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Commentary

Clinical versus radiological findings: A paradox in diagnosing minor hamstring injuries

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ABSTRACT

Hamstring injuries occur commonly in athletes participating in sports that require sprinting/high velocity running, kicking a ball or agility. In the first instance, clinical assessment and management play a pivotal role in managing these injuries. Radiological investigations such as ultrasonography (US) and magnetic resonance imaging (MRI) are also recommended to confirm one or more parameters related to hamstring injury (the location, length, cross-sectional area, volume, edema, hemorrhage, etc.) and predicting return-to-play. However, hamstring injuries that are minor in nature, diagnosed clinically, may not be discernible on conventional US or MRI in some cases. Certain reasons for these paradoxical (clinical vs. radiological) findings may include pain referral to the posterior thigh from lumbosacral dysfunction or sciatic nerve pathoneurodynamics. Conversely, minor hamstring injuries might remain indiscernible within the threshold of conventional MRI sensitivity. To date, there is neither clear consensus on a standardized criteria nor strong evidence for using MRI to prognosticate return-to-play following hamstring injuries. This paper briefly discusses the controversy between contradicting clinical and radiological findings encountered by clinicians in the diagnosis of minor hamstring injuries. If posterior thigh pain appears with clinical signs and symptoms of a minor hamstring injury without pain referral from neighboring structures, but presents with negative findings on US or MRI, the diagnosis remains a challenge. However, such conditions are pragmatically treated as (nonstructural) hamstring injuries unless certain differential diagnoses can be established.

Introduction

Muscle injury is the principal type of injury among athletes participating in explosive power and endurance (athletic) events, and hamstring injuries account for majority of these cases [1]. In fact, a 3-year observational study among track-and-field athletes revealed that hamstring injuries accounted for 24% of all injuries and around 75% of all muscle strains of the lower limb [2]. Typical features of a hamstring injury include sudden onset of pain in the posterior thigh occurring during acceleration or running, leading to instant cessation from a match or a competition, associated pain and/or weakness on resisted knee flexion, pain during passive stretch or straight leg raise, a deficit in the active range of knee extension, and tenderness on palpation of the injured muscle [2–7]. Appropriate early diagnosis and management of hamstring injuries play a pivotal role in aiding early return-to-play (RTP) and preventing recurrence. In most cases of minor hamstring injuries, clinical examination seems sufficient to guide conservative management [8] and predict recovery times [9]. Although clinical assessment remains the mainstay of diagnosis and management of these injuries in community settings, radiological investigations such as ultrasonography (US) and magnetic resonance imaging (MRI) help confirm clinical diagnoses. US is a cost-effective noninvasive technique without ionizing radiation which is useful in identifying partial or complete hamstring tears but less sensitive to avulsion fractures of the ischial tuberosity [10–13]. MRI is the "gold standard" technique for investigating muscle injuries [14] and has been recommended to assess the length, volume, cross-sectional area, and location of injury, and the presence of hemorrhage or edema in the hamstrings [9,12]. However, clinically diagnosed hamstring injuries of less severe grades may not be discernible on MRI [9,15], US [5] or both [16,17]. Whether such cases presenting with negative imaging findings need to be treated as hamstring injuries based solely on clinical diagnosis and reasoning, or not, remains a challenge.

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Clinical and radiological grading of hamstring injuries

Hamstring injuries are classified depending on causative factors (contact/extrinsic or non-contact/intrinsic [stretching-type and sprinting-type] mechanisms) and the location of injury (muscle belly, musculo-tendinous junction or tendon; proximal or distal; medial or lateral hamstring) [13,18–20]. The mechanism of injury can be ascertained using subjective interview and videographic analysis of the circumstances of injury if possible [21]. In addition, the location of injury can be assessed with clinical examination and radiological investigation of the injured site.

The severity of hamstring injury can been clinically graded based on, but not limited to, either the deficit in knee range of motion or the period of absence from sports participation. Schneider-Kolsky et al. (2006) grade hamstring injuries as mild (<10°), moderate (10°–25°) and severe (>25°) based on the deficit in active knee extension range of motion of the injured limb compared to the uninjured side [9]. Later, Malliaropoulos et al. (2010, 2011) further delineated this classification as grades I (<10°), II (10°–19°), III (20°–29°), and IV (>30°) [4,5]. An alternative classification based on the period of absence from sports training and match play categorizes hamstring injuries as minimal/slight (0–3 days), mild (4–7 days), moderate (8–28 days) or severe (>28 days) [15,22]. Interested readers are referred to comprehensive narrative reviews on classification and grading of muscle injuries by Hamilton et al. (2015) [20] and Guermaz et al. (2017) [13] for more details.

Chan et al. (2012) have proposed a new system for classifying acute muscle strains based on imaging that addresses specific localization of the site of injury as proximal, middle and distal, and categorizes muscular lesions as intramuscular, myofascial, perifascial, myotendinous or a combination [23]. Furthermore, a modified Peetrons classification for the imaging diagnosis of muscle injury [15,23–25] includes grades 0–3: grade 0 - no muscle pathology abnormality detected in imaging, grade 1 - lesion involving less than 5% of cross-sectional diameter of the muscle involved (2 mm–1 cm maximum), evidence of edema (feathery pattern) but without any architectural disruption, grade 2 - partial muscle tear with edema, hemorrhage, and architectural disruption involving 5–50% of the muscle volume or cross-sectional diameter, and grade 3 - complete muscle tears or tendon rupture with complete retraction. On MRI, grade 1 and 2 hamstring injuries show aberrant T2-weighted hyper-intensity or edema of a muscle or tendon without (grade 1) or with partial fiber distortion (grade 2) while grade 3 injuries present with complete muscle rupture or tendon avulsion [26,27]. Identification of T2 hyper-intensity at the site of muscle injury is declared as a positive MRI finding for hamstring (strain) injury [28]. On the other hand, in US, fluid collection (hematoma or edema) appears as a less hyperechoic, hypoechoic or anechoic lesion (depending on the time elapsed between injury occurrence and US examination) compared to the normally echogenic tendon with grade 1 injuries, while grade 2 and 3 injuries with torn muscle or tendon fibers manifest as a deficit in the normal monotonous muscle-tendon complex [24,26]. Whenever muscle lesions are not readily identified with MRI or US, they are classified as non-structural injuries owing to lack of evidence of muscle fiber disruption [8,29].

Is imaging investigation an adjunct to support clinical diagnosis of hamstring injuries?

Clinical examination of hamstring injury primarily involves eliciting reproduction of pain with resisted isometric contraction and passive stretch (knee extension with hip flexion) of the hamstrings and tenderness on palpation, quantifying an active knee extension deficit, and observing bruising in the region of the injured site [4–7]. Objective measurement of deficit in active knee extension has been reported to better predict the speed of clinical recovery and risk of reinjury in elite athletes with hamstring injuries confirmed with US [4,5]. Along with clinical assessment, the US and MRI parameters might help estimate the rehabilitation period and time to RTP. MRI findings could assist with correlating the extent of deficit in neuromuscular performance with that of morphological changes in injured hamstrings. For instance, isokinetic strength deficits (≥10%) of the injured leg compared to the uninjured leg [30–32], and MRI signs of muscle injury (T2 hyperintensity) [32,33] are evident in injured hamstrings at RTP.

Due to the financial cost of MRI, these types of investigations are not always feasible [12]. US is an easily accessible and cost-effective technique compared with MRI but US findings primarily rely on the skill of a sonographer [10–13] and there is a chance of misdiagnosing injured muscle (medial vs. lateral hamstrings), old and recent hamstring injuries [17]. Nevertheless, US has been used to diagnose acute hamstring injuries and monitor their course [6], and also measure hamstring muscle thickness during isometric contraction at different angles of knee flexion to assess muscle function following RTP [34]. Both US and MRI have been reported to be a useful combination in analyzing the site and extent of the injury and to monitor the healing process [35].

A combination of clinical and US findings relating to acute muscle injuries (including hamstrings) has been found to be effective in estimating RTP to certain extent [6]. Clinical and MRI assessments of acute hamstring injuries are strongly correlated ($r \geq 0.58$) with the time needed to RTP but clinical prediction to RTP and MRI findings are moderately correlated ($r = 0.36$) [9]. Indeed, rather than US [4] or MRI [9] findings, clinical assessment appears adequate or slightly better than imaging to predict clinical recovery times and RTP. This might be because radiographic diagnosis is usually solely based on imaging parameters while a clinician assesses the relevant history, previous injuries, general health status, and other contributing factors to posterior thigh pain before prognosticating the convalescence period, recovery time, and RTP [9].

Individuals without prior hamstring injury, but with or without current symptoms of proximal hamstring tendinopathy, can present with an enlarged tendon and increased edema in the vicinity of the ischial tuberosity in MRI [36]. An increase in T1 and T2 signal intensity is commonly noticed in the proximal hamstring tendons despite the absence of clinical symptoms indicative of disease or injury. However, peritendinous oedema and increased tendon size are commonly noticed in, but not limited to, symptomatic hamstring tendinopathy [36].

It is plausible that minor hamstring injuries may not be discernible with MRI and/or US [9,28]. Sometimes a positive finding for hamstring strain injury on MRI may not be detected with US or vice versa [17]. Whether a positive MRI or US finding is mandatory to confirm a clinical diagnosis of minor hamstring injury or tendinopathy remains uncertain. MRI [9] or US [4] are recommended for predicting recovery time following rehabilitation for severe hamstring injuries but not for mild and moderate (grade I and II) injuries because clinical prediction to RTP serves better in such cases. Nevertheless, grade II injuries (24%) recur more than grade I (9%), III (8%), and IV (0%) injuries [4]. Furthermore, one study reported lack of recurrence of (clinical) grade I hamstring injuries with negative MRI findings (Modified Peetrons grade 0) in the same season [37].

Studies reporting negative MRI findings for certain individuals presenting with clinical symptoms and signs of hamstring injury are summarized in Table 1. Verrall et al. (2001), Connell et al. (2004) [17], Schneider-Kolsky et al. (2006) [9], and Gibbs et al. (2004) [37]

Table 1
Summary of studies reporting positive and negative imaging findings for individuals with a clinical diagnosis of hamstring injury.

Authors	Cases with a clinical diagnosis of hamstring injury or tendinopathy (n)	Imaging modality					
		MRI		Ultrasonography		MRI and ultrasonography	
		Positive findings n (%)	Negative findings n (%)	Positive findings n (%)	Negative findings n (%)	Positive findings n (%)	Negative findings n (%)
Askling et al., 2013 [21]	86	75 (87)	11 (13)	–	–	–	–
Cohen et al., 2011 [27]	43	41 (95)	2 (5)	–	–	–	–
Connell et al., 2004 [17]	60	42 (70)	18 (30)	45 (75)	15 (25)	36 (60)	9 (15)
Corazza et al. 2013 [35]	13	12 (92)	1 (8)	–	–	–	–
Ekstrand et al., 2016 [15]	299	264 (88)	35 (12)	–	–	–	–
Ekstrand et al., 2012 [22]	207	180 (87)	27 (13)	–	–	–	–
Gibbs et al., 2004 [37]	31	17 (55)	14 (45)	–	–	–	–
Malliaropoulos et al., 2010 [5]	165	–	–	90 (55)	75 (45)	–	–
Schneider-Kolsky et al., 2006 [9]	56	38 (68)	18 (32)	–	–	–	–
Silder et al., 2013 [38]	55	52 (95)	3 (5)	–	–	–	–
Slavotinek et al., 2002 [46]	37	32 (86)	5 (14)	–	–	–	–
Verrall et al., 2006 [7]	35	30 (83)	5 (17)	–	–	–	–
Verrall et al., 2003 [3]	80	68 (85)	12 (15)	–	–	–	–
Verrall et al., 2001 [28]	32	26 (81)	6 (19)	–	–	–	–
Zissen et al., 2010 [16]	35[a] 65[b]	27 (77)	8 (23)	25 (38)	40 (62)	7 (20)	6 (17)

MRI – Magnetic resonance imaging.
[a] Underwent both MRI and ultrasonography: 20 patients showed MRI-positive and ultrasound-negative findings while 2 demonstrated MRI-negative and ultrasound-positive findings of proximal hamstring tendinopathy or peritendinitis.
[b] Underwent ultrasonography.

reported MRI-negative findings of injury for 19–45% of sportspeople clinically diagnosed with hamstring injuries. From Table 1, it is evident that MRI-negative findings for a clinical diagnosis of hamstring injury could range from 5% [27,38] to 45% [37] depending on the severity of hamstring injury and sample size assessed.

The causes for MRI negative findings in cases with a clinical diagnosis of hamstring injury might include pain referred or emanating from the lumbosacral spine or entrapment of the sciatic nerve, and injuries indiscernible within the threshold of MRI sensitivity [3,9,28,37]. A previous lumbosacral spine injury might be a significant risk factor for "back related posterior thigh pain" [28] and more information on risk factors for hamstring injuries is available elsewhere [39]. Moreover, Hunter and Speed (2007) define posterior thigh pain as "pain that is experienced on the posterior thigh, between the ischial tuberosity and the lower border of the popliteal fossa" [40]. Apart from hamstring strain injury, posterior thigh pain could result from ischiogluteal bursitis, ischial tuberosity apophysitis or avulsion fracture, hamstring enthesopathy, "hamstring syndrome" (pain is localized at the ischial tuberosity but radiates to the hamstring muscle during or after physical activity), posterior compartment syndrome of the thigh, abnormal neural tension of the sciatic nerve, piriformis syndrome, myositis ossificans, bone tumours, vascular claudication, spondyloarthropathies or sacroiliitis, and referred pain from the lumbar spine or the sacroiliac joint [41,42]. Nevertheless, Verrall et al. (2003) found that of MRI-confirmed injuries, 91% of hamstring injuries were of sudden onset, 84% occurred after a significant warm-up, and 97% presented with a sudden onset of injury during play after the warm-up period [3]. Those muscle strains which remain indiscernible to MRI or US might require contrast-enhanced techniques [43] if clinicians or researchers are further interested in a radiological diagnosis of injury. However, contrast-enhanced MRI requires injection of chemical substances into the body (gadolinium or gadodiamide) and has associated risks (e.g. nephrogenic systemic fibrosis) [44]. In addition, contrast-enhanced US has not been reported to facilitate the diagnosis of acute muscle injuries [6]. Further studies substantiating the utility of contrast-enhanced MRI or US in diagnosing hamstring injuries are warranted.

People presenting with negative signs of hamstring injury in conventional MRI but with clinical symptoms and signs of hamstring strain remain a challenge to diagnose and treat. Ekstrand et al. (2012) found no evidence of pathological fibre distortion in 70% (145/207) of sportsmen with a clinical diagnosis of hamstring injury. Among them, 13% (n = 27) and 57% (n = 118) presented with MRI grades 0 and 1, respectively. The severity of hamstring injuries for individuals with negative MRI findings (Modified Peetrons grade 0) ranged from minimal to moderate clinical grades based on their time of absence from sports participation. However, severe hamstring injuries (>28 days of absence from sports participation) always presented with positive MRI findings [22].

Askling et al. (2013) investigated football players with hamstring injuries caused by sprinting and stretching activities associated with simultaneous excessive hip flexion and knee extension (commonly occurring during high kicking and slide tackling). Amongst them, all MRI-negative injuries were found to be associated with a sprinting type of injury mechanism [21]. However, the authors also reported cases of MRI-positive injuries sustained during sprinting. Further studies are warranted to substantiate whether hamstring injuries of mild to moderate severity and/or related to sprinting commonly manifest with MRI-negative signs.

Silder et al. (2013) found discordant findings between MRI and clinical diagnosis of the muscle injured (medial or lateral hamstrings) in nine individuals with hamstring injury. Three of these participants did not show any signs of hamstring injury on MRI. It is apparent that a diagnosis based on clinical examination may not exactly identify the muscle injured (medial or lateral hamstrings) which could be confirmed with an MRI. Even so, minor hamstring injuries may not be discernible with MRI investigation [38].

Whenever patients have posterior thigh pain with negative radiological signs for muscle or fascial injury of the thigh and absence of evidence for pain referral from the lumbopelvic spine and/or aberrant sciatic nerve neurodynamics, they should be treated with a diagnosis of 'nonspecific posterior thigh pain'. Although clear guidelines are available regarding the assessment and treatment of hamstring injuries [45], further clinical guidelines to manage 'nonspecific posterior thigh pain' might be of use to clinicians. If individuals demonstrate clinical signs of hamstring injury with or without MRI evidence of muscle strain, therapeutic strategies aimed at rehabilitation of the hamstrings have been implemented [3,9,21,22,37]. Conversely, Slavotinek and colleagues (2002) argued that posterior thigh pain with MRI-negative findings for hamstring injury could plausibly be treated as pain referred from the low back region [46]. Clinicians should remember that patients with hamstring injuries demonstrating MRI-positive findings would show early resolution of clinical symptoms with signs of healing persisting on MRI [38].

A recent systematic review of 12 studies by Reurink et al. (2015) reported that there is no strong evidence for (1.5-T) MRI findings to prognosticate the time of RTP following an acute hamstring injury; 11 of the 12 included studies had a high risk of bias [25]. Moreover, there is moderate evidence [25] to substantiate that hamstring injuries with negative MRI findings are associated with a shorter time of RTP ranging from 6 to 16 days following injury occurrence [3,9,17,21,22,27,37,46].

Individuals with negative MRI findings of hamstring injury have been found to have better prognosis when compared to others with positive MRI findings [3,9,28]. Examinations performed by clinicians (e.g. physical therapists) seem to predict the duration required for recovery, or RTP, more precisely than positive MRI findings for minor hamstring injuries [9]. Having said that, it would be advisable to adhere to clinical diagnosis and management of mild to moderate grade hamstring injuries because routinely performing MRI is not possible for community-level or recreational athletes in primary health care and local sports injury clinics. At the same time, clinicians should be aware that there might be difficulties in precisely locating the muscle injured (medial or lateral hamstrings) and ascertaining the anatomy and extent of injury with clinical examination, and recommending RTP during the convalescence stage might increase the chances of hamstring injury recurrence.

To date, there is no agreement within the literature regarding a standardized criteria on RTP following hamstring injuries [47]. Without a follow-up MRI investigation, there is a risk of advising premature RTP based solely on clinical resolution of symptoms, which does not always coincide with the complete healing of injured muscle evident on MRI. Nonetheless, predicting a safe RTP exclusively based on (MRI and US) imaging parameters is difficult because radiological signs of healing persist despite of resolution of clinical symptoms and imaging modalities are less likely to explicitly reflect structural and mechanical characteristics of the injured muscle [12]. Around 90% of athletes with clinically recovered hamstring strain injuries, cleared for RTP, have been found to exhibit elevated signal intensity within muscles on MRI-sensitive fluid sequences and 34% showed signs of new fibrous tissue formation [33]. Normalization of this MRI signal intensity does not seem to be a mandatory requirement for RTP [33]. However, there might be chances of injury recurrence in some of these athletes owing to changes in myotendinous structure and altered dynamic contraction mechanics following injury [48]. Isokinetic strength deficits and residual oedema have been apparent in injured muscles at RTP but recovered in the following six months despite the presence of muscle atrophy and scar tissue in MRI [32]. Whenever a clinically diagnosed hamstring injury is not responding to muscle rehabilitation strategies, then MRI might be required [13] to confirm the clinical diagnosis, rule out other potential structures at fault, and also plan appropriate intervention based on clinical reasoning.

Imaging investigations can be used as an adjunct to correlate and/or confirm clinical diagnosis of a physical impairment. Even asymptomatic individuals can present with structural aberrations of the proximal hamstring tendon in imaging studies but not present with clinical symptoms that require intervention [36]. Imaging investigations are not always needed or feasible, at least in community settings or private clinics, whenever a clear clinical diagnosis of a minor hamstring injury could be established based on subjective and objective neuromusculoskeletal examination and clinical reasoning. On the other side, along with clinical assessment, MRI is useful for moderate to severe hamstring injuries (Peetrons grades 2 and 3) for guiding the management decision, monitoring the course, and predicting the recovery time of such injuries. Also, MRI would be advantageous for research purposes if a confirmatory imaging diagnosis of hamstring muscle injury is mandated.

Conclusion

The diagnosis of hamstring strain injury is commonly based on clinical assessment and reasoning. US and MRI have been used to confirm the clinical diagnosis of hamstring injury, at least for elite athletes if not for community-level and recreational athletes. Clinical assessment serves better than imaging (MRI or US) in predicting the convalescence period, recovery times, and RTP for mild and moderate (clinical grades I and II [$< 25^\circ$ deficit in active knee extension]) hamstrings injuries. US or MRI have been recommended for planning rehabilitation and predicting RTP for severe hamstring injuries. Clinically diagnosed minor hamstring injuries, minimal to moderate grades (<28 days of absence from sports participation) or grades I and II, might remain indiscernible on conventional MRI or US (Modified Peetrons grade 0) and are recently classified as nonstructural injuries. There is moderate evidence to support early RTP within approximately 2 weeks and a better prognosis for MRI-negative hamstring injuries. The chances for recurrence of hamstring injuries appear to be less for athletes with MRI-negative findings of injury than those with MRI-positive findings, which needs further substantiation. MRI-negative, clinically diagnosed, minor hamstring injuries can be pragmatically treated as hamstring injuries in the absence of differential diagnoses for posterior thigh pain. Although minor hamstring injuries are amenable to clinical examination and conservative management without imaging investigation, MRI could be used to describe the anatomy and extent of injury, tailor the management to the individual, and monitor the course, residual signs of healing, long-term remodeling, and injury recurrence of moderate and severe hamstring injuries.

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Conflict of interest

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Competing interests

None.

Author contribution

AA is solely responsible for conception, design, drafting, revising, critical appraisal, and final approval of the manuscript submitted for consideration by the journal for publication.

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