Research article

The pre-signing medical examination: The radiologists’ role

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ARTICLE INFO

Keywords:
Pre-signing
Screening
MRI
Football
Sports injury

ABSTRACT

Purpose: to review the role of the radiologist in reporting pre-signing medical imaging prior to athlete transfer between clubs.
Method: When a professional athlete transfers from one club to another they may undergo a transfer or "pre-signing" medical examination, of which imaging forms a major component. The purpose of imaging is to enable the overseeing sports physician to make a risk assessment on the athlete that may influence decisions such as the duration of contract offered. Imaging studies have to be performed and reported often within limited time constraints, usually by MSK radiologists specialised in sports imaging. This article describes the role of the sports radiologist in reporting pre-signing medical imaging studies, and discusses some of the common pathology identified, as well as some of the ethical and medicolegal issues encountered.
Results: Not applicable. This is a review article.
Conclusion: the sports radiologists report of the pre-signing medical is an important component of the decision making process to sign an athlete, and is closely linked to the physical examination.

1. Introduction

The pre-signing medical has become an integral part of the transfer process of professional athletes when they move between clubs. Medicals are often performed for a number of sports though they are most commonly undertaken in professional soccer. Imaging evaluation forms an important stage of the pre-signing medical evaluation. This article aims to explain the role of the sports radiologist in the reporting of pre-signing medical imaging, including some of the challenges and pitfalls of what is essentially an injury screening process.

The pre-signing medical is composed of four key areas; cardiorespiratory assessment, physical capacity testing, clinical examination and imaging. The imaging and clinical examination elements are closely linked, and it is usual that the reporting radiologist enters into a discussion with the clinician performing the examination so that clinical and radiological correlation can be made. If abnormalities are identified on imaging that may be considered potentially unstable or imminently progressive, such as an osteochondral lesion in a knee, then these may influence the transfer negotiations such as the term of the contract offered, or may possibly jeopardise the transfer altogether.

2. Preparation

The reporting radiologist first needs to consider whether their level of personal indemnity is sufficient to consider reporting pre-signing medical imaging. Indemnity should specify cover for pre-signing medicals which ensures the radiologist is covered for potential legal challenges from the player, relating to loss of earnings or negative publicity incurred by an adverse screening examination, or challenges from the club signing the player, who may seek compensation if the player underperforms due to an injury that was overlooked in the pre-signing screening exam. Transfer fees have risen exponentially in recent years with figures as high as 300 million euros for an individual player, though the majority in the English Premier League range from 7 to 60 million euros. This is clearly a large financial investment for the club and they want to make sure their investment is in good physical condition. The competition between clubs to acquire the best possible available players means the decision by a club to purchase a new player is often concealed until the last minute. The clinician and radiologist involved with the pre-signing medical usually have little time to do any background research into the injury history of the player, which may be difficult to obtain. Websites, such as www.transfermarkt.com, provide a brief summary of footballers documented injuries and the duration of time they were out from play, though these are not entirely reliable. The clinical history taken by the clinician may also not be entirely reliable as the player may not be completely forthcoming about the full details of prior injury or surgery, for fear it may jeopardise a transfer, from which they will benefit financially.

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https://doi.org/10.1016/j.ejrad.2019.07.017
Received 30 April 2018; Received in revised form 10 July 2019; Accepted 15 July 2019
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3. Aims of imaging

The purpose of the signing MRI screen it to document the current status of the most commonly injured body regions of the athlete prior to transfer. Almost equally important, is the utility of the signing MRI screen to act as a baseline of imaging studies upon which to compare if the athlete sustains future injury. This is also very helpful for the radiologist who may be called upon to imagine the player later during their career with the club. It is not common practice for the imaging studies of players to be transferred along with their medical records to their new club, however there have recently been calls for this to change. The imaging history of an athlete should be just as important as their clinical history. Some imaging manufactures have proposed the creation of an “Imaging Passport” essentially like a PACS DICOM folder, that contains all prior imaging studies of an athlete, and transfers with the athlete as they move between clubs. This has advantages for the medical teams involved with the signing medical but may not be as welcomed by the players agents or club managers, who may be keen to sell a player who has a poor injury history which they may wish to conceal.

4. Imaging protocols

The signing MRI screen is often performed under tight time constraints as players may only be available for a medical for a limited period of time. In addition many clubs leave signings until the last few days of a transfer window in an attempt to get a better, last minute deal on what has become known as “transfer deadline day”. Imaging protocols therefore have to be streamlined. The most commonly imaged body regions are the lumbar spine, pelvis including hips, knees and ankles. If the athlete has a significant history of major or recurrent injury in a specific area, such as the hamstrings, then additional body regions may be included accordingly. For goalkeepers it is common practice to also image the shoulders.

5. Lumbar spine

A typical signing MRI protocol would include sagittal T2, STIR and high resolution T1 imaging of the lumbar spine with axial T2 sequences through the two most caudal disc spaces as well as any other levels of obvious pathology. The majority of signing MRI studies of the lumbar spine are normal. The most common abnormalities are disc degeneration and small disc herniations that are often incidental sub-clinical findings. The purpose of the STIR and high resolution T1 acquisitions is for the detection of spondylolysis. It is unusual for active stress response of the pars interarticularis to be present on a pre-signing MRI, with chronic non-united (grade 4) spondylolysis being a much more common finding [1]. This is most commonly seen at L5, and in older athletes, may be associated with early spondylolisthesis or foraminal impingement of the exiting L5 nerves between the inferior pedicular cortex and the exposed posterior annulus of the L5/S1 disc. Associated spinal stenosis is an uncommon finding.

Features of chronic repetitive hyperextension related micro-trauma may also be evident in the articular processes. This manifests as small ossicles arising from the tips of the inferior or superior articular processes, which are embedded in the facet joint capsule [2]. These injuries usually develop during adolescence, and may be associated mild facet arthritis in older athletes.

Small disc herniations are commonly identified, particularly at the L4/5 ad L5/S1 levels. These are often surprisingly clinically indolent compared to those seen in the non-athletic population, even when producing neural impingement on imaging studies. If identified, discogenic neural compromise should be carefully correlated with findings of neural tension on clinical examination, or history of prior lower limb muscle injury.

6. Pelvis

A typical signing MRI protocol of the pelvis would include large field of view coronal fluid sensitive fat saturated or inversion recovery sequence, axial fluid sensitive fat saturated and T1 weighted sequences, sometimes supplemented with small field of view high resolution imaging of each hip for labral and chondral lesions. There is a wide spectrum of degenerative and over-use related imaging findings in the pelvis and hips in soccer players, of which the reporting radiologist must be aware. It is important to note these commonly sub-clinical imaging findings, but remain aware of features that may indicate current clinical exacerbation or potential for lesion progression. Imaging of the pubic symphysis is abnormal in the majority of soccer players, even in academy aged athletes as young as thirteen. The primary symphyseal clef and fibrous articular disc often shows degeneration with high signal change on fluid sensitive sequences and marginal pubic bone hypertrophy. There may also be pubic bone cortical bone remodelling producing sub-articular contour abnormality. This reflects the chronic, repetitive shearing stresses sustained throughout the symphyseal clef during sprinting and cross field kicking. Mild bone marrow oedema is often present bilaterally in the parasymphseal region of the pubic bone in actively training footballers [3] and it is important to identify this separately from features of excessive osseous stress response. Features that may suggest clinically significant pubic symphysis overload are pubic marrow oedema that is particularly intense on fluid sensitive sequences and low signal on T1 imaging. Associated oedema of the parasymphseal ligaments and musculature are negative prognostic imaging features that may predict a more protracted clinical resolution [4].

Incomplete fusion of the pubic apophysis with apophyseal oedema and apophyseal cleft cyst formation are features of pubic apophysitis which is more likely to be symptomatic than simple pubic marrow oedema [5]. These findings may be chronic para-symphesial stress fracture clefts or failure of fusion of the pubic apophyseal plate. Thickening of the parasymphseal ligament complex is another commonly encountered finding, usually involving the anterior pubic ligament with extension into the inferior arcuate ligaments in more advanced cases. As the parasymphseal ligament complex degeneration and repetitive stress progresses, the ligaments may start to separate from the bone producing features often referred to as micro-avulsion or stripping. If micro avulsion extends beneath the inferior extent of the anterior pubic ligament or the inferior arcuate ligament it is analogous to the secondary cleft. What is more concerning is anterior pubic ligament micro-avulsion which extends beneath the fibro-cartilagenous footprint of the adductor longus and the pyramidalis tendon insertions. This anatomical relationship has been described as the pyramidalis-pubic ligament-adductor complex (PLAC) [6]. This is commonly seen in older soccer players and is often sub-clinical, though associated oedema in the parasymphseal muscles of adductor brevis and pectineus, may alert the radiologist to raise concerns that there may be currently symptomatic pubic symphseal overload. Anterior pubic ligament micro-avulsion may also extend superiorly beneath the attachment of the pyramidalis tendons, which may be associated with lower abdominal or inguinal pain.

Imaging of the hips if also frequently abnormal in soccer players, who may be otherwise training and playing regularly without any specific clinical symptoms. The labrum should be carefully reviewed noting changes of degeneration, chondralabral junction separation and small labral tears which are frequently present, particularly in the antero-superior quadrants. This can be challenging as dedicated small field of view, high resolution imaging of each hip is not always routinely performed for pre-signing imaging, unless the athlete is known to have a history of symptomatic labral injury or hip impingement. MR arthrography is not a practical option during pre-signing scans due to time constraints, so small labral tears or sublute acetabular chondral delamination lesions may be overlooked on large field of view 1.5 T imaging. However these are such common sub-clinical findings in
soccer players, that they do not usually have a negative impact on a
decision to sign a player. Features that are more likely to cause symp-
toms are regions of labral detachment and paralabral cysts, also within
the antero-superior distribution.

Chondral lesions of the acetabulum are frequently seen in associa-
tion with labral tears and are more likely to progress than femoral
chondral lesions. However the hip imaging performed during a pre-
signing exam frequently utilizes large fields of view, often at 1.5T, that
may limit the diagnostic accuracy for small acetabular chondral defects
or regions of chondral delamination.

Femoral and acetabular morphology that may contribute to clinical
findings of femoroacetabular impingement (FAI) is frequently en-
countered. Cam morphology of the anterior or superior femoral head/
neck offset has been reported with a prevalence of 43% in asympto-
matic adult hips, with a prevalence in footballers reported as high as
75%. Cam morphology should be commented on, along with features
that have a reported association with repetitive cam FAI such as fibro-
cystic change or focal bone marrow oedema in the region of cam
morphology [7]. The acetabular morphology should also be examined,
commenting on features of retroversion or excessive lateral femoral
coverage which may combine with cam morphology to produce clini-
cally relevant FAI.

7. Knees

Significant emphasis is put on the status of the knee joints when
reporting pre-signing MRI exams. This is mainly due to the high load
volume and biomechanical demands of the knee joint during kicking,
sprinting and direction change associated with soccer. The menisci and
weight bearing chondral surfaces sustain the majority of this load. A
typical signing MRI protocol of the knee would include sagittal, coronal
and axial combination of high resolution proton density fat saturated
and proton density sequences of no greater than 3 mm slice thickness.
Small degenerative tears in the anterior horn of the lateral meniscus
may be a common sub-clinical finding and do not usually raise concerns
for the referring clinician. Larger, potentially displaceable tears of the
posterior horns are more concerning as these could progress more
suddenly, requiring arthroscopic repair or resection, thus missing va-
luable playing time for the club Fig. 1. It is not uncommon to identify
chronic, small, healed tears, which are clinically stable. These demon-
strate intermediate signal on T2 or intermediate weighted MR se-
quencies, and should not be mis-read as active tears, as this may ad-
versely influence the signing or contractual negotiations. Due to time
constraints it is very uncommon to proceed to imaging modalities with
a reported higher sensitivity for differentiating healed from active
meniscal tears, such as CT arthrography [8].

Careful attention should be made to the chondral surfaces, particu-
larly on the weight bearing aspects of the tibial plateauas and femoral
condyles. Small full thickness fissures may rapidly progress to delami-
nation lesions or even full thickness defects when subject to rotational or
shearing forces. Fissures with underlying sub-chondral bone marrow
oedema should be identified, as progressive fluid accumulation in the
sub-chondral marrow may become a pain generator or progress to sub-
chondral cyst formation Fig. 2. Identification of atraumatic osteochon-
dral lesions such as osteochondrosis dessicans may pose a reporting di-
lemma. A large proportion of these lesions are stable, though features of
progressive osteochondral fragment instability such as surrounding fluid
signal, or marrow oedema and cyst formation in the lesion bed, should be
highlighted. The referring club may ask what is the probability for os-
teochondral fragment displacement. Realistically this cannot be pre-
dicted from imaging, though the reporting radiologist can usually give
some guidance as to whether an osteochondral fragment shows features
concerning for a “loose in situ” status Fig. 3. As with the hip, additional
clarification of osteochondral lesion status with MRI or CT arthrography
is usually a practical option due to time constraints within which one
must conduct the pre-signing medical assessment.

Fig. 1. A zoomed image from the pre-signing MRI screen shows a small, chronic
superiorly surfacing oblique tear is noted in the apex of the posterior horn of the
lateral meniscus (Fig. 1A). This was asymptomatic and not detected on clinical
examination. Three months after the signing the player presented with pos-
terior knee pain following a twisting injury. MRI demonstrates new apical at-
tenuation of the posterior horn of the lateral meniscus reflecting a vertical
longitudinal extension of the previously noted small apical tear (Fig. 1B). The
zoomed image (Fig. 1C) shows an unstable apical flap tear fragment showing
posterior displacement into the popliteal hiatus requiring resection (arrow).

The anterior cruciate ligament (ACL) is a common site of injury in
football and this structure should be carefully evaluated for signs of old
partial tearing or footprint avulsion. On average one player per pro-
fessional soccer squad sustains a complete ACL rupture every second
season [9]. If an ACL graft is present, the status of the graft is clearly
important, and particular attention should be made to graft fixation,
orientation and potential complications such as osteophytic notch im-
pingement, partial tears, and intrasubstance ganglion cyst formation.

Previous surgical reconstruction of the medial collateral ligament
and posterolateral corner stabilisers poses another challenge for the
reporting radiologist, as very little, if any, surgical history is provided at
the time of the signing. The player may have had surgery performed
anywhere in the world, and a background knowledge of the varied
surgical techniques and devices is often required to elucidate what
procedure has been performed and for what purpose. Only then can the
imaging status of the surgical repair be evaluated for integrity and
potential complications (Fig. 6).

The status of the quadriceps and patellar tendons is an important
component of the signing scan evaluation. It is not uncommon for
young academy level athletes to have sub-clinical proximal insertional
patellar tendonopathy. This is not usually a clinical concern in isolation,
though its presence is important to highlight, as this may influence the
training load management of the athlete.

8. Ankles

Ankle injury makes up for around 10% of lost playing time in football.
This most common cause is ligament injury. A typical signing MRI pro-
tocol of the ankle would comprise three sequences, sagittal, coronal and
axial, utilising high resolution proton density fat saturated and proton
density weighted imaging. Ligament status is one the most important
questions when reading MRI of the ankles for pre-signing. Old injury to
the anterior talo-fibular ligament (ATFL) is almost ubiquitous in soccer
players, and the majority of pre-signing MRI studies will show some
signs of prior ATFL injury, even in young academy aged players. A thickened
scarred ATFL is often associated with chronic periosteal stripping injury at
the fibular attachment. This finding may be associated with meniscoid
lesions and chronic synovitis in the anterolateral recess which may form a
focus for anterolateral impingement. Finding may be associated with meniscoid
lesions and chronic synovitis in the anterolateral recess which may form a
focus for anterolateral impingement. It is not uncommon to identify
chronic complete tearing and atrophy of the ATFL on pre-signing MRI
studies. Providing the calcaneofibular ligament (CFL) is intact, this does
not usually pose clinical concerns for ankle instability and usually does not
adversely influence signing decisions or contractual terms. If ATFL defi-
ciency is noted, the tibio-talar joint should be evaluated for signs of ex-
cessive chondral wear and early arthrosis. This may suggest the ligament
deficiency is manifesting as functionally significant ankle instability. If
both the ATFL and CFL are completely deficient this is a more concerning
finding that may predispose the athlete to future osteochondral injury.

The chondral surfaces and sub-chondral bone should be carefully
reviewed for signs of chondral fissures, flap lesions and osteochondral
lesions. Features that suggest chondral lesion instability such as fluid
signal surrounding the osteochondral fragment or cyst formation within
the osteochondral lesion bed may raise more concerns for future frag-
ment displacement or symptoms and thus may influence the terms of a
contract offered to the player.

Tarsal coalition is an important finding to exclude, especially when
reporting signing scans on younger academy level athletes. If present,
coalition may predispose to future problems associated with hindfoot or
midfoot stiffness, tarsal bone stress injury, posteromedial impingement
as well as early onset arthrosis [10] Fig. 4.

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**Fig. 2.** The pre-signing MRI screen identifies focal sub-chondral bone marrow
oeodema on the weight bearing surface of the medial femoral condyle with
overlying chondral high signal abnormality (Fig. 2A). Closer inspection shows a
subtle oblique full thickness chondral fissure overlaying the sub-chondral bone
marrow oedema (Fig. 2B). This was not suspected on clinical examination or
history. The player presents with medial joint line pain and new effusion in
the second week of pre-season training. Subsequent MRI (Fig. 2C) shows progres-
sion of the chondral fissure into a well defined and displaced full thickness
chondral defect with new sub-chondral bone marrow oedema.

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**Fig. 3.** Fig. 3A shows a well defined grade 2 osteochondral lesion on the lateral
trochlear reflecting osteochondrosis dessicans identified on the pre-signing MRI
screen. The lesion bed is outlined by marrow oedema and early cyst formation
(arrows). The potential risk of osteochondral lesion progression and fragment
instability was discussed at the time of the signing and decision to sign the
player was made. Six months into the season the player presented with joint
effusion and a palpable articular body in the supra-patellar recess. Fig. 3B - The
osteochondral fragment had undergone sub-division with fragment displace-
ment (block arrows) into the supra-patellar recess and lesion bed respectively
(arrows).
Ankle tendonopathy is a frequent finding in pre-signing scans, most commonly affecting the peroneal tendons. This may even be present in young academy age athletes presenting with tendon thickening, intrasubstance high signal change and even partial thickness longitudinal split tears. This is frequently sub-clinical and of little concern to the referring medical team. Older athletes in their late second or early third decade may have more established tendon pathology, such as Achilles tendonopathy. If this shows features of reactive phase changes such as paratendonitis or subtle tendon thickening this is simply managed with load modification. If more advanced degenerative phase changes are present, such as partial tears, foci of mucoid degeneration or advanced insertional tendonopathy, these findings could have potential for progression and may influence contractual negotiations.

9. Shoulders

Imaging of the shoulders does not form part of the standard signing medial evaluation for outfield soccer players, but is undertaken for goalkeepers. There is a wide spectrum of repetitive overuse pathology and early degenerative features that are often found in a goalkeeper's shoulder, the majority of which are asymptomatic. Another consideration is the playing career of goalkeepers, which is usually significantly longer than outfield players. As such the “asset years” of a goalkeeper may extend into their early third decade, when more degenerative pathology can be expected. Small low grade articular sided “rim rent” tears of the supraspinatus tendon, rotator cuff tendonopathy and intrasubstance delamination are common findings. Small labral tears involving the postero-superior and posterior labral are also common sub-clinical findings. If superior labral tears are seen extending into the biceps tendon insertion, this should raise more concern for correlation with a careful evaluation for specific labral clinical tests.

The presence of an os acromiale, or narrowing of the sub acromial outlet due to acromial downsloping or subacromial enthesophyte formation are important features to exclude, particularly in a young goalkeeper. These features may predispose to early rotator cuff tendonopathy or tear formation [11].

The anteroinferior labrum should be evaluated for features of anterior instability such as tears or focal detachment. This can sometimes be challenging without MR arthrography, particularly if MR imaging is performed at 1.5T. Small anteroinferior labral lesions are not uncommon in older goalkeepers, many of whom do not report any prior episode of instability and have clinically stable shoulders [12]. Anteroinferior labral lesions associated with glenoid chondral defects should raise more clinical concern, as these may progress rapidly in goalkeepers due to the repetitive loading of the glenohumeral joint whilst diving. Chondral flap lesions or defects may rapidly progress to glenohumeral arthrosis with associated capsulitis and stiffness which can be a functionally limiting condition for a goalkeeper.

10. Discussion

Once the pre-signing MRI screen has been reported to the referring clinician, there usually follows verbal discussion around any particularly concerning imaging findings, which is very helpful for the clinical team conducting the pre-signing medical. This should ideally be done after the
clinical examination has been performed so that any imaging abnormalities can be correlated with clinical signs or clinical history from the player. Ultimately it is the club physician or physiotherapist who has the overall say as whether they think the player is medically fit.

As already discussed, there is a myriad of imaging abnormalities that are often sub-clinical in footballers, and a large proportion of the pathology detected on pre-signing can be dismissed as “normal for soccer”. Many imaging abnormalities however documented in the pre-signing report are useful to the referring clinician as these form a baseline picture of the athlete’s anatomy and joint status, as some sub-clinical findings, for example femoral cam lesions, small acetabular labral tears, tendinopathy and small disc herniations, that may become symptomatic in the future. Having the pre-signing imaging report and imaging acts as a useful reference upon which to compare future imaging studies should that anatomical region become symptomatic in the future.

The pre-signing MRI screen is not without its problems and may unearth imaging abnormalities that are asymptomatic, but once identified, may compel the referring clinician to perform further investigation to declare the athlete medically fit. A player with a known history of recurrent, high grade hamstring injury may require further imaging with ultrasound to evaluate potential scar tissue or perineural scarring of the sciatic nerve. These additional imaging requirements may add time to the medical which is often at a premium, and some medica}