



Branding/ Reputation

- EDITORIAL, *L. DONOSO BACH*
- THE ART OF INFLUENCING
- CLICK, LIKE, RETWEET: HEALTHCARE REPUTATION ONLINE, *M. ENNIS-O'CONNOR*
- SOCIAL MEDIA IN HEALTHCARE, *S. SYED-ABDUL*
- SOCIAL MEDIA: GETTING IT RIGHT IN THE MARKETING PLAN, *R. SMITH*
- THE RIPPLE EFFECT: SUSTAINABILITY IN HEALTHCARE, *W. CLARK*

AI AND RADIOLOGY, *P. CHANG*
HAPPY STAFF, SAFE PATIENTS,
U. PRABHU

QUALITY AND SAFETY: ROLE OF
THE BOARD, *L. ROBSON*

QUALITY AND SAFETY IN
RADIOLOGY, *L. DONOSO BACH,*
G. BOLAND

SPORTS MEDICINE IMAGING,
G. RODAS/ K. NASIF

THE PAYER DETERMINES, BUT IT IS
NOT THE PATIENT, *P. KAPITEIN*

EXCHANGING 'MAMMOGRAPHY'
SCREENING WITH 'BREAST
CANCER' SCREENING, *N. CAPPELLO*

POINT-OF-CARE ULTRASOUND
SCANNERS, *ECRI*

CONNECTING IMAGING AND
INFORMATION IN THE ERA OF AI,
D. KOFF

ELECTRONIC CLINICAL HANDOVER,
J.J. COUGHLAN

DECONSTRUCTION OF BUSINESS
PROCESSES TO DISRUPTION OF

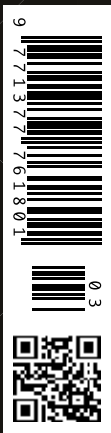
BUSINESS MODELS, *P-M. MEIER*

ENHANCING THE PATIENT
EXPERIENCE, *D.G. RELIGIOSO,*
E.S. DECIUS

ROBOTIC COMPANION ON WARD,
M. KEEN

BRINGING LIVE MUSIC TO
ADULTS AND CHILDREN ACROSS
HEALTHCARE, *S. ROWLAND-*
JONES

HEALTH SPENDING IN GREECE
UNDER RESTRAINT MEASURES,
D. LAPPOU



Diagnostic imaging in sports medicine

Radiologists collaborate with sports physicians for optimal performance

How diagnostic imaging can be used in sports medicine and how different techniques can be used to assess muscle injuries.

Diagnostic imaging in sports medicine

As muscle injuries represent more than thirty percent of sports injuries, with great implications for professional teams, musculoskeletal radiologists need to share the new knowledge of sports medicine in terms of diagnosis, prognosis and return to play in muscle injuries.

New injury classifications have been published, in order to connect the imaging findings and clinical examination and thus improve the grade of severity of muscle injuries and the possibility of re-injuries.

It is very important to get the best diagnosis after muscle injuries in order to determine the severity of the injury (in other words the time for return to play/sport/competition) and the risk of re-injury.

For this reason, cross-collaboration is of key importance between:

- Sports physicians with vast experience in muscle injuries and return to play together with expertise in ultrasound
- Musculoskeletal radiologists with a background in muscle injuries and expertise in new imaging sequences and 3 Tesla magnetic resonance imaging (MRI)

Ultrasonography and magnetic resonance imaging are currently the most frequently applied techniques in sports medicine. Imaging is crucial to confirm and assess the extent of sports-related muscle injuries and may help to guide management, which directly affects the prognosis. Prognosis based on the available clinical and imaging information is vital.

Classification of muscles injuries

Although different classification systems have been published, because they are used in daily practice, it may be challenging to classify injuries due to varying muscle architecture, lesion extension, activities when the lesion occurred and even the mechanism.

Recently three new classifications have been proposed:

1. Munich Consensus Classification (Mueller-Wohlfahrt et al. 2013)
2. British Classification System (Pollock et al. 2014)
3. FCB Barcelona and Aspetar Classification (Valle et al. 2017)

These classifications focus on different factors that are key for a best diagnosis and prognosis:

1. Mechanism of injury
2. Location of the injury
3. If myofascial, myotendinous or intramuscular tendon affected
4. If there is retraction of fibres or not
5. Extension of oedema (& cross-sectional area)
6. If it is a re-injury

These classification systems are based on the current available research and experience of clinical experts from different institutions with experience in assessing a high volume of muscle injuries.

However, we need a consensus to improve communication between all sports physicians and radiologists in athlete-related professional relationships regarding muscle injuries.

How MRI findings contribute to diagnosis and prognosis

3 Tesla MRI techniques have contributed to getting better images of the muscle architecture and muscle injuries, especially the level and quantity of myoconnective tissue. This means that the extracellular matrix involved might be variable, based on the principle that the more connective tissue is damaged, the greater the functional impairment—and worse prognosis.

Currently we are able to read how muscle injuries affect the myoconnective tissue, myofascia, i.e. more peripheral injury, myotendinous, i.e. typical muscle



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“MANY SPORTS MEDICINE PHYSICIANS HAVE LEARNED TO APPRECIATE HIGH-QUALITY IMAGING TO HELP GUIDE ATHLETES IN RECOVERY”

injury with feather imaging as well as intramuscular tendon injury. We have clinical evidence that when an injury has affected the intramuscular tendon, such as the common biceps/semitendinosus tendon, the prognosis was far worse and the incidence rate of an injury was higher.

When the doctor identifies a gap or retraction of muscle fibres, it shows there is a criterion for bad prognosis—a “marker” with less scientific evidence. In practical terms this means that the severity of a muscle injury in the same location can depend on the different histoarchitecture alteration, i.e. the difference between an injury that can last weeks or needs to be prescribed surgical treatment.

Predicting return to play and re-injury risk

At least for now there is no strong evidence that a 1.5 Tesla MRI finding is useful for predicting the time to return to sports. There is evidence in the sports medicine world that normalisation of increased signal intensities on MR images is not required for a successful return to play, suggesting that functional recovery precedes structural recovery on imaging.

But our impression is that no studies have been carried out using 3 Tesla MRI, and only hamstring injuries have been studied. Perhaps in the future, MRI examinations will be more useful. Firstly, this would

demonstrate that the first criterion for return to play is a positive diagnosis and everyday imaging techniques would indeed help us. Secondly, in the rehabilitation process if something occurs with an individual, we can monitor the response using both ultrasound (US) and MRI, together with monitoring of pain, flexibility, fatigue and strength.

In the future, there will no doubt be new evidence and we will be able to focus on areas such as:

- How fibrosis in previous injury has affected the recovery process, seen on T1-weighted MRI images
- How elastography could help as a marker of flexibility
- How we can see changes in the architecture remodelling using diffusion tensor imaging
- How the healing process by T2-weighted mapping is changing in terms of recruitment of muscles

Ultrasound, at least in our experience, is good for monitoring the healing process and controlling haematoma, fibrosis, architecture repair etc. It is cheaper and more useful but it’s certainly not the best return-to-play marker decision.

Another frequent question in our field is whether MR imaging findings allow us to predict re-injury? The answer is not for now—there is no great evidence to support the use of MR imaging findings to assess extent of injury or histoarchitecture-affected fibrosis for identifying athletes at increased risk of re-injury. However, our impression is that it will take place, but more research is needed.

Many sports medicine physicians have learned to appreciate high-quality imaging to help guide athletes in recovery processes, although the clinical evaluation itself and other tools such as GPS values, must

guide the final Return to Play decision, at least at the moment.

Ultrasound imaging of muscle injuries

These days, at least in Spain, using ultrasound (US) is similar to a cardiologist using a stethoscope. We always diagnose muscle injuries with the support of ultrasound. This requires vast experience, but it is really useful and we encourage specialists from other countries to also use this tool.

In our opinion, we agree that using ultrasound is less sensitive than MR imaging, but on the other hand with US you can observe and monitor very easily. Soon the evolution of the healing process, identifying if haematoma persists, fibrosis appears and if the fibrillary architecture is remodelling in the right way, will become clear. This is naturally really useful for daily practice.

Another advantage of using ultrasound for the evaluation of healing in muscle injuries is the ability to perform a dynamic assessment before and after muscle contraction, which may or may not depict persistence of fibre disruption, after clinical management and rehabilitation. This is very important in the evaluation of moderate to severe muscle injuries, which are the reasons why Return to Play may be delayed.

Future techniques

Advanced MR imaging techniques available for muscle assessment are not applied routinely in clinical practice. But it's true that professional medical staff are promoting and asking radiologists for new techniques for better diagnosis and prognosis.

For example:

- T2-weighted mapping may be useful from a sports medicine perspective. T2 values increase in stressed muscles and can help us know activation or changes in muscle recruitment after muscle injuries
- Diffusion tensor imaging allows diffusion quantification of anisotropic tissues and allows us to see muscle fibre direction tracking, to detect minor muscle injury and to differentiate injured muscles from normal.



- Skeletal muscle MR elastography can be used for studying the physiologic response of normal or damaged muscles. In fact, it has been found that there is a difference in the stiffness of muscles after injury.

This and more is coming and the future will most likely encompass positron-emission tomography (PET), in order to know more about functional and metabolic muscle changes and the relation to pre- and post-muscle injuries, including the recovery process. ■

KEY POINTS



- ✓ Muscle injuries represent more than thirty percent of sports injuries
- ✓ Optimal diagnosis of muscle injury determines the severity of the injury and time to return to play and risk of re-injury
- ✓ Cross-collaboration between sports physicians and musculoskeletal radiologists is of key importance
- ✓ US and MRI are the most used techniques in sports medicine
- ✓ In future, T2-weighted mapping, DTI, MR elastography and PET are expected to play a greater role as more research on these is done



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