

RETURN TO PLAY AFTER ACUTE HAMSTRING INJURIES

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Hamstring injuries are the most prevalent time-loss injuries in major sports like football and track and field athletics^{1,2}. Besides being out of play due to the injury, high re-injury rates remain a major problem following acute hamstring injuries¹.

For medical staff there are three important time points while dealing with acute hamstring injuries:

1. Just after injury, we are forced by the athlete and coaching staff to predict the return to play (RTP) duration. But can we accurately predict the duration of the injury?
2. At RTP, we have to balance between quick RTP and re-injury risk. Are there

evidence-based criteria to guide our RTP decision?

3. After RTP, we will be held responsible for the re-injuries. Can we identify the players with increased re-injury risk?

For these three time points, magnetic resonance imaging (MRI) is more readily available than ever before – especially in the elite athlete^{3,4} – and has gradually gained a magical reputation as the crystal ball that answers all the questions of the injured athlete. Without imaging the injury, there is no peace of mind within the team. In this paper we will argue that at all three key time points we should rely on our clinical findings and that,

currently, MRI has almost no additional value.

AT INJURY: CAN WE PREDICT THE DURATION OF THE INJURY?

After injury, the main question of the athlete, coaching staff and press is: when can they return to play? In the last 2 decades a number of studies have been published which aimed to identify potential prognostic variables for time to RTP after hamstring injury.

Limited value of MRI

Previous research mainly focused on the prognostic value of MRI. In a recent

TABLE 1

<i>Prognostic factor</i>	<i>Association with time to RTP</i>
<i>Injury mechanism: sprint-type versus slow stretch-type^{36,37}</i>	<i>Slow stretch-type longer than sprint-type</i>
<i>Self-predicted time to RTP⁹</i>	<i>Shorter when estimated shorter and vice versa</i>
<i>Flexibility deficit measured with the passive straight leg raise test⁹</i>	<i>Longer with larger flexibility deficits</i>
<i>Time taken to walk pain free³⁸</i>	<i>>1 day means a longer time to RTP than ≤ 1 day</i>

Table 1: Prognostic factors for the time to RTP obtained with clinical examination.

published systematic review of the literature we found that there is currently no strong evidence for any MRI finding on the prognosis for the time to RTP after an acute hamstring injury⁵. This conclusion was mainly based on two limitations in the current literature:

1. Multiple studies on hamstring injuries found correlations between different MRI measures and the time to RTP. Unfortunately, these are limited to univariate analyses on correlations between MRI parameters and RTP. None of the studies analysed the additional value of MRI to clinical evaluation in multivariate models. No one has established if the addition of MRI helps predict RTP.
2. There is a considerable risk of bias in most of the studies on this topic as the clinicians are not blinded to the MRI as they treat their players.

Why is blinding crucial to prevent bias?

“All my MRI Grade I hamstring injuries take 3 weeks because I let all my MRI grade I hamstring injuries go back after 3 weeks.”

When studying prognostic factors, the outcome measure should be independent of the prognostic factor of interest to prevent biased results⁶. For daily practice this implies that the RTP decision-maker is unaware and blinded to the potential prognostic factors like baseline MRI results.

Self-fulfilling prophecy – Breaking Bad and the Observer Effect

The lead character in the TV series Breaking Bad went by the pseudonym

of ‘Heisenberg’ – an oblique reference to quantum mechanics’ uncertainty principle and the strange phenomenon that observing some particles changes the properties of these particles. Here, we feel that observing hamstring injury on MRI changes the way the observer behaves (but not the hamstring injury itself). Take the example of an ‘MRI-negative injury’. The knowledge that there is no sign of injury seen on MRI will likely affect judgements of the injured athlete and the medical staff involved and result in a faster progression through rehabilitation and return to play than in MRI-positive injuries. It is a self-fulfilling prophecy that without blinding for the MRI findings, the factor ‘MRI-negative injury’ will most likely be associated with a shorter time to RTP. To our knowledge, of the 12 studies documenting RTP after hamstring injury where MRI was available⁵, only two had the clinicians blinded to the MRI^{7,8}

Adequately measured time to RTP, by clearly defined RTP criteria and blinding of subjects and clinicians involved in the rehabilitation or RTP decisions, is therefore compulsory for a low risk of bias.

The clinical view

Although a proper history and physical examination is the basis of our clinical practice, it is remarkable that these aspects have only gained limited attention and are underrepresented in the current literature on hamstring injuries. In contrast to the prognostic value of MRI, only a few studies reported the prognostic value of clinical examination for the time to RTP (table 1).

In clinical practice the diagnostic work-up generally consists of history, physical examination and possibly additional imaging. We argue that the prognostic value of scans is only of clinical relevance when it provides additional prognostic value after clinical evaluation. As none of the studies included in the systematic review analysed both clinical and MRI findings, it remained unknown whether the MRI findings provide such additional prognostic information.

Recently, we examined the predictive value of both clinical and MRI parameters for time to RTP in a double blind study design⁹. A multivariate analysis allowed us to study the prognostic value of MRI findings complementary to the clinical factors. The results revealed that MRI did not provide additional prognostic information in our study population. Similarly, recently-collected data at Aspetar on RTP after acute hamstring injury in 90 professional athletes showed little additional benefit of MRI. Using regression analysis to explain predictors of time to RTP, clinical examination alone explained about 50% of the variance, while adding MRI to the clinical examination added less than 5% variance explained. In a practical sense, this additional information is clinically meaningless and would not helpfully change the prognosis of any injured athlete (unpublished data).

Can we provide a prognosis in clinical practice?

Although our knowledge has improved at a group level, the current available research does not satisfactorily answer this question

for the individual athlete. We will illustrate this with two examples.

The prognostic parameters found in our study (self-estimated time to RTP and deficit in passive straight leg raise) explained only 20% of the total variance of the time to RTP. The mean time to RTP was 44 ± 18 days, indicating that approximately 95% of the athletes returned to play between 8 and 80 days (mean \pm two times the standard deviation). With the athlete's own prediction of time to RTP added to the passive straight leg raise deficit we could only narrow the range down slightly. For an athlete, with a self-estimated time to RTP of 42 days and a passive straight leg raise deficit of 10° , the 95% confidence interval for the estimated time to RTP by the model is 16 to 83 days, instead of 8 to 80 days.

In the largest series on the prognostic value of MRI, Hallen et al. found that in professional football players MRI grading was significantly correlated with injury time¹⁰. This study found, for each injury grade (in days \pm standard deviation): grade I= 18 ± 19 ; grade II= 24 ± 13 ; grade III= 60 ± 57 . By applying these results to an individual professional football player with a grade II hamstring injury, we can estimate that there is a 95% chance that he returns to play within 0 to 50 days (mean 24 days \pm two times the standard deviation of 13 days).

The athlete, coaching staff and press will justly argue that these estimations of the injury time are a long way from being satisfactory. Currently, we cannot answer the athlete's most important and simple question.

AT RTP: ARE THERE EVIDENCE-BASED RTP CRITERIA?

It is a major challenge to decide whether an athlete can safely return to play and estimate the risk of re-injury when they do. The high re-injury rate reflects this challenge¹¹. Re-injury has been reported to occur predominantly in the first weeks after RTP¹¹. In reviews and surveys there are five commonly mentioned criteria and/or evaluations, but there is currently no firm evidence to back up these opinions^{3,12,13}:

1. Clinical evaluation.
2. Athlete's reported subjective readiness.
3. Normalised muscle strength assessment.
4. Follow-up MRI.
5. Successful and asymptomatic

completion of a sport-specific functional field test.

Necessarily, RTP decisions are multifaceted and, as previously recognised, in professional sports it might be preferable to have a player with a hamstring strain return to sport at 3 weeks with a 10% risk of recurrence but playing in the key games, than returning at 8 weeks, having missed all the key games – but with a risk of recurrence of 0 to 5%^{14,15}.

Asymptomatic on clinical evaluation: mostly used, but not validated

History-taking represents an essential tool of our daily clinical decision-making process and may be enhanced by using patient reported outcome questionnaires. The patient-reported outcome potentially reflects the self-reported readiness to return to sport, but has never been systematically investigated or validated in hamstring injuries. Currently, the only hamstring-specific patient-reported outcome is the hamstring outcome score, originally developed as a risk factor screening tool. Further studies should focus on its validity as a tool for assisting RTP decisions¹⁶.

Clinical tests that are generally used include muscle palpation, flexibility testing and strength testing either performed manually or using a strength measurement device. Although these clinical tests have been used for decades to assess readiness to RTP after hamstring injury, they have never been validated for this purpose. More recently, Askling et al. introduced a new hamstring test which

evaluates subjective insecurity during an active ballistic hamstring flexibility test (often referred to as the Askling-H test)¹⁷. This test was shown to be reliable, but whether it is a valid test to assess readiness for RTP remains unknown.

Athletes' subjective readiness

Analogous with RTP after anterior cruciate ligament reconstruction, RTP after a hamstring strain injury is likely to be influenced by fear of re-injury and the subsequent psychological readiness of the injured athlete¹⁸⁻²⁰. In anterior cruciate ligament reconstructions the psychological readiness to return to sports has been successfully evaluated with the Anterior Cruciate Ligament Return to Sport after Injury scale²⁰. This scale measures the athlete's psychological state and has been shown to be associated with RTP and can potentially identify athletes at risk^{18,20}.

For practitioners working with high-level athletes, psychological responses may be a crucial element of our RTP assessment, affecting the decision even when there is complete functional readiness and no symptoms reported on functional field testing. As in daily practice, psychological evaluation could complement future evidence-based RTP guidelines. Aspetar's hamstring-related research is currently focusing on this important RTP topic.

Normalisation of isokinetic strength is not necessary for a successful RTP

An isokinetic strength deficit less than 10% is generally recommended for a safe

MRI has gradually gained a magical reputation as the crystal ball that answers all the questions of the injured athlete

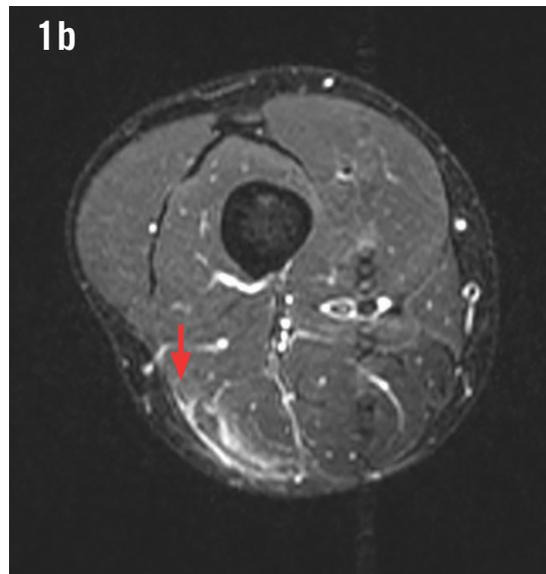
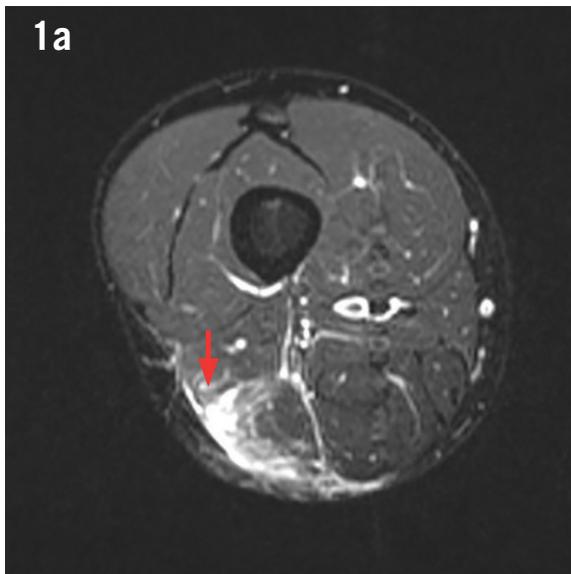


Figure 1: a) Short-tau inversion recovery (STIR) image of the initial injury showing oedema (intramuscular increased signal intensity) of the biceps femoris (arrow). b) STIR image at RTP showing oedema around a centre of fibrosis (intramuscular low signal) at the site of the injury.

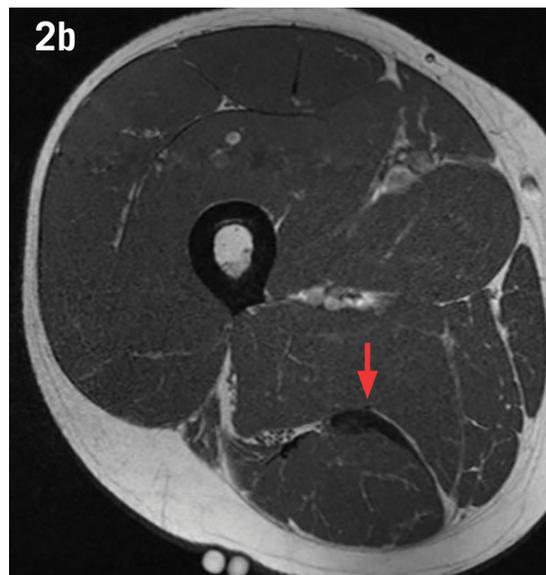


Figure 2: a) T1-weighted image of the initial injury showing no abnormality. b) T1-weighted image at return to play showing an area of intramuscular low-signal intensity at the site of the injury, indicating fibrous tissue formation.

RTP^{13,21}, but this has never been validated. Therefore, a study was performed at Aspetar that evaluated isokinetic strength measurements in 52 professional football players with hamstring injuries after completing a standardised rehabilitation programme¹⁵. When compared with the uninjured leg, 67% of the clinically recovered hamstring injuries showed at least one hamstring isokinetic testing deficit of more than 10%. There was no significant difference of mean isokinetic peak torques and 10% isokinetic deficits in players without re-injury (n=46) compared with players with re-injury (n=6). Normalisation of isokinetic strength does not seem to be a necessary result of the successful completion of a football-specific rehabilitation programme.

MRI does not help us assess readiness for RTP

MRI has been suggested to monitor recovery after injury and support decisions for RTP, but this too has not been validated³. We therefore conducted a study to provide more insight into the value of MRI in RTP decision-making²².

In this study we pooled MRI data from a Qatari and Dutch cohort of 53 athletes within 3 days of RTP after recovery of an acute hamstring injury and recorded re-injuries within 2 months after RTP²². Oedema was observed on MRI at RTP in 89% of the clinically recovered hamstring injuries (Figure 1). Five athletes (10%) sustained re-injury. The presence and extent of the oedema was similar in those athletes that sustained a re-injury and those who did not.

Thus normalisation of oedema on MRI is not required for a successful RTP and the extent of MRI abnormalities is not associated with the risk of re-injury.

Sport-specific functional field testing

In our experience, the gap between the treatment table and the pitch is often a wide one, and the steps between clinically performed examination/exercises and on-field requirements (e.g. repeated sprinting under fatigue) can be similarly large. In a shared decision-making model, the athlete's opinion is central, however it can be difficult for the athlete to accurately gauge their readiness if they have not been exposed to training and match demands prior to returning to sport²³.

TABLE 2

<i>Prognostic factor</i>	<i>Association with re-injury risk</i>
<i>History</i>	
<i>Previous hamstring injury</i>	<i>AHR 1.33 for each previous injury</i>
<i>Injury characteristics</i>	
<i>BF injury</i>	<i>BF at increased risk compared to SM and ST injury</i>
<i>Assessment after RTP</i>	
<i>Active knee extension deficit</i>	<i>AHR 1.13 for each degree deficit</i>
<i>Decreased isometric knee flexion strength</i>	<i>AHR 1.04 for each Newton deficit</i>
<i>Presence of focal hamstring tenderness at palpation</i>	<i>AHR 3.95</i>

Table 2: Prognostic factors for re-injury risk²⁸ more degrees of active knee extension deficit after RTP (adjusted odds ratio 1.13; 95% confidence interval 1.03 to 1.25). AHR=adjusted hazard ratio, BF=biceps femoris, SM=semimembranosus, ST=semitendinosus.

A sport-specific field test is the ultimate test of the athlete's readiness to load the injured muscle as is required during (match) play and subsequently it comes with its own risk of re-injury. Less rigorous field tests potentially reduce the re-injury risk during testing, but give rise to uncertainty as to whether the athlete is ready or not. We recommend that this final stage of sport-specific testing is not a stand-alone test, but should be preceded by a criteria-based rehabilitation programme to maximise the chances of a successful RTP. The logistics of exposing the injured athlete to match-specific demands can be difficult to perform in a clinical situation unless there is easy access to sporting facilities. Despite its suspected clinical relevant value, only Aspetar's study included the sport-specific testing as one of the RTP criteria¹⁵.

In conclusion, as long there remains a lack of quantifiable, valid and reliable determinants for RTP, there will persist a tension between early RTP (primary outcome in most trials) and risk of recurrence (predominantly used as secondary outcome).

Absence of evidence-based criteria: expert opinion RTP criteria

In the previously discussed studies we found that MRI and strength testing do not

help us in assessing whether an athlete is ready to RTP. Unfortunately, there are still no validated criteria to assess whether an athlete can safely return to play. In the absence of any validated criteria we tentatively suggest the following practical criteria to guide RTP decisions:

- Absence of localised discomfort on palpation and isometric strength testing.
- A pain-free complete range of motion compared to the uninjured leg using the active knee extension test.
- Symptom-free repeated maximal sprinting for sprinting-type injuries and symptom free repeated maximal lengthening tests for lengthening-type injuries.
- Successful progression through a progressive rehabilitation programme, including sport-specific functional (field) testing.
- Symptom-free completion of three to five (group) training sessions before resumption of (partial) match play.

AFTER RTP: CAN WE ASSESS RE-INJURY RISK?

In a systematic review from 2012 it was shown that there was only limited evidence for three re-injury risk factors¹¹: an initial injury with a larger volume size on MRI²⁴, MRI Grade I injury^{25,26} and a previous ipsilateral

anterior cruciate ligament reconstruction²⁷. In new and larger studies these three risk factors have been reinvestigated and will be presented below.

New evidence for clinical re-injury risk factors

In a prospective follow-up study of 64 athletes we examined a multitude of parameters assessed with clinical examination and MRI²⁸. A multivariate analysis allowed us to establish which parameters were independently associated with re-injury risk. This analysis revealed that several parameters assessed with clinical examination within 1 week after RTP were associated with the re-injury risk: the number of previous hamstring injuries, active knee extension deficit, isometric knee flexion force deficit at 15° and the presence of localised discomfort on palpation (table 2). All (n=17) re-injuries occurred in biceps femoris injuries.

These independent risk factors for re-injury can be easily monitored in clinical practice to identify those athletes at higher risk of re-injury. Using risk ratios associated with these factors allows clinicians to calculate the relative re-injury risk. For example, athletes with localised discomfort on hamstring palpation just after RTP are four times more likely to sustain a re-injury compared with those athletes without. An athlete is at 33% more risk of re-injury if there is one previous hamstring injury and at 77% more risk (1.33×1.33=1.77) if there are two previous hamstring injuries, compared with no previous hamstring injury. Preventive measures, such as reduction in high-risk activities or preventive exercises can be applied preferentially to those athletes at increased risk for re-injury.

New: no evidence for MRI re-injury risk factors

In the above-mentioned study we also evaluated a large number of MRI parameters²⁸. After including both the clinical and the MRI parameters in the multivariate analysis we found that none of the MRI parameters were independently associated with the re-injury risk.

The largest MRI study on hamstring injuries in professional football has



In RTP prognosis, RTP decision-making, and re-injury risk assessment, we should rely on our clinical findings



shown that the re-injury rate of biceps femoris is 18%¹⁰. For the semitendinosus and semimembranosus this percentage is respectively 0% and 5%. Knowledge about which muscle is involved is therefore relevant for re-injury risk management. Although this study used MRI to locate the injury, involvement of the long head of biceps femoris can be easily diagnosed by clinical examination.

MRI at RTP and re-injury risk

In clinical practice there is a common belief that scar tissue is an important factor in the aetiology of hamstring re-injury. This belief is reflected in the literature on muscle injuries, in which scar tissue formation is the most frequently suggested predisposing factor for re-injury^{21,33}. Treatment modalities and rehabilitation protocols often pretend to be aimed at preventing/minimise scar tissue formation²¹. Recently there are even reports of the use of anti-fibrotic drugs (Losartan) in the treatment of muscle injuries³³.

Unfortunately there is no evidence from clinical studies that fibrosis actually is a risk factor. To assess whether this fibrosis observed on MRI at RTP was associated with re-injury risk we conducted a joint Aspetar and Dutch study in which we studied a large sample size by pooling the data of the Aspetar and the Dutch-HIT study cohorts³⁴. In this prospective study on 108 hamstring injuries with a 1-year follow-up we observed that at RTP, 41 athletes (38%) had fibrosis on MRI with a median volume of 1.5 cm³ (interquartile range 1.5 to 3.9). In

both the athletes with and without fibrosis 24% sustained a re-injury. Thus, the MRI-detected fibrosis was not associated with re-injury risk.

During our research work in recent years we have experienced that, in the field of hamstring research, fibrosis as a cause of re-injury was practically considered a fact, although there is no actual clinical evidence to support this. The results of our study do not support this current general belief that fibrosis is an important factor in the aetiology of muscle re-injuries.

COMPLETE HAMSTRING RUPTURES

The exception where imaging can be of additional value?

We think there is an indication for additional imaging in case of a suspected complete hamstring rupture, often an avulsion of one or more of the proximal or distal hamstring tendons. These rare conditions should not be missed as they are associated with a prolonged recovery and may lead to functional impairments³⁵. Surgical fixation may be indicated, but controlled trials are lacking. Additional imaging can help to confirm the diagnosis, may guide decision making regarding surgery and also has value in the pre-operative planning.

CONCLUSION

Clinical parameters are most valuable for predicting the time to RTP. MRI does not seem to provide additional information on time to RTP prognosis in hamstring injuries. Despite the prognostic value of the

identified clinical parameters, the individual prognosis on the time to RTP remains inaccurate. Providing such a prognosis should be done with caution, as it may lead to unrealistic expectations.

At RTP, MRI does not help us assess readiness for RTP and re-injury risk. Both the extent of the oedema and the fibrosis on MRI are not associated with re-injury risk. Unfortunately, there are still no validated criteria to assess readiness for RTP after acute hamstring injury. Clinical monitoring after RTP can identify those athletes at higher risk for re-injury.

In conclusion, in RTP prognosis, RTP decision making, and re-injury risk assessment, we should rely on our clinical findings; MRI currently has almost no additional value.

References

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