professor Steve Haake, AWRC Director, comments: “We are delighted that Toshiba has become AWRC’s first industry partner joining Government’s backing. Media articles about overweight children, rising levels of obesity and diabetes appear in a newspaper almost every day. Most recently the World Health Organisation reported that nearly three quarters of men and two thirds of women in the United Kingdom will be overweight by 2020. That’s less than 5 years away!

“Sedentary behaviour and a stream of rich food can lead to all sorts of problems appearing in our lives as chronic disease. This was highlighted by a 2011 report for the Department of Health, which showed that increasing physical activity could reduce the risk of type II diabetes and colon cancer by up to 50%, heart disease and stroke by up to 35%, depression by 30% and the other scourge of our day, Alzheimer’s disease, by 30%”.

“With these statistics and predictions in mind, the Advanced Wellbeing Research Centre has been set up to become the most advanced research and development centre for physical activity in the world, creating ‘innovations that help people move’ in sport, healthcare, physical activity and leisure”.

Acting as a hothouse of innovation, the AWRC will bring together a set of industry partners who manufacture and supply technology and equipment including apps, activity loggers, sports equipment, orthotics, and clinical devices. The main focus of the AWRC research and innovation will be on how technology is used, how people interact with technology that helps them become more physically active, and how improvements in physical health are captured and monitored in order to provide an evidence base regarding the positive impact of physical activity on health.

Projects will aim to find out what works in large populations, initially using the population of Sheffield as a field laboratory. Additionally, the AWRC is set to become a critical assistance partner for the National Health Service by providing an evidence base that proves the positive impact of exercise on the health of the population in the United Kingdom.

Mark Hitchman, Toshiba Medical’s UK Managing Director comments: “Our partnership with AWRC forms a critical part of Toshiba’s strategy to invest and partner in research projects that will have considerable benefits to NHS efforts and the population in the United Kingdom at large.

“AWRC will target wide swathes of the population, from those who are completely sedentary to those who are most active; from young to old, from those in the most deprived communities to those in the most affluent; from those at home to those in work, in education or in elite sport.

“Toshiba’s imaging equipment and exercise monitors will play a crucial role in identifying and understanding the positive effects of exercise on health, whilst helping to provide accurate diagnoses and recovery paths for those that are injured.”

As well as the AWRC, Toshiba’s radiology equipment is powering not just some of the leading medical institutions, but also some of the World’s leading sports organisations and community-based sports facilities such as Manchester United Football Club, FC Barcelona, Barnet Football Club, The Tessa Sanderson Foundation and Academy and the recently held 2014 Glasgow Commonwealth Games. 

References
1 http://dx.doi.org/10.5402/2011.459636
In 2016 Toshiba Medical UK announced the launch of a formal partnership between the Tessa Sanderson Foundation and Academy (TSFA), Homerton Hospital and the Sir Ludwig Guttman Health and Wellbeing Centre. The partnership sees sports injury and musculoskeletal specialists from two nationally-renowned centres of sports medicine excellence using state-of-the-art medical imaging technology within a sports foundation to manage athletes’ health and wellbeing.

Toshiba Medical partners with Real Madrid

Toshiba Medical has signed a four-year contract (2016-2020) with Spain’s Real Madrid football club to be its official medical systems partner.

Through this partnership, Toshiba Medical will cooperate with the medical staff of the club to maintain the players’ peak physical fitness, so that they can perform to the best of their abilities. Provision of a state-of-the-art medical support environment at the club will help to protect players from injury, assist with diagnosis of any injuries, and support rehabilitation. Toshiba Medical will provide cutting-edge medical systems at Real Madrid’s medical facility.

The six advanced diagnostic imaging systems to be installed at the facility include Toshiba Medical’s 3T Vantage Titan™ Magnetic Resonance Imaging system, Aplio™ 500 Platinum Series and Aplio™ 300 Platinum Series Ultrasound systems, and a Mobirex™ Radiology system.

Real Madrid competes in the Premier Division of the Spanish football league. It is one of the world’s leading football clubs and has been recognized by FIFA (the Fédération Internationale de Football Association) as the best club of the 20th Century. Last season, Real Madrid won the UEFA (Union of European Football Associations) Champions League. It was the 11th European Championship Cup for the club.

Toshiba Medical UK announced the UK’s first of its kind medical imaging Academy at Barnet FC

Toshiba Medical and Barnet FC bring world class radiology equipment and services to elite athletes, radiology professionals and the local community through an advanced medical centre and Medical Imaging Academy based at The Hive. Toshiba Medical and Barnet Football Club are developing an advanced medical centre that will provide elite footballers, athletes and the wider community with world class radiology equipment and access to faster treatment options from Barnet FC’s facilities at The Hive. At the same time, the new medical centre will house the UK’s first integrated Medical Imaging Academy for radiology professionals, run by Toshiba Medical. It will be the first of its kind in the UK, providing the medical community with a centre of excellence for radiology education, including CT, MRI, Ultrasound and general X-Ray equipment and clinical applications.

Tessa Sanderson Foundation and Academy joined forces in 2016 with Homerton University Hospital, the Sir Ludwig Guttman Health and Wellbeing Centre and Toshiba Medical

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Toshiba Medical partners with Manchester United Football Club to aid in the prevention and management of injuries via leading-edge imaging that supports accurate diagnosis and treatment. Through high performance partnerships such as these, Toshiba Medical aims to assist in the transfer of knowledge and expertise that allows everyone to maximize their sporting enjoyment, whether amateur or professional.

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Musculoskeletal MRI in Football Medicine – essential, useful or too much information?

Dr Steve McNally

In the higher echelons of professional football, where financial resources are greater, the use of MRI as a diagnostic aid has been prevalent for the past 20 years. However, it has not always been employed as part of a validated clinical process with scans being requested sometimes for political reasons or simply in response to player/coach demand. The potential ramifications of MRI findings can go far beyond clinical management and affect transfer fees, player asset value, contract terms and conditions, insurability and medicolegal matters.

Radiologists reporting ‘abnormal’ findings can have detrimental effects on player wellbeing or confidence (or that of his/her therapist) leading to over-caution in training or rehabilitation and subsequent reduction in performance or athletic development. Clinical experience and scientific research show that many such ‘abnormal’ findings are in fact adaptive or developmental in response to the physical and biomechanical stresses of the sport and whilst they need to be recorded and noted once a player has been subjected to MRI examination, the interpretation by the referring practitioner is key as is subsequent communication to the player.

When interpreted within context by experienced sports physicians, therapists and radiologists working as a team, MRI can add great value if applied at appropriate times and situations as an adjunct alongside good clinical management. The advent of newer MRI techniques has increased diagnostic and screening/profiling possibilities and the development of functionally relevant protocols and sequences could enhance player care even further. Caution will be needed in how imaging information may be interpreted and potentially misused by those with business interests rather than patient welfare. This article will give an overview of musculoskeletal MRI as utilised in professional football though MRI is also becoming more widely used in the assessment of players from a cardiological and neurological perspective.

Clinical Relevance

Injury diagnosis

The majority of clinicians in professional football will not refer a player for MRI in the early stages of injury assessment partly because it is unlikely to change their immediate clinical management and also because their budgetary resources will not permit it. Amateur and recreational players are only likely to be referred for MRI if they have a significant injury and have been referred on to secondary care specialists such as orthopaedic surgeons.

Conversely, at top professional levels there is often increased pressure from the player and the manager/coach to give an immediate prognosis for an injury (‘when will I be back, Doc?’) and MRI has become fashionable as having a key role in that diagnostic and prognostic decision-making process. I have experienced situations where players have demanded a scan within minutes of leaving the pitch with muscle pain and whilst there are some infrequent indications for early MRI following a significant trauma it is often

Figure 1: Coronal oblique PD FS image of a 17 year old footballer’s pelvis showing typical functional stress-related bone oedema in the pubic body bilaterally.
better to wait for the clinical picture to evolve and to allow the necessary physiological response to injury to occur in order that MRI can detect relevant pathological findings (oedema/haemorrhage, etc.). The timing and sequences applied will therefore depend on many factors such as player age, nature of trauma, time since trauma and suspected tissues involved. Player and coach education in these aspects is important as a means of managing the immediate situation which understandably causes anxiety in highly driven and motivated individuals who will be anxious about future results, performances, careers and the financial and personal implications of an injury. The more widespread use of ultrasound scanning by sports team physicians over recent years has been very helpful in appeasing players/coaches and in alleviating such anxieties whilst also being clinically useful as it is easily applied, relatively cheap and allows daily monitoring of injury evolution. MRI added to that combination at the right time with the right sequences and the right interpretation within context is often very valuable.

### Joints (bone, cartilage ligament)

Traumatic injuries to the knee, ankle and midfoot joints are very common in football, predominantly in the form of ligament sprains/ruptures; overuse injuries can affect those joints but also the lumbar spine, hips and pubic symphysis. Shoulder, elbow and wrist injuries are less common but are often significant when present, including dislocations, subluxations, fractures and loose bodies. Whilst X-rays still play a role as the primary investigation for the suspected fracture and ultrasound can be of use in superficial bony and ligamentous lesions, MRI is the go-to modality for the complete assessment from an imaging perspective in joint injury, particularly if there is associated joint swelling (effusion or haemarthrosis) and/or clinical signs of instability.

As football is an inherently ‘traumatic’ sport in terms of mechanical joint loading and from contacts with the ball and other players, a diligent radiologist will report many ‘positive’ findings on MRI scans many of which may be noted but disregarded by the team physician when evaluating a player. Many such MRI findings represent normal adaptation responses to the demands of the sport or the stage of skeletal maturity of the player and are not necessarily pathological. Examples include transient marrow oedema in the pubic bones of an adolescent player (Fig. 1) or thickening of the medial collateral ligament of the knee in response to repetitive kicking and tackling actions. Other findings previously thought to be less significant radiologically such as ‘bone bruises’ following contact trauma are now taken more seriously and have been re-termed as micro-trabecular fractures in recognition of the underlying pathology (Fig. 2).

In my experience, MRI appearances ‘over-grade’ the severity of superficial ligament injuries when compared to a combination of clinical and ultrasound examination findings. Nevertheless MRI is essential to confirm the severity of deeper or internal joint ligament injuries such as knee cruciate ligament injury, particularly if the clinical signs are inconclusive (Fig. 3). MRI is the gold standard for imaging articular cartilage and meniscal cartilage injury, both of which may be acutely traumatic or chronically degenerative in origin in footballers or may occur in combination with ligament injury (Fig. 4). Bone marrow oedema on T2 or STIR sequences may indicate metabolic activity in an injured region such as the pars interarticularis of a lumbar vertebra or proximal shaft of a 5th metatarsal bone.

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Figure 2: Axial PD FS image of a footballer’s right knee showing a bony contusion in the medial proximal tibia due to a stud impact injury.

Figure 3: Axial & sagittal PD FS images of a footballer’s right knee showing subtle oedema in the posteromedial bundle of the posterior cruciate ligament in keeping with a grade 1 sprain (green arrows).
in the foot (common stress fracture sites in footballers). Marrow oedema may persist long after functional recovery and bone loading capacity has returned so its presence must not be the sole arbiter of a return to training activities (Fig. 5).

CT scanning has some advantages over MRI when assessing certain bone and joint injuries and both may be needed in combination to fully evaluate a hip impingement or lumbar spine stress fracture. The increasing image resolution afforded via 3T MRI imaging, however, is of great value when safely screening or profiling young footballers for anatomical factors that might predispose them to typical football injuries, e.g. hip adductor muscle strains associated with pubic symphiseal or sacroiliac degeneration or CAM/pincer-type hip dysplasia (Fig. 6).

Muscle/tendon MRI is most useful for differentiating between the ‘MRI-positive’ (i.e. oedema, haemorrhage +/- structural disruption) and the ‘MRI-negative’ (i.e. no oedema, haemorrhage or structural disruption). High resolution ultrasound scanning in combination with clinical history and examination is sufficient in most cases to confirm structural injury but can be less helpful in confirming a functional injury where subtle muscle oedema may be present. MRI can be ‘over-sensitive’ with regard to muscle oedema causing dilemmas for the treating practitioner when determining the pathological from the normal reactive increase in lymphatic and vascular fluid post-exercise. Timing of MRI examination after clinical presentation is therefore important. 24 to 48 hours is generally accepted as sensible practice to reduce the risk of false negatives or positives by scanning too soon. The widely used Peetron’s grading system to describe muscle oedema and structural disruption is being superseded by alternative classification systems bespoke to athlete muscle evaluation as they are deemed to be more specific or relevant to clinical decision making. These include classifications based on MRI appearances alone or those based on combining clinical presentations and examination findings with ultrasound and/or MRI appearances (Fig. 7 & 8).

Debate exists as to the validity of MRI in determining key factors for the player, therapist and coach such as prognosis and return to play decisions and there is no doubt that injured muscles can remain ‘MRI-positive’ for some time after functional recovery and return to play has been achieved. Whilst the scientific research may not always be conclusive, experiential practice supports the use of MRI for accurate anatomical location and structural integrity assessment in key muscle injuries such as quadriceps, hamstrings and calf as the information gleaned can influence rehabilitation programmes in order to restore full performance whilst minimising re-injury risk. MRI may be the only way of identify deep groin/pelvic muscle injury in footballers that is beyond the depth of view of ultrasound scanning.

Footballers’ tendon injuries are readily amenable to assessment by ultrasound in view of their relatively superficial location (patellar, Achilles, peroneal, tibialis posterior being those most often affected). The higher spatial resolution, the ability to assess dynamically

Figure 4: Axial STIR images of the 5th lumbar vertebra in a 20 year old footballer showing bilateral bone marrow oedema in the pars/pedicle region preceding eventual stress fracture formation.

Figure 5: Localised residual oedema in the same player’s right pars/pedicle region 8 months later (2 months after a return to full training).

Figure 6: Coronal PD FS image of an 18 year old footballer’s left hip showing CAM-type femoral head configuration with associated labral tear from repetitive impingement during kicking and running actions. Note the presence of pubic symphiseal degenerative changes, a common associated finding.
and with Doppler/Microvascular Imaging and Elastography/Tissue Characterisation make ultrasound the modality of choice in most cases but MRI can add value when assessing the musculotendinous junction particularly if structural injury is very subtle or when examining longer tendons that follow a convoluted course (e.g. peroneus longus/flexor hallucis longus). Newer MRI techniques (ultra-short TE sequencing) may begin to tilt the balance more in favour of MRI.

**Screening/profiling**

It is difficult in many clinical settings to justify the use of MRI as a screening tool if the word ‘screening’ is utilised correctly within context of the Wilson-Jungner criteria (see below).

1. The condition sought should be an important health problem.
2. There should be an accepted treatment for patients with recognised disease.
3. Facilities for diagnosis and treatment should be available.
4. There should be a recognizable latent or early symptomatic stage.
5. There should be a suitable test or examination.
6. The test should be acceptable to the population.
7. The natural history of the condition, including development from latent to declared disease, should be adequately understood.
8. There should be an agreed policy on whom to treat as patients.
9. The cost of case finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole.
10. Case finding should be a continuing process and a not “once for all” project.

In an elite football club setting, however, the relative definitions of terms such as ‘important health problem’ and ‘economically balanced in relation to medical care as a whole’ will be viewed differently and MRI becomes a more acceptable screening tool for certain conditions. In reality there is insufficient scientific evidence to meet some of the other criteria such as ‘latent/asymptomatic early stages’ and ‘recognised treatment pathways’ and the players expect their healthcare and performance optimisation to be managed on an individual basis albeit within a team ‘population’ setting. In view of that I prefer to avoid the term ‘screening’ and replace it with ‘profiling’ as that enables the individual player to be compared to himself over time (injury surveillance) or against a group which can be defined in many ways (age, ability, playing position, etc.). MRI can be a powerful addition to all the other aspects of health and performance profiling that medical & science professionals can undertake on footballers.

Examples of such profiling include body composition assessment, muscle length, cross-sectional area and volume, skeletal maturity that can be specific to areas relevant to football such as pelvis and knee joints as opposed to standardised wrist imaging for skeletal age estimation. Emerging techniques utilising 3T MRI can assist with profiling muscle fibre type and joint cartilage composition via non-invasive means which makes the assessment very acceptable to the athlete patient.

Since access to players for screening/profiling purposes can be difficult to obtain, having a dedicated MRI facility close to hand is essential. However, there is usually one opportunity to profile a player when he/she joins the club (although the nature of the transfer system can also make that very difficult at times).

**The ‘Signing/Transfer’ medical**

The common perception portrayed by the media is that footballers either ‘pass’ or ‘fail’ their transfer medicals when joining a new club. As there are no legislative or industry-defined criteria for fitness to play professionally this is not strictly true. Each scenario will be different depending on the context of the transfer and this might be influenced by the duration of the proposed contract, the size of the transfer fee, the terms and conditions of the contract and financial aspects such as salaries and agent’s fees. The process is more one of risk assessment and an opportunity to gather baseline information in order to assist with the player’s subsequent medical care should he/she join the club. Whilst a transfer medical can be likened to a pre-employment medical where the initial duty of care is to the employer, a duty of care is also assumed towards the player whether...
he eventually signs or not, particularly if adverse findings are detected. MRI scanning can therefore be very informative but also fraught with ethical and medicolegal issues in such circumstances.

One of the major limiting factors in transfer medicals is time available, particularly if it takes place near the end of the transfer window periods. MRI scanning is usually the most time-consuming aspect of the medical assessment, even if limited sequence protocols are employed, and it might be impossible to include MRI if a transfer takes place in the final hours of ‘deadline day’. Whenever possible it is our policy to include a limited sequence protocol examining lumbar spine, pelvis, hips, knees and ankles with additional sequences if clinically indicated from history and physical/functional examination. The scanning time needed is around 2.5 hours plus any transport time if this has to be undertaken at a remote facility. It’s a long time for a player to be on the scanner table so maximising comfort and minimising sequence time is essential for full compliance and a positive ‘first experience’ for the player at his/her intended new club.

Although there is no consensus amongst football medics regarding the value of transfer medical MRI and many medicals take place without them being performed, it seems logical that the more information one is aware of when investing in a high value player the better, especially with regard to the detection of asymptomatic or subclinical pathology. Evolving articular cartilage lesions in joints or painless degenerative tendinosis might not cause a problem but could also be performance-limiting and potentially career-threatening; knowing about their presence in advance can help by modification of training loads and initiation of preventative programmes as part of asset management. MRI provides a baseline checkpoint which can be referred back to for comparison if needed.

As decisions, risk assessments and recommendations are usually required immediately after completion of the medical examinations it’s vital to have experienced radiologists available 24/7 to report and discuss within clinical and functional context. In high value transfers it is not unusual to undertake ‘double reporting’ to seek a range of unbiased opinion.

‘Performance’ imaging
In addition to standard anatomical MRI, post-processing applications can visualise structures in a more impactful manner (e.g. fat and lean mass) and quantify muscle tissue dimensions and volume. This can be very important for monitoring results of conditioning or rehabilitation programmes when comparing the player to him/herself or to a population of players who have been profiled in a similar manner.

MRI spectroscopy can be utilised to measure amounts of substances key to muscle function or fibre type composition, e.g. carnosine content is closely related to the proportion of fast-twitch fibres a player has within the muscles. This can have implications for his/her genetically-determined performance potential, prescription of training programmes and recovery strategies post exercise (Fig. 9).

Compositional assessment of joint cartilage is an exciting new development for football medicine as it has the capacity to detect microstructural and biochemical changes within the articular cartilage before eventual structural defects become apparent on standard MRI. Whilst many players are able to play professionally with established articular cartilage defects this pathology is one of the major career-limiting factors for a footballer if hip, knee or ankle are affected. Even if able to play without recurring joint pain, swelling or mechanical dysfunction, secondary injury or performance impairment is likely due to associated muscle inhibition or protective hypertonicity. The ability to detect pre-symptomatic changes in the cartilage by quantitative T2 mapping may facilitate early implementation of preventative strategies thereby prolonging athletic performance and the long-term health of the joint beyond the playing career.

1.5T v 3T
Although scanning with a 3T rather than a 1.5T scanner will not alter the subsequent clinical management in the majority of cases of typical football injury, 3T does offer advantages in terms of reduced scanning time (and hence patient comfort and acceptability). If time is no issue, better image quality is possible particularly for smaller joints such as the foot or wrist where subtle ligament or joint injury might otherwise go undetected. The radiographer and radiologist

![Figure 9: Spectroscopy of soleus muscle to assess carnosine content as an indicator of type 2 ‘fast-twitch’ muscle fibre proportion.](image-url)
will need to amend their 1.5T techniques and some time may be required to fine-tune a 3T scanner to the area under examination. The effort will be worthwhile leading as it leads to beautiful images. Findings that previously were impossible to detect need to be interpreted carefully in conjunction with the treating sports physician. Another advantage of 3T MRI in the sports medicine setting is that emerging technologies such as those described above for performance profiling are more readily applicable in higher field strengths.

**Summary**
As the physical demands of professional football and the financial investments in the industry continue to increase year on year, the pressure on club medical & science teams to maintain their players in top condition also increases. Some injuries are inevitable and the aim then is to return the player to the pitch at the required performance level with minimised risk of re-injury in the shortest possible time. MRI has a role to play in that overall process and it will continue to evolve as technologies develop and practitioners become familiar and confident in applying them within this unique area of sports medicine.

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Red Bull sponsors various football and ice hockey clubs. To promote talented young athletes in these two sports, Europe’s most state-of-the-art athletic academy was opened in Salzburg-Liefering two years ago. Some 400 young athletes are being trained and fostered at the Academy, the site of a former harness racing track. The Red Bull Football and Ice Hockey Academy can only be described using superlatives: In only 21 months’ time, seven football fields, an indoor arena and two ice rinks were built on the 100,000 square meter property. There is approximately one instructor for every 10 young athletes. The athletes are housed dormitory style, in 88 double rooms. An activity park, ice hockey dry training centre, multi-purpose hall, body-building gym and regeneration area are all available to the athletes around the clock.

Imaging in modern sports medicine

Two team doctors, affectionately called ‘Doc’ by their charges, look after the players’ physical well-being and handle the performance diagnostics. They are assisted in this not only by a team of massage and physical therapists but also by the Xario 200. “Those who deal in-depth with the technical possibilities of ultrasound know that near MRI quality can be achieved with it for many applications,” agree team doctors Dr. Jörg Eichinger, cardiologist and Dr. Thomas Hoffelner, injury and sports traumatologist. “Muscle fibre injuries are practically our daily bread and can be perfectly covered with the Xario 200,” says Dr. Hoffelner, expert in diagnosing and treating the entire musculoskeletal system, praising the device. Dr. Eichinger knows the Xario 200 from his practice: “I had good experiences with it. Here at the Red Bull Football and Ice Hockey Academy, we acquired additional ultrasound machines for soft tissue which I had not used before for my cardiology patients. Because using the device is easy and intuitive, learning new techniques is not difficult,” says Dr. Eichinger. And the cardiologist knows what he’s talking about, since he tested six different devices by various manufacturers and ultimately chose the Xario 200 by Toshiba.

Team Doctor Dr. Hoffelner has noted major differences in terms of display: “We still have a predecessor model at the clinic, and the difference is quite noticeable. Precision Imaging and ApliPure™+ produce exceptionally clear images that show each individual...
“When an injury occurs, we can very quickly determine whether and which treatment is needed.”

Dr. Jörg Eichinger

lesion, clearly demarcated,” says the sports traumatologist, adding: “For our applications when examining our players, it’s important for the results of the exams to be accurate and available very quickly. We can use ultrasound for everything from cardiac problems to the stomach to the lower leg muscles. QuickScan automatically optimises the image with a simple push of a button, which not only saves time but also allows for uninterrupted, seamless work processes.”

Easy documentation

The fitness status of the football and ice hockey players is documented multiple times during the performance diagnosis. “Saving the various images that are available with a push of a button is necessary in order to obtain reference values. For muscle injuries, in particular, it’s important to see the images side by side”, says Dr. Hoffelner. Once per year, all the athletes of the Red Bull Football and Ice Hockey Academy undergo an medical examination, and the football and ice hockey A-teams have additional exams if they have acute symptoms. “Before contract conclusion, all new athletes come in for routine fitness checks, which also includes a heart ultrasound,” says Dr. Eichinger. But it’s during the matches that the Xario 200 really proves its worth - in “real time”: “When an injury occurs, we can very quickly determine whether and which treatment is needed. For young players, especially, we’re trying as much as possible to use diagnostic means that avoid radiation exposure,” both doctors agree. It’s clear the Xario 200 is in the lead 1:0!

“Muscle fibre injuries are practically our daily business and can be ideally covered with the Xario 200.”

Dr. Thomas Hoffelner
Hyaluronic acid protection of cartilage

Xavier Alomar MD

A 42-year old marathon man, healthy and asymptomatic, runs a marathon every 15-30 days. The patient underwent a MRI exam of both knees one month before a marathon and another after the injection of hyaluronic acid (4ml high density) in the articular left knee and performed a marathon of 45 km. This preliminary study intends to assess the protective effect of the hyaluronic acid injection in the patellar cartilage during a long and loading effort. The MRI protocol includes axial spin-echo T2 mapping sequence (TE=24.8, 37, 49, 62, 74.4, 90 ms, Slice thickness=3mm, TR= 2000 ms, FOV=14x14, Matrix=320x192).

Post-processing and analysis
MRI manufacturer post-processing was first performed study by study, but it was difficult to assess the value variations in the cartilage, due to signal intensity changes in this area. Post-processing was then performed on a dedicated workstation (OleaSphere®) which allows to assess quantitative measurements of T2 map computed using a Bayesian approach and to visualize the T2 maps from two different dates (before and after running). T2 mapping is intended to measure the transverse relaxation from a spin-echo sequence, and T2 parameter being very sensitive to noise and sampling, the Bayesian probability theory is used to estimate this parameter.

Automatic co-registration of both exams was applied based on the femur localization. Since the patella moved between the two exams, a manual adjustment was done to match the cartilage zone.

Figure 1: left knee. The middle image shows T2 map before running. The right image shows T2 map after hyaluronic acid injection and 45 kilometres of running. The left map shows the subtraction of these two dates.

Figure 2: right knee. The middle image shows T2 map before running. The right image shows T2 map after 45 kilometres running. The left map shows the subtraction of these two dates.
Subtraction maps were computed to assess value changes for both knees. Quantitative values allow to confirm and quantify post-effort lesion.

**Image findings**

A dissection of medial patellar cartilage of the left knee is observable, water was trapped in the crack and the T2 maps values increase. The subtraction map shows no significant changes on T2 values in the lateral patellar cartilage and minimal changes in the crack. The right knee did not undergo injection, the subtraction map clearly shows higher T2 values than those of the left knee that suggests an increase water proportion in the matrix.

The comparison of both subtraction maps from T2 maps before and after running confirms the separate analysis done previously. Focal regions of interest (ROIs) containing thirty five pixels (7mm2) were drawn in the central patellar cartilage of the left (ROI1) and right (ROI2) knees and a significant difference was remarkable (ROI1=2.23; ROI2=7.58) (Fig. 3).

In addition, free hand ROIs surrounding the cartilage were drawn in the left (ROI3) and right (ROI4) knees and they also show a major increase in values of the subtraction map of the right knee, compared to those of the left knee (ROI3 =1.95; ROI4=5.57) (Fig. 4).

**Discussion**

The cartilage in joint areas helps to absorb the strengths and share the loads supported by the joints. These structures supporting repeated loads for many years can be broken, but their degeneration always comes before. The consistency of these structures changes but without any modification of their morphology or their size.

T2 mapping sequences are commonly used to quantify the grade of the edema and the alteration of connective tissues, part of the cartilages in the human body. Therefore, the degree of chondral degeneration can be measured before its breakage.

In order to assess the efficiency of a treatment intended to repair or protect the articular cartilage, it is essential to undertake a longitudinal study, using images that quantify the chondral damage prior and post-treatment. Measuring the signal variations in the cartilage using ROIs is very complicated. That is why subtracting images from two different exams is very useful to assess the changes in the cartilage composition. Such technique helps to rapidly, simply and objectively quantify the effects of the different chondral therapies. Figures and statistical works allow to demonstrate their efficiency.

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Figure 3: subtraction maps from T2 maps before and after running of right and left knees with focal ROIs in the central patellar cartilage; axial T2 series of right and left knees after running.

Figure 4: subtraction maps from T2 maps before and after running of right and left knees with free hand ROIs surrounding the cartilage; axial T2 series of right and left knees after running.

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

Dr Steve McNally

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/musculoskeletal 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
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.

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**Figure 3:** cSMI of periosteal neovascularity in tibial sesamoiditis

**Figure 4:** cSMI of periarticular/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 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. //
Clinical Experience with 4D Ortho Application
Dynamic CT Post Processing of the Musculoskeletal System

Pedro Augusto Gondim Teixeira MD, PhD, Alain Blum MD, PhD

Motion is frequently involved in the pathogenesis of musculoskeletal diseases. With static imaging methods, the diagnosis of dynamic pathology (e.g. friction and impingement syndromes) is based on secondary findings only. This fact and the frequency of these conditions underscore the importance of dynamic imaging modalities in the evaluation of musculoskeletal diseases. Wide area-detector CT is suited to dynamic study of joints, allowing volumetric study of bone and intra-articular ligaments during physiologic motion or under stress maneuvers.

Dynamic CT is complementary to other dynamic methods, helping overcome some of their limitations, such as evaluation of bony and intra-articular structures with ultrasound or superimposition of structures on fluoroscopy. Dynamic CT is most frequently used for the evaluation of the wrist, but can be used on various joints (shoulder, hip, elbow, knee, and ankle).

Up until now, the analysis of dynamic CT images was mostly subjective. Without specific tools quantitative analysis is time consuming and poorly reproducible, since measurement points must be selected manually on each acquisition volume (e.g. eight to ten per maneuver). Although subjective analysis of dynamic data is helpful in individual cases, developing general diagnostic criteria and scientific evaluation of the diagnostic performance with this method are hampered by the absence of quantitative data.

When performing musculoskeletal dynamic studies, a single motion or maneuver should be imaged per acquisition to avoid parasite motion (e.g. accessory motion distinct from target motion), which can complicate image interpretation. Parasite motion can be reduced by patient training and appropriate immobilization during acquisition, but complete suppression is difficult to achieve. When significant parasite motion is present, motion of one bone has to be evaluated relative to other moving structures, which may lead to diagnostic errors and makes the learning curve for the analysis of dynamic CT studies particularly long.

The 4D-Ortho application has two features that greatly improve analysis of dynamic joint studies by limiting the impact of subjectivity and parasite motion. Firstly, distance and angular measurements throughout the motion cycle can be obtained semi-automatically. Secondly, all motion can be displayed with respect to a given bone, which remains fixed or locked. Preliminary clinical testing of the 4D-Ortho tool is presented below.

**Basic principles**

Musculoskeletal dynamic CT is performed by acquiring multiple, low-dose volumes of the target zone during motion. The 4D-Ortho application is based on the registration of each individual bone of the body part examined in all the acquired volumes. This is possible because, regardless of their respective position, bones are non-deformable structures. Once this process is completed, any point of any bone can be found automatically in all acquisition volumes.
4D-Ortho works as follows: All the volumes of a given dynamic acquisition are loaded. Multiplanar and a 3-D volume rendered images are displayed. Time controls allow the examiner to browse the images from all the volumes acquired. The examiner may then select a bone to be locked by placing a seed point anywhere within its medullary cavity (Fig. 1). Any bone can be selected - the target bone may vary depending on the evaluated pathology or the maneuver performed. After processing, all motion is displayed with respect to the locked bone, greatly reducing the influence of parasite motion.

Independently of the bone locking procedure, distances and angles can be measured with 4D-Ortho. The points selected for the measurement are plotted automatically to all volumes, increasing measurement reproducibility and greatly reducing post-processing time. To measure a distance, the volume that depicts the greatest distance between the points to be measured must be selected. Then, using multiplanar and/or volume rendered reformats, the points to be measured are selected. The selected point must be placed in the cortical bone near the bone surface, as opposed to the medullary cavity. Processing is launched, and once completed, the distances between the selected points throughout the motion cycle are displayed in a graphic (Fig. 2). The same procedure is applicable for angular measurements. By selecting two points within a bone and two points in another, two lines are created. The angle between these two lines can be measured automatically in all acquisition volumes (Fig. 3).

**Clinical experience**

Since 2008, dynamic CT has been performed in our institution for the evaluation of musculoskeletal diseases. Wrist and ankle dynamic CT studies performed routinely were post-processed using the 4D-Ortho application. A total of ten studies were included in this analysis. All studies were performed with a 320 detector-row CT scanner (Aquilion ONE™, Toshiba Medical Systems, Otawara, Japan) using intermittent acquisition mode with a one second inter-volume interval. Acquisition lasted 8 to 12 seconds. Tube output parameters were adapted to patient anatomy. In the wrist, radio-ulnar deviation was performed and in the ankle, prono-supination of the foot.

Bone locking was possible in all cases and improved visual analysis markedly, by reducing the influence of through-plane motion. In our opinion, the use of a static reference for motion analysis allows a...
better appreciation of the amplitude of the target motion and improves the analysis of each individual moving bone.

Distance and angular measurements were feasible in all patients allowing quantitative analysis of clinical data. Measurement post processing may fail if the selected points are within areas of prominent motion artefacts, which should be avoided by optimal patient training and immobilization.

**Discussion and conclusion**

4D-Ortho was successfully used in the evaluation of clinical data, offering reproducible, semi-automatic measurements of distances and angles. Musculoskeletal dynamic CT is a relatively new technique and its clinical application is just beginning. Quantitative analysis is of great importance for the dissemination of this technique, since it facilitates the establishment of general diagnostic criteria that currently remain absent in literature. Clinical studies are currently being performed with the aid of 4D-ortho application in normal and pathologic patients, to assess normal and pathologic variation of distances and angles during different types of motion and in different joints.

Despite the importance of quantification in musculoskeletal dynamic CT, subjective analysis remains paramount for the interpretation of these studies. Visual understanding of motion paths and bone relations is important for diagnosis and may shed new light into the physiopathology of musculoskeletal diseases. In complex joints, such as the wrist, multiple carpal bones move with respect to each other, adding to the complexity of the analysis. Bone locking improves visual analysis of dynamic data, making it easier to appreciate fine motion and bone displacement.

In conclusion, 4D-Ortho represents a major development in the post processing of musculoskeletal dynamic CT. This application has the potential to improve diagnostic performance and reproducibility of musculoskeletal dynamic CT, playing an important role in the clinical application of this technique.

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Before the new cycle racing season begins, all professional riders are given medical checks. That happens at lotto-belisol as well. A reporter for VISIONS Magazine was allowed to see what goes on during these checks.

The riders from the Lotto-Belisol WorldTour team undergo their initial check measurements of core stability and muscle strengthening in the radiology department of the CHC Clinique St. Joseph in Liège (Belgium). Tests are also conducted in the Académie Robert Louis-Dreyfus, the training centre of the Standard Liège football club, and in the Centre Cardiologique Orban. “Our winter programme consists of various elements”, explains Lotto-Belisol team doctor Jan Mathieu. “First of all core stability and muscle strengthening. Injury prevention concentrates mainly on the stability of the neck, back, knees, pelvis and abdomen. It’s very important to take up the correct posture on the bike, on racing bikes as well as time trial models.

**Difference in strength**

We look at two levels in strength training. On the one hand is the muscle mass. Here we check how many muscle fibres are present in the body, what types of muscle there are and whether fat infiltration has to be removed.

On the other hand there is the strength of the muscles. We measure this using an isokinetic test in order to get an idea of the difference in strength between the muscles for the same joint in the left and right legs. Furthermore, we look at the response of those joints under the influence of forces. The test data are recorded in the computer by the dynamometer and by means of graphs and calculations give a reliable and repeatable picture of the strength of the muscles and the joints.

We perform initial measurements of all riders in November, and take those measurements as the baseline. There is dissimilarity in nearly all riders at that stage, especially where the leg muscles are concerned. One leg is more developed than the other. In the case of Jurgen Van Den Broeck we saw a considerable difference between his left and right leg after his knee operation. If you don’t deal with that loss of volume, you automatically compensate and you get injuries in the longer term. The physiotherapists therefore give all riders a programme that they have to follow for three months. In the meantime they get together every week to perform exercises, to see how their bodies are evolving, and to make adjustments where necessary. Then there are medical tests at the end of January to see whether their bodies are better balanced.” The connection between core stability and muscle strengthening is not unimportant. Doctor Mathieu explains: “A pedalling motion has to be regarded as a lever action. It is therefore very important for your lower back to be stable.
If that isn’t the case, then you can’t apply maximum force. Compare it with a barrier at a level crossing. If the arm is unsecured, the barrier can’t close.”

Then there is the cardiological test, which is required by the UCI. “Professional riders’ heart muscles are subjected to very heavy loads”, acknowledges Mathieu. “The UCI requires an exertion test - during which a cardiogram is made - or an ultrasound test of the heart, to check that all the valves are working properly. We do both. We can’t take risks. It would be terrible if a rider fell of his bike because of a heart abnormality.”

**Most heavily-stressed muscle**

Current team leader Mario Aerts had to give up cycle racing in 2011 because of cardiac arrhythmia. “It doesn’t occur often, but you have to act upon it every time there is a signal. Unfortunately, performing preventive checks is the only thing we can do. In the case of major abnormalities we can only recommend stopping. You certainly don’t become a professional rider in order to lead a healthy life, that much is clear. The heart is a rider’s most heavily-stressed muscle.”

A fourth test is the calcium measurement. “At Lotto-Belisol we have a lot of riders with broken bones”, Mathieu points out. “That’s often caused by a lack of calcium in the body. There has been research into the possible cause of this, and it turns out that riders’ sustained riding motion causes calcium to be deposited in their muscles and to remain there, instead of going into the bones. You can achieve the desired calcium level by walking a lot, but that’s not something for riders. We therefore give them dietary supplements such as vitamin D.”

Finally, a blood test is also part of the medical testing. “We check whether all the parameters in the blood are correct, such as for the liver and kidneys.”

**Knees and lower back**

“Because we have little influence on traumatological problems, we concentrate mainly on chronic complaints”, says physiotherapist Tim Aerts. “Studies show that 50 percent of all professional riders suffer with their lumbar region, and one in three with their knees. We as a team are therefore focussing on those places, because limited time and budgets mean you can’t investigate everything. By tackling those two areas we can increase the riders’ capacities quite a lot. It is important that we find the weak spots preventively and improve them in a subsequent phase. This can be done by screening the riders individually in clinical tests. Our medical think
Maxime Montfort goes through the Aquilion ONE CT scanner.

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Unique Imaging Combination Delivers a Winning Result On and Off the Pitch

With a unique imaging partnership firmly in place between Toshiba Medical and Manchester United, team physician Steve McNally offers an insight into how cutting-edge scanning equipment is already making a difference on and off the pitch.

Manchester United’s Team Physician and Head of Football Medicine Steve McNally explains how the Toshiba equipment installed at the AON Training Complex five miles away from United’s Old Trafford stadium – a 3T MRI scanner, CT scanner and six ultrasound machines – has a whole gamit of benefits.

For the medical staff, and the club’s new manager David Moyes who took over from the legendary Sir Alex Ferguson on July 1, the on-site scanning equipment helps keep current players needing treatment and potential new signings away from the glare of cameras, and particularly those attending a medical ahead of a transfer.

Dr McNally, recognising that new signings are big news, said: “The first place that these players often get spotted is at the local private hospital. We have always had an excellent relationship with local hospitals…but we have to get our players there without being seen by the paparazzi.

It is also the same with injuries. If a player is seen walking into hospital with an air cast boot on his ankle and is assumed to be out of the next game that is big news and affects our competitive advantage.”

Events have moved swiftly since thoughts first turned three years ago to redesigning the training facility and the potential to significantly enhance the on-site medical facilities.

The medical centre, which will serve around 80 full-time professional players and youth scholars together with approximately 170 academic schoolboys, is now nearing completion; the MRI and CT equipment is set to become operational shortly, and the ultrasound facility has been in place since January for musculoskeletal examinations and is being configured for cardiac screening.

Cardiac screening, which has long been high on the club’s agenda, took on greater relevance and profile in recent months following the dramatic scenes last season when Bolton Wanderers player Fabrice Muamba collapsed during a league game.

Such occurrences are extremely rare – only about one in 200,000 athletes will have an unexplained death usually due to cardiac causes – but Dr McNally says it is vital for Manchester United as a Club employing and developing players to do everything possible to ensure detectable causes for such incidents are identified and he aims to work closely with Toshiba to help further improve detection and diagnosis in this area.

Musculoskeletal screening and looking for intrinsic defects or deficiencies in tendons, joint cartilage, lower back and hip joint development are areas which lend themselves well to imaging in all forms, predominantly ultrasound and MRI but also CT in certain situations where health benefits significantly outweigh the risks of ionising radiation exposure. There is also potential for using imaging to assess body composition and body fat levels.

“Managers and coaches have long held body fat as an important factor in assessing a player’s fitness but we are still quite rudimentary in the way we measure that”, he said. “If we can develop an image where there is a body map with body fat highlighted in areas we can work on with specific exercises I think that sends a strong message to a player and coach. We can then work on it with specific exercises and nutritional strategies.”
Manchester United’s team doctor Steve McNally sees a winning combination in the partnership with Toshiba.

Similarly, with many young players on the club’s books, the development and growth of those in their early teens or even younger is important both from the individual’s well-being perspective and the club’s commercial investment in terms of coaching and contractual agreements. Any predictors of physical development for a young player are invaluable to a coach but Dr McNally stressed the importance of using non-ionising modalities in this respect, wherever possible.

As Team Physician, he also believes there will be an evolving role through the new medical suite – and the equipment it contains – in terms of injury management and prevention.

The game is getting faster each year – the club’s statistics from the 2012-13 season show the team had 37% more sprints per game than four seasons ago with more of those being high-intensity sprints – leading to greater injury potential.

Injuries to key players, he explains, can have a “domino effect” on other squad members who may be required to play, even when they may not be totally ready.

For example a long term injury to an experienced player in a key position not only reduces the chances of competition success but may lead indirectly to several other players sustaining injury. Having the latest equipment available means rapid diagnosis of an injury, prompt direction to appropriate rehabilitation or specialist advice, and then monitoring the effects of the treatment interventions.

One of the early benefits will be to continue the improvements in secondary (or re-injury) prevention that have taken place over the past 10 years.

“If a player gets injured now he tends to come back and stay back and also we do not have that knock-on effect on others,” said Dr McNally.

“I think the decline in secondary injury rates was aided by club doctors using scanning to monitor things on a daily basis because it added another level of confidence to our diagnostic decisions and the advice we could give to physiotherapists and rehabilitation experts.”

Dr McNally stressed the importance of not rushing players back after injury, but of also not being over-cautious in their return to playing.

“We have to try to pick the right time for the player and the right time for the club and hopefully those two things will continue to improve with the facilities that we have at our fingertips,” he added.

With patient safety paramount, Manchester United is also set to become the first club to set up a ‘radiology passport’ for players, which would record their scans as they move from one club to another. Dr McNally explained that Toshiba was the ideal partner for the club because the equipment specification was exactly what was required; Toshiba has the same ‘can do’ attitude as Premier League Champions Manchester United; has an extensive network of expertise within the company from clinical levels to engineering and technology; offers learning opportunities for Dr McNally and his staff; and the partnership has longevity with a commitment over five years.

But what has been satisfying for both club and manufacturer, at such an early stage of the agreement, is that the partnership is already having a significant impact.

Dr McNally stated that using Toshiba’s Aplio 500 system had already made a difference in the latter half of last season and he has been impressed with the resolution and the ability to see things he was not seeing before.

Citing an example of a player who was having problems flat-out sprinting and experiencing localised hamstring pain, he described how ultrasound revealed a focal muscle tear, which was bridging well but was a likely cause of dysfunction in the muscle, so the player was rested for the following game.

“He came back the next week with no problems so hopefully we may have prevented exposure to a potential six to eight week injury by taking a player out and managing him differently,” Dr McNally concluded.

In another example a player had soreness in a calf muscle and a similar small lesion was noted. A treatment regime was implemented on the basis of that early detection, which resulted in the player being available thereafter throughout the season.

The unique initiative – under the strapline “Delivering Premier Clinical Performance” – is already proving a winning combination for Manchester United and Toshiba as together they harness the potential of medical imaging to help keep the world’s best footballers at the top of their game.
Together, we complete the image.

**Made For Life**

Toshiba Medical is rearming its commitment to its Made for Life philosophy and launching a new theme and advertising campaign called "Together, we complete the image".

This campaign supports our Made for Life philosophy by focusing on our tradition of customer collaboration, developing products that are made for clinicians, patients and partnerships.

At Toshiba Medical, we listen to customers to truly understand their needs in imaging and beyond. Our goal is to work hand-in-hand with our partners to deliver flexible solutions that not only meet their needs but deliver optimal health opportunities for patients.
Together, we complete the image.

Made For life

Toshiba Medical’s SportsMed Program
Delivering exceptional care to everyone.

Toshiba Medical Workshop: Saturday 13th May 13:00 – 14:30 at TRIBUNA
Role of Imaging in the Diagnosis of Injuries and Return to Play

Hear from the medical teams of FC Barcelona and Real Madrid, as they discuss the use and advantages of dedicated imaging centres in the diagnosis, treatment and clinical management of players. From 13:00 to 14:30 Toshiba Medical’s workshop includes sessions on Ultrasound and MRI in Football Players, Pathways and Decision Process and there will be Q&A.

Chair: Ara Kassarjian and Gil Rodas
Speakers: Luis Cerezal, Lluís Til, Xavier Alomar, Sandra Míchó, Fernando Idoate, Bryan English, Fabrizio Tesconi, Jesus Olmo

Ultrasound and MRI Workshops at Toshiba Medical booth:
Learn from the experts, a hands-on opportunity.

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<tr>
<th>Saturday 13th May</th>
<th>Sunday 14th May</th>
<th>Monday 15th May</th>
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<td>12:30 – 14:30</td>
<td>Workshop at TRIBUNA (13:00 – 14:30)</td>
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Workshop at TRIBUNA (13:00 – 14:30)

15:00 – 16:00
Hip and Thigh
Ramon Balius / Carles Pedret / Lluís Til

16:30 – 18:00
Upper Extremity Nerves
Jordi Palau / Pablo Barceló / Ruben Sáiz

13:15 – 14:15
Fundamentals of MRI image acquisition & analysis

10:00 – 11:00
MSK MRI - advanced and emerging techniques to improve clinical practice