

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad



Research article The pre-signing medical examination: The radiologists' role

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ARTICLE INFO	A B S T R A C T
Keywords: Pre-signing Screening MRI Football Sports injury	 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 "presigning" 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

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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 0720-048X/ Crown Copyright © 2019 Published by Elsevier B.V. All rights reserved.

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.tranfermarkt.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.

3. Aims of imaging

The purpose of the signing MRI screen it to document the current status of the most commonly inured 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 image 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 arthrosis 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 higher 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 cleft 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 cleft during sprinting and cross field kicking. Mild bone marrow oedema is often present bilaterally in the parasymphyseal 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 symphyseal overload are pubic marrow oedema that is particularly intense on fluid sensitive sequences and low signal on T1 imaging. Associated oedema of the parasymphyseal 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-symphyseal stress fracture clefts or failure of fusion of the pubic apophyseal plate.

Thickening of the parasymphyseal 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 parasymphyseal 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 pyramidalispubic ligament-adductor complex (PLAC) [6]. This is commonly seen in older soccer players and is often sub-clinical, though associated oedema in the parasymphyseal muscles of adductor brevis and pectineus, may alert the radiologist to raise concerns that there may be currently symptomatic pubic symphyseal 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, chondrolabral 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 sublte 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 symptoms are regions of labral detachment and paralabral cysts, also within the antero-superior distribution.

Chondral lesions of the acetabulum are frequently seen in association with labral tears and are more likely to progress than femoral chondral lesions. However the hip imaging performed during a presigning exam frequently utilizes large fields of view, often at 1.5 T, 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 encountered. Cam morphology of the anterior or superior femoral head/neck offset has been reported with a prevalence of 43% in asymptomatic 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 fibrocystic 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 clinically 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 valuable playing time for the club Fig. 1. It is not uncommon to identify chronic, small, healed tears, which are clinically stable. These demonstrate intermediate signal on T2 or intermediate weighted MR sequences, and should not be mis-read as active tears, as this may adversely 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, particularly on the weight bearing aspects of the tibial plateaus and femoral condyles. Small full thickness fissures may rapidly progress to delamination 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 subchondral cyst formation Fig. 2. Identification of atraumatic osteochondral lesions such as osteochondrosis dessicans may pose a reporting dilemma. 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 osteochondral fragment displacement. Realistically this cannot be predicted 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 posterior knee pain following a twisting injury. MRI demonstrates new apical attenuation 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 professional 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 impingement, 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 protocol of the ankle would comprise three sequences, sagittal, coronal and



Fig. 2. The pre-signing MRI screen identifies focal sub-chondral bone marrow oedema 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 overlying 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 progression of the chondral fissure into a well defined and displaced full thickness chondral bone marrow oedema.

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. 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 deficiency is noted, the tibio-talar joint should be evaluated for signs of excessive 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 fragment 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.



Fig. 3. Fig. 3A shows a well defined grade 2 ostechondral 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 displacement (block arrows) into the supra-patellar recess and lesion bed respectively (arrows).



Fig. 4. Pre-signing MRI screen identifies multiple abnormalities in the ankle with a displaced, traumatic grade 4 osteochondral lesion on the lateral shoulder of the talar dome (arrow). A posteromedial talo-cacaneal fibrous coalition is also present (arrow head). The features of instability of the osteochondral lesion and the potential problems of ankle stiffness and accelerated degenerative change associated with the coalition, were felt to be high risk with regard to signing the player. The club therefore elected not to offer the player a contract in this case.

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 goalkeepers 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



Fig. 5. The pre-signing MRI screen (Fig. 5A) identified an old apophyseal avulsion of the left anterior inferior iliac spine (arrow), in this now skeletally mature footballer with a normal rectus femoris tendon insertion on the right (block arrow). The player sustained an acute complete avulsion of the normal right rectus femoris tendon origin during the first game of the season, shown in Fig. 5B (arrow). This is clearly an unpredictable and coincidental injury, unrelated to the previous contralateral apophyseal avulsion. However unpredictable, this injury lead the purchasing club to ask whether the injury could have been anticipated from the pre-signing imaging findings.

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 1.5 T. 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 glenohuneral 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



Fig. 6. Coronal proton density image of a particularly problematic knee from a pre-signing MRI screening. The imaging revealed a failed ACL graft (arrow), lateral tibiofemoral arthrosis with bone on bone articulation, and complex degenerative tearing of the lateral meniscus (block arrows). These findings were deemed too great a risk to offer this player a contract.

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, tendonopathy 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 Fig. 5. Examples of such pathology may be old fractures that have undergone fibrous union or regions of resolving osseous contusion or stress response, that may warrant further imaging with CT. 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 medicals

performed at the last minute may forgo further investigation in the interests of completing the signing before the deadline. Ultimately presigning MRI screens are a luxury, and the extent to which players are investigated is often dependent upon the medical budget of the club, with less wealthy, lower league clubs often settling for imaging of just the knees and ankles. Indeed, some signings that are rushed through at the last minute, complete without any imaging being performed if time constraints do not allow. The reporting and preparation of pre-signing MRI screening is often high intensity work done under tight time constraints, but ultimately the optimal scenario is one of no imaging abnormalities. The description and perceived significance of imaging abnormalities is largely based upon the radiologists experience of reporting imaging studies in soccer players. This ensures an accurate but concise report is produced that does not generate unnecessary alarm that may adversely influence any decision to sign a player. In summary 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. These elements of the medical evaluation have to be delivered with speed and accuracy to ensure an informed decision can be made on what is an increasingly costly investment for professional sports clubs.

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