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A Comparison Between Clinical Assessment and Magnetic Resonance Imaging of Acute Hamstring Injuries

Michal E. Schneider-Kolsky,[*†‡] PhD, Jan Lucas Hoving,[§] PhD, Price Warren,[‖] BAppSc, and David A. Connell,[‡¶] FRANZCR

From the [†]Department of Medical Imaging and Radiation Sciences, Monash University, Clayton, Victoria, Australia, the [‡]Department of Medical Imaging, Victoria House Private Hospital, Prahran, Victoria, Australia, the [§]Department of Epidemiology and Preventive Medicine, Monash University, Alfred Hospital, Melbourne, Victoria, Australia, the [‖]Centre for Health, Exercise and Sports Medicine, University of Melbourne, Victoria, Australia, and the [¶]Department of Radiology, Royal National Orthopaedic Hospital, Brockley Hill, Stanmore, Middlesex, United Kingdom

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Background: Physicians evaluating hamstring strains in professional football players are increasingly turning to magnetic resonance imaging to support the clinical diagnosis and management of the injury. However, little information is available to assess how magnetic resonance imaging compares with the clinical evaluation in establishing the duration of rehabilitation required.

Hypothesis: Magnetic resonance imaging of hamstring strains can be useful in determining duration of rehabilitation.

Study Design: Cohort study (Diagnosis); Level of evidence, 1.

Methods: Fifty-eight professional football players with a diagnosis of hamstring injury made by the team physician were enrolled in the study. All players underwent magnetic resonance imaging and a clinical evaluation by an independent physical therapist within 3 days of the injury. Presence, type, and location of injury were recorded in each examination. The physical therapist estimated the time required until return to competition, and the radiologist used the length of the injury (coronal view) to establish rehabilitation duration. Both clinicians were blinded to the other modality.

Results: Clinical and magnetic resonance imaging assessments were in agreement in 38 of 58 cases (65.5%). In 18 cases (31.0%), a clinically positive diagnosis was made, but no abnormalities were evident on magnetic resonance imaging. In 2 cases (3.4%), magnetic resonance imaging detected an injury, whereas the clinical examination had negative or equivocal findings. Both clinical examination and magnetic resonance imaging findings were strongly correlated with the actual time required to return to competition ($r = .69$, $P < .001$ and $r = .58$, $P < .001$, respectively). The correlation coefficient between clinical predictions and magnetic resonance imaging findings was moderate ($r = .36$, $P = .006$).

Conclusion: This study shows that magnetic resonance imaging is not required for estimating the duration of rehabilitation of an acute minor or moderate hamstring injury in professional football players.

Keywords: hamstring injuries; magnetic resonance imaging (MRI); physical therapy; rehabilitation

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The professional athlete who strains a hamstring muscle will be evaluated in the first instance by a trainer or physician present during training or competition. Traditionally, a diagnosis will be made at that time point and in many instances the athlete is sent for radiologic assessment to support the clinical diagnosis and provide further assessment of the extent and severity of the injury. The resulting diagnosis is often dependent on a combination of input from both sources and can be used to customize the rehabilitation program and guide the physician and trainer in returning the athlete back to competition.

Muscle injuries may be imaged with either ultrasound or MRI. Magnetic resonance imaging has been the preferred

*Address correspondence to Michal E. Schneider-Kolsky, PhD, Department of Medical Imaging and Radiation Science, Monash University, Clayton, Victoria 3800, Australia (e-mail: michal.schneider-kolsky@med.monash.edu.au).

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modality in recent years and has offered a highly detailed imaging analysis of the extent of injury for elite athletes.[1,4,8,9,16,17] The costs and availability of MRI, however, may preclude the use of this modality for routine assessment of injuries among junior or amateur athletes and those engaged in minor league football or community-level athletic activities in general. In an earlier study, we have shown that sonography is equally sensitive as MRI in assessing the presence of a hamstring injury in the acute stage. However, a more detailed analysis of the injury profile was achieved using MRI, in particular during the healing phase.[3]

Sports clinicians and physical therapists who assess the injuries of athletes firsthand continue to question the costs involved and the additional perceived benefits of imaging, whether sonography or MRI, in assessing the time of rehabilitation required for minor (grade 1) and moderate (grade 2) hamstring strains. The pain and stiffness associated with such hamstring injuries usually resolve within 1 to 2 weeks, and the player appears clinically normal and, in most instances, resumes training and competition soon thereafter. However, the underlying injury may persist for several weeks longer, contributing to loss of strength and flexibility in the muscle in the weeks after the injury.[3,8,10] Premature return to competition may thus account for the high rate of reinjury observed among Australian Rules footballers.[13,14] Nevertheless, many footballers can return to competition without sustaining a reinjury, despite the persistent injuries demonstrated by MRI.[3] It can be debated whether the assessment of the presence and degree of acute pain and stiffness as measured during a clinical assessment is an equal or better indicator of the prognosis than radiologic findings using MRI.

We undertook this study with the aim (1) to compare estimates of rehabilitation duration based on either a clinical diagnosis or MRI findings with the actual time needed to return to competition and (2) to analyze the level of agreement between clinical and radiologic assessment with regard to presence or absence of injury.

METHODS

Recruitment of Subjects and Selection Criteria

Professional footballers playing in the Australian Football League who received a diagnosis from the trainer or physician of an acute hamstring injury during either training or competition during the 2002 season were invited to participate in the study. The initial diagnosis of hamstring strain was made by the club doctor or physical therapist during training or competition. Players attended the department of medical imaging at our institution within 3 days of the injury, where an independent investigator assessed their eligibility for the study. Players were enrolled if their symptoms included acute onset of posterior thigh pain and if they were unable to complete their training session or game at the time of injury and had pain provocation or deficits during range of motion and strength testing. Players were excluded if they had either a chronic or an ongoing hamstring injury at the time of presentation at the clinic or had contraindications to MRI, including severe claustrophobia, intracranial aneurysm clips, pacemaker, or foreign metallic objects. The study protocol was approved by the hospital human research ethics committee affiliated with our clinic, and all participants gave informed consent.

Data Collection

Players' demographic details and record of previous hamstring injuries were taken immediately on recruitment. The players then proceeded to MRI, followed by a clinical assessment conducted by an independent physical therapist (with more than 10 years of experience in the diagnosis of hamstring injuries) who was blinded to the radiologic findings. A musculoskeletal radiologist with more than 8 years of experience in reporting hamstring injuries interpreted the MRI scans and recorded the pathologic characteristics according to a prespecified protocol (see below). The radiologist recorded the length of injury as observed on coronal views (in millimeters) and, on the basis of this finding, gave an estimate of the recovery time for each case. The estimation of duration of rehabilitation was based on our earlier findings, which showed that the length of the injury on MRI is a good predictor for time required until recovery.[3] Recovery time was defined as the number of days from the initial injury until return to competition (successful completion of game).

Players were monitored throughout the entire playing season for return to competition after the initial injury, as well as recurrence of hamstring strains using a questionnaire that was sent to the treating physical therapist. Only the first hamstring injury during the season was used in the assessment.

Magnetic Resonance Imaging

The players were positioned prone on the table and examined using a 1.5-T superconducting unit (Sigma LX, GE Medical Systems, Milwaukee, Wis). A phased-array surface coil (Shoulder Array, Medrad, Indianola, Pa) was strapped over the thigh and centered over the region of maximal tenderness as identified by the player. A coronal localizing image was obtained followed by these sequences:

1. axial and coronal oblique fast spin echo imaging along the longitudinal axis of the hamstring complex: repetition time/echo time, 4000/45 ef; 512 × 384 matrix; 2 signals acquired; 20-cm field of view; 5-mm section thickness with no gap; echo train length of 8 to 12 and
2. axial and coronal oblique fast spin echo inversion recovery imaging along the longitudinal axis of the hamstring complex: repetition time/echo time, 5000-6500/35-55 TI 120; 256 × 224 matrix; 2 signals required; 20-cm field of view; 5-mm section thickness with no gap.

Outcome Measures (MRI)

The injured area was identified and the following 6 radiologic measures assessed: injured muscle(s) involved, site(s) of injury within the muscle unit, injured area (percentage cross section), length of injured area (mm), presence of intermuscular and presence of intramuscular hemorrhage. Magnetic resonance imaging findings were considered abnormal if abnormal signal intensity or echo texture could be detected. If more than one muscle was injured, the muscle with the greater area of signal or echo texture abnormality was considered the primary site of injury, and assessment criteria were taken for that particular muscle. Magnetic resonance imaging can distinguish between acute, recent, and chronic injuries. Edema is commonly seen after hamstring injuries, and the edema generally requires 6 to 10 weeks to resolve. Hence, the presence of residual edema or blood fluids without obvious muscle damage suggests that a recent injury occurred (in the previous 6-10 weeks). Chronic injuries can be demonstrated by residual scar tissue, which is easily visible on MRI. Scar tissue remains in the previously injured muscle for good, and although the ability of the muscle to lengthen is reduced as a consequence, the power of the muscle remains unaffected by the presence of scar tissue.

Clinical Assessment

The clinical examination was conducted by an independent physical therapist who was blinded to the radiologic assessments. The clinical assessment was performed immediately before or after the MRI and within 3 days of injury onset. Five standard physical therapy tests (described below) were performed on both legs to asses the location and degree of injury of the hamstring muscle(s) and evaluate the degree of pain and stiffness in comparison with the noninjured leg. No particular warm-up or preparation was required of the players before assessment. The tests were performed on a level plinth with the player's head resting on the couch. All measurements were recorded using a standardized data collection form. The 5 tests are outlined below.

Passive Straight Leg Raise (PSLR). The PSLR is a combined measure of hamstring extensibility and/or mobility of pain-sensitive neuromeningeal structures.[2] The noninjured leg was measured first. While in the supine position, the player was asked to completely relax the leg while the physical therapist lifted the leg off the plinth with the knee fully extended. At the first point of reported stretch or discomfort/stiffness (being the same pain/stiffness that the player complained of and in the same region), the angle between the leg and the horizontal was recorded using a bubble inclinometer. The inclinometer was placed on the anterior tibial border at a distance 15 cm below the midpoint of the tibial tuberosity, which was marked in pen with an *X*. These measurements were recorded on the standard assessment form with the number of degrees recorded as either a pain or resistance reading.

Active Knee Extension (AKE). The AKE test is a measure of hamstring muscle length in a position of hip flexion, similar to running, kicking, and striding activities.[6] Players were tested in the supine position with the hip maintained at 90° of flexion against a wooden frame. The noninjured leg was measured first with the thigh vertical and the posterodistal aspect of the thigh resting lightly against the frame. Correct vertical position of the thigh was measured with a spirit level with the lateral femoral condyle being vertically above the most distal palpable point of the greater trochanter. With the ankle relaxed in plantar flexion, the player was asked to actively extend the knee while maintaining light contact with the horizontal part of the frame. A temporary myoclonus of alternating contraction and relaxation of the quadriceps and hamstring muscle groups tends to occur at the maximum angle of AKE. At this point, the player was instructed not to force the leg past the point of initial mild resistance, and the player was then asked to slightly flex the knee until myoclonus ceased. At the first point at which the shaking ceased, the angle between the vertical and the tibia was recorded using an inclinometer. The positioning of the inclinometer was identical to the placement used for the PSLR test. This angle of knee flexion indicates the point of hamstring resistance. With the injured leg, the point of pain onset (being the same pain and in the same place as the player complained of) was measured, and again the number of degrees was recorded. If no pain was felt, the angle of resistance was recorded on the assessment sheet.

Manual Muscle Testing. The manual muscle test in the prone position was performed by asking the player to lift his heel by bending his knee to the point at which the toe was off the couch and asking him to hold that position while a gentle, steadily increasing resistance was applied to the heel (about 15°). The player was instructed to alert the physical therapist of the first sign of pain, that being the same pain in the same place in the posterior thigh that prevented him from continued participation in football. The test was recorded as positive or negative, a positive test result being one in which there was pain and a negative test result being one in which maximum resistance was applied and no discomfort reproduced. This test was repeated with the knee in 90° of flexion and again recorded as a positive or negative result on the standard assessment form. The 2 positions of the manual muscle test were recorded as separate results.

Active Slump. The slump test is used to assess the mobility of pain-sensitive neuromeningeal structures, which have been suggested as a potential source of pain in the posterior thigh presenting as in hamstring injuries.[17] It is performed with the subject in the sitting position while holding thoracolumbar flexion. Knee extension is the measured variable. Limitation of knee extension alone does not indicate a positive result but rather reproduction of symptoms related to cervical spine movements.

In the sitting position with the edge of the plinth in contact with the popliteal fossa at the back of the knee, the player was instructed to clasp his hands loosely behind his back. He was then asked to tuck his chin onto his chest and slump, bringing his shoulders toward his hips. Next, full active dorsiflexion of the foot on the noninjured leg was requested and the player was asked to actively extend his knee until he felt a significant stretch. The angle between the horizontal and the tibia (knee flexion) was measured using the inclinometer. The inclinometer was positioned identically to that of the PSLR and AKE tests, 15 cm below the midpoint of the tibial tuberosity on the anterior tibial border. This test was then repeated for the injured leg with knee extension taken to either the point of resistance as above or hamstring pain onset with the player clarifying that the pain was in

TABLE 1
Criteria for Establishing a Clinical Diagnosis for Acute Hamstring Injuries

Injury	Pain	Deficit in Range of Motion[a]	Estimate of Rehabilitation,[b] d
Grade 1	Nil	Mild	< 7
	Mild	Mild	7-14
Grade 2	Moderate	Moderate	21-28
	Moderate	Severe	> 28
Grade 3	Severe	Severe, with or without presence of palpable gap at site of injury	Surgery

[a]Mild, <10°; moderate, 10° to 25°; severe, >25°. These measurements refer to the difference in range of motion between the injured and noninjured leg. Please note that the prognosis is not based on this measurement alone.
[b]Guide only—rehabilitation time may vary according to confounding factors.

TABLE 2
Characteristics of 58 Professional Male Football Players Presenting With an Acute Hamstring Injury

Characteristic	Mean ± SD
Age, y	24 ± 3.8
Height, cm	186.3 ± 6.0
Weight, kg	87.9 ± 8.7
Dominant leg injured	33/58 (56.8%)
Previous hamstring injury	34/58 (58.6%)

the same region as his injury. The player was then asked to extend his neck to a neutral position and describe the change in sensation that occurred in the hamstring. For the test to be positive, the player's original hamstring pain had to be reproduced and then decreased with cervical extension. Again, this test was repeated, and the mean of the 2 measurements was recorded on the standard recording sheet. Hence, on the injured leg, the active slump was recorded both in degrees and as either positive or negative.

If at least one positive finding (pain or stiffness) was demonstrated during any of the PSLR, AKE, and manual muscle tests (15° and/or 90°) described above, the player was classified as having a hamstring injury. The outcome of the active slump test was used as additional information in cases in which a back-related injury was considered. The outcomes of all tests were used to determine the grade and location of the injury. Criteria for grading of the injuries were based on Oakes.[11] Table 1 illustrates the criteria used by the physical therapist to establish his prognosis. On the basis of these findings, the physical therapist estimated the duration of rehabilitation until successful return to competition.

All data, including radiologic and clinical assessments, were entered into a database by an independent investigator who also performed the statistical analyses. The radiologist and the physical therapist remained blinded to each other's rehabilitation estimates throughout the entire study period. No information was available to either examiner about the type of rehabilitation training allocated to the players by the clubs.

Statistical Analysis

Correlation between successful return to competition and clinical and radiologic findings was performed using Spearman rank order correlation statistics. Strength of relationships was determined a priori as weak (r = .1-.29), moderate (r = .3-.49), or strong (r = .5-1.0). Differences in median estimates between successful return to competition and clinical and radiologic estimations were performed using Wilcoxon signed rank test. The relationship between the overall clinical assessment, the 6 criteria used to evaluate the injury on MRI, and the time required to return to competition was evaluated using multiple regression analysis. Criteria entered included site of injury, longitudinal length of injury (coronal view, mm), cross-sectional area of injury (axial view, percentage of total muscle area), presence of scar tissue, presence of intermuscular hematoma, presence of intramuscular hematoma, and outcome of clinical assessment (presence of injury). Significance was accorded when $P < .05$. All analyses were performed with SPSS (version 12.0, SPSS Science Inc, Chicago, Ill).

RESULTS

Sixty-one consecutively recorded hamstring strains were identified by the club physicians in 61 players during the study period. All of these players were invited to participate in the study. One player refused to participate, and 2 players did not undergo the clinical assessment after consenting and undergoing the MRI. These were excluded from the analysis, leaving 58 players as study participants who fulfilled all the inclusion and exclusion criteria. The median time from injury until assessment at the clinic was 2.0 days (range, 0-3 days). Demographic details of the players are shown in Table 2. Thirty-four of the 58 players (58.6%) presenting for the study had experienced hamstring injuries in previous seasons.

Table 3 shows the level of agreement between clinical and radiologic assessment with regard to presence or absence of injury. Equivalent diagnoses were made in 38 of 58 cases (65.5%). In 18 cases (31.0%), the presence of pain and/or stiffness did not correlate with injury on MRI, but these players recorded abnormalities or pain during the clinical examination. Of those 18, 9 (50%) had suffered a hamstring injury in previous seasons. In contrast, 2 cases (3.4%) showed obvious abnormalities on MRI, but the clinical tests were apparently negative and performed without eliciting any pain or reduced flexion (Figure 1).

Both the duration of rehabilitation based on the clinical assessment and the recorded length of injury as observed on MRI were strongly correlated with actual time to successful competition (r = .69, $P < .001$ and r = .58, $P < .001$, respectively) (Table 4). When the radiologist attempted to predict the time it would take for a player to return to play based on

TABLE 3
Presence of Hamstring Injury in 58 Professional Football Players Based on Clinical Assessment and MRI

	MRI Result					
	Positive		Negative		Total	
	n	%	n	%	n	%
Clinical						
Positive	38	65.5	18	31.0	56	96.5
Negative	2	3.4	0	0.0	2	3.4
Total	40	68.9	18	31.0	58	100

TABLE 4
Correlation Between Predicted Rehabilitation Duration and Actual Rehabilitation Based on a Clinical Assessment, Length of Injury (MRI, Coronal View), and a Radiologic Assessment (MRI) Among Professional Football Players Presenting With a Hamstring Injury

	Actual Rehabilitation r^a	P
Clinical estimate	.69	<.001
Length of injury (MRI)	.58	<.001
MRI estimate	.52	<.006

[a]Spearman rank correlation.

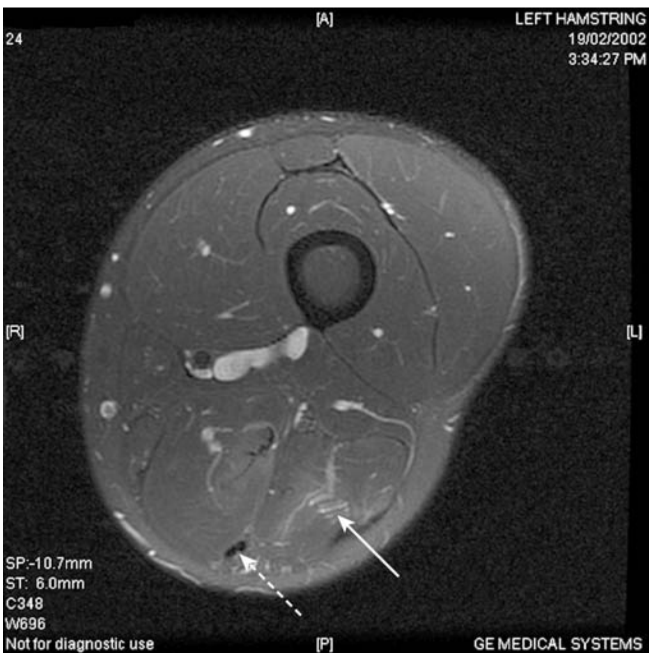

Figure 1. Moderate-grade hamstring injury in a 26-year-old male professional football player in the upper third of the thigh. Axial MRI obtained 2 days after injury demonstrates a recent injury of the biceps femoris (solid arrow). Scar tissue (dashed arrow) surrounding the semitendinosus tendon indicates a chronic injury. A small amount of edema is present, suggestive of an injury that occurred about 6 to 10 weeks before scanning. This player was classified as injury free during the clinical examination, returned to competition after 14 days, and reinjured the same muscle during his first game back.

the length of the injury, the correlation coefficient was slightly lower but was still significantly correlated with the actual time taken to return to competition ($r = .52, P < .001$). Table 5 shows the predicted and actual time of recovery according to grade of injury as assessed in the clinical examination and according to the degree of injury as observed on MRI. Multivariate analysis showed that 4 of the criteria in the model were significant predictors of recovery time, namely the longitudinal length of the injury as observed on coronal images (MRI; $P < .001$), the cross-sectional area of the injury (MRI, axial views; $P = .01$), the site of injury (biceps femoris; $P = .04$), and the grade of the injury as assessed during the clinical test ($P = .001$). None of the other criteria reached statistical significance. The correlation coefficient between clinical prediction of the time it would take for a player to return to play and length of injury as measured on MRI was moderate ($r = .36, P = .006$). Overall, the assessment made by the physical therapist performed slightly better than did the one by the radiologist using MRI.

DISCUSSION

To our knowledge, this is the first study to compare a clinical assessment and prognosis of hamstring injury with a radiologic assessment. We chose to use MRI for this study because it is more reliable than is sonography in demonstrating and measuring the extent of injury and is not operator dependent. In an earlier investigation, we demonstrated that the length of muscle fiber injury when measured on coronal views is strongly correlated with the actual time of rehabilitation needed until return to full training or competition.[3] This measure can therefore be used by less experienced radiologists in assisting and supplementing the clinician's diagnosis.

In 20 of the 58 cases investigated (34.4%), the clinical and radiologic diagnoses were discordant with regard to presence or absence of injury. In 2 cases, the clinical test underestimated the extent of the injury. In 1 of these 2 cases, the physical therapist detected only a minor injury in the hamstring muscle complex, but extensive muscle fiber damage was seen on MRI. This player had some restricted motion on the length and the resistance tests in the biceps femoris (<10° difference) and some pain during the manual muscle testing. On MRI, however, this player had an injury of the biceps femoris involving 80 mm of muscle, with mild intermuscular hemorrhage, as well as a chronic injury to the semitendinosus (Figure 1). The presence of a relatively small amount of edema is suggestive of a recent rather than an acute injury because edemas and blood fluid products tend to resolve slowly over several weeks. Interestingly, the sciatic nerve appeared involved on MRI. An earlier article

TABLE 5
Predicted and Actual Duration of Recovery According to Grade of Injury on Clinical Assessment and According to Injury Characteristics on MRI

			Predicted Duration of Recovery		Actual Duration of Recovery		
	n	%/Total	Median	Range	Median	Range	P^a
Clinical assessment							
All cases	58	100	14.0	0-35	21.0	4-56	<.001
No injury	2	3.4	10.5	7-14	13.5	13-14	.31
Grade 1	25	43.1	7.0	0-21	9.0	5-35	.06
Grade 2	32	55.1	24.0	14-35	27.0	4-56	.32
MRI							
All cases	58	100	14.0	0-42	21.0	4-56	<.001
Length (coronal view)							
No injury	18	31.0	0.0	0-0	8.0	5-28	<.001
<60 mm	9	15.5	7.0	7-21	21.0	4-35	.008
≥60 mm	32	55.1	21.0	35-42	22.5	5-56	<.001
Diameter (axial view)							
No injury	18	31.0	0.0	0-0	8.0	5-28	<.001
<10%	9	15.5	14.0	7-28	24.0	12-35	.008
≥10%	32	55.1	21.0	7-42	21.5	4-56	<.001

[a]Wilcoxon signed rank test.

has demonstrated that patients with lower back pain have restricted range of motion and decreased extensibility of the hamstring muscles. However, this was caused not by hamstring stiffness per se but by the decreased tolerance to stretch in these muscles.[7] The player in our study had a negative active slump test result, was pain free several days after the injury, and returned to competition 14 days after the assessment. During his first competitive game, however, he reinjured the biceps femoris at the same location identified on MRI 2 weeks earlier. He was 26 years old, had suffered several hamstring injuries during previous seasons, and had undergone knee reconstruction surgery (ACL graft) 2 years before our study. We suspect that this player was suffering from a chronic injury as well as lumbar spine dysfunction, which may have been mimicking an acute hamstring strain.[12,15]

The second player in this group was assessed by the physical therapist as having a minor grade 1 injury to the semitendinosus. This player had no previous hamstring injuries, and his rehabilitation was estimated by the physical therapist to take 7 days. On MRI (coronal view), however, he had a 100-mm-long injury to the semimembranosus muscle at the musculotendinous junction (Figure 2). The radiologist estimated a rehabilitation period of 3 weeks. The player returned to competition 13 days after the injury and remained injury free for the remainder of the season.

In 18 cases (31.0%), the clinical assessment suggested an injury to the hamstring, whereas the MRI examination revealed no intramuscular hyperintensity suggesting muscle fiber damage or obvious injury. All cases except one in this group were diagnosed by the physical therapist as grade 1 injuries on the basis of the physical therapy tests, suggesting minor injury only. Eight of those players were able to return to competition within 1 week; 4, within 2 weeks; and 1, at 3 weeks. The one exception in this group was a player who was classified with a grade 2 injury to the biceps femoris on the basis of the physical therapy tests, with a predicted rehabilitation period of 21 days. This player returned to competitive play 28 days after the injury. The MRI scan demonstrated no abnormality. Orchard et al[15] has noted that lumbar spine– related hamstring strains can present clinically as acute hamstring muscle strains, and these are often negative on MRI. This may have been the case in this player; however, the clinical assessment precluded a back-related injury in this player.

In 3 other studies comparing clinical assessment of hamstring strains and MRI, 18%, 19%, and 45% of posterior thigh pain, diagnosed as hamstring strains, were negative on MRI.[5,8,18] A sudden onset of posterior thigh pain occurring after a warm-up period appears to be associated with a positive MRI finding.[19] Lower back–related nerve impingement was suggested as the cause of the hamstring pain and stiffness in the study by Verrall et al,[18] and a previous back injury was identified as a significant risk factor for hamstring-related injuries. The latter study had only 31 participants, and in those players with a negative MRI result, time of rehabilitation was significantly shorter (6.6 days) than in the group with a positive MRI result (20.2 days), indicating that a positive MRI result was a good indicator of time required to return to full training.

Supporting the theory that posterior thigh pain may be contributed to by a lumbar spine–related abnormality[15] is

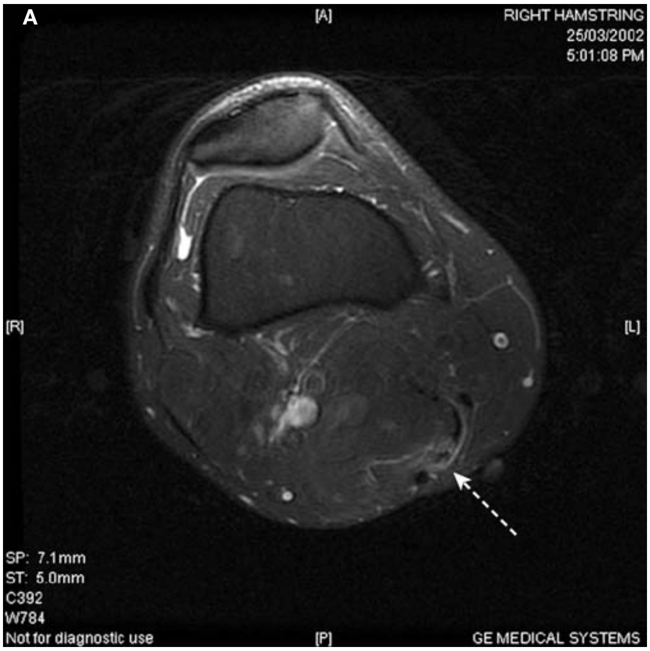

Figure 2. Moderate-grade hamstring injury in a 25-year-old professional football player presenting with suspected hamstring strain on the day of injury. Axial MRI (A) demonstrates injury to the semimembranosus muscle with mild intermuscular hemorrhage (arrow). The coronal view of injury (B) showed hyperintensity extending over approximately 100 mm of the semimembranosus muscle (arrow). Clinical evaluation of this player had negative results, he returned to competition after 13 days, and he remained free from further hamstring injuries for the remainder of the season (5 months).

the fact that 5 of the players in this group in our study apparently sustained an injury but were able to continue to play or train within a short time after the incident. Eight players with a negative MRI result all returned to competitive play after 1 week and did not record a further hamstring injury for the remainder of the season, an outcome similar to that reported by Gibbs et al.[5] In contrast, those players with a positive MRI result needed almost twice the time for successful rehabilitation (22.9 days) and reinjured their hamstrings in 25% of cases later on in the season.

Of interest is the fact that MRI performed better in cases with more serious injuries, those with an injured area of >60 mm or >10% on cross section. In those cases, the correlation between estimated and actual recovery was very high, whereas minor injuries were more difficult to evaluate using MRI with regard to duration of recovery (Table 5). The physical therapist appeared to be more accurate in estimating recovery times in minor injuries.

Although one of the limitations of our study relates to the varying methods of rehabilitation employed by different football clubs, we believe this impact is minimal. The subjects in this study came from the same competition level, having daily access to sports physicians, sports physical therapists, and fitness and training coaches. These rehabilitation teams have similar levels of education and training, with similar treatment and rehabilitation programs for hamstring strains. Players with hamstring injuries usually have daily treatment and rehabilitation sessions and are required to complete 1 or 2 full-pace game-simulation training sessions before returning to competition. Because both the physical therapist and the radiologists in this study were blinded to the rehabilitation approach, we believe that this effect has no impact on the validity of the comparison.

The results reported here have shown that, overall, both a clinical and a radiologic evaluation of the injury can be useful predictors of the duration of rehabilitation required. The clinical evaluation, however, is more accurate than is MRI in predicting the length of time likely to be required before return to play is possible. This result is interesting, given that on multivariate analysis, both types of assessment had a significant predictor of recovery duration, namely the length of injury (MRI) and the grade of injury (clinical; both $P < .001$). Further contributing to the physical therapist's more accurate prognosis may be factors that were not part of the clinical evaluation per se. Such consideration may include the player's general health as well as past injury and surgical history, which were not part of the analysis in this study. In addition, it is possible that the consideration and assessment of lumbar or neural referred pain may further contribute to the diagnosis and prognosis of posterior thigh pain consistent with the diagnosis of hamstring strain. This may include consideration of past history of lumbar problems.

In conclusion, compared with a clinical assessment, a positive MRI result appears useful as a predictor for duration of rehabilitation only in cases of moderate or severe hamstring injuries. Although we did not include any cases that went to surgery, we also believe that it may be helpful in the planning of surgical interventions. The outcomes reported here should provide some valuable feedback to health professionals working with professional football players, as well as other athletes and amateurs with hamstring injuries.

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