Excellently reliable for MRI grading and prognostic parameters in acute hamstring injuries

B Hamilton, R Whiteley, E Almus, B Roger, C Geertsema, Johannes L Tol

ABSTRACT

Background Categorical grading and other measurable MRI parameters are frequently utilised for predicting the outcome of hamstring injuries. However, the reliability and smallest detectable difference (SDD) have not been previously evaluated. It therefore remains unclear if the variability in previously reported results reflects reporting variation or actual injury status.

Methods 25 hamstring injuries were scored by two experienced radiologists using the Peetrons grading and specific prognostic MRI parameters: distance from ischial tuberosity (cm), extent (cranio to caudal, anterior to posterior, medial to lateral; cm), maximum cross-sectional area (%), volume (cm³) of the oedema. The interobserver and intraobserver reliability was calculated along with the SDDs for each scale variable.

Results There were 3 Grade 0 (12%), 11 grade 1 (44%), 9 grade 2 (36%) and 2 grade 3 (8%) injuries. Cronbach’s α values for grading were 1.00 (inter) and 0.96 (intra), respectively. The intraclass correlation coefficients for the prognostic MRI parameters were between 0.77 and 1.0. The SDDs varied between each parameter.

Conclusions Excellent interobserver and intraobserver reliability was found for grading and prognostic MRI parameters in acute hamstring injuries. In daily practice and research, we can be confident that scoring hamstring injuries by experienced radiologists is reproducible. The documented SDDs allow meaningful clinical inferences to be made when assessing observed and reported changes in MRI status.

INTRODUCTION

Muscle injuries account for up to 30% of all sporting injuries, with the hamstring complex being the most frequently injured site.1-3 MRI is considered useful in confirming injury diagnosis, severity and prognosis, with categorical and continuous scoring systems constituting validated indicators of time to return to a sport.4-9

A recent cohort study in European football established the clinical relevance of a widely used categorical grading system.10-11 However, hamstring injuries may be considered a heterogeneous group and other researchers have focused on prognostic MRI parameters such as intramuscular location and extent of the injury.7-9 For example, the location, in particular the continuous distance to the ischial tuberosity, has a fair5 to good6 correlation with time to return to preinjury function. Similarly, measurements of the extent of the injury in three planes have shown correlation coefficients between 0.39 and 0.74 (table 1).5-8 With increasing MRI availability, understanding the clinical relevance of each of these variables continues to evolve.

Despite the frequent application of these MRI parameters, there are no data published regarding the reliability and smallest detectable differences (SDDs) in the MRI interpretation of hamstring muscle injuries. As a result, it remains unclear if the variability in study findings reflects a variability in the reporting or actual MRI status. The aim of this study was to evaluate the interobserver and intraobserver reliability and document SDDs of MRI grading and other prognostic parameters in acute hamstring injuries.

METHODS

The investigation formed part of a randomised controlled trial evaluating acute hamstring injuries (ClinicalTrials.gov number NCT01812564). Approval was obtained from the Ethics Committee of Aspetar, Qatar Orthopaedics and Sports Medicine Hospital and informed consent was obtained from all included patients.

Patients were recruited between November 2009 and December 2012 at an orthopaedic and sports medicine hospital in Qatar. For this substudy, 25 patients out of the recruited cohort who met distinct inclusion criteria (acute onset of posterior thigh pain, MRI performed within 5 days from injury, age > 18 years and male) were randomly selected. One investigator randomly selected 25 patients by circling the unique anonymised patient study number on a list of all patients.

MRI

The players were positioned supine and examined with a 1.5 Tesla Siemens Espree. In addition to a phased array coil, two-body matrix coils were strapped over the thigh and centred over the

Table 1 Prognostic MRI parameters

<table>
<thead>
<tr>
<th>Prognostic parameters</th>
<th>References</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from ischial tuberosity</td>
<td>Askling et al</td>
<td>0.54</td>
</tr>
<tr>
<td>Extent of oedema</td>
<td>Askling et al</td>
<td>0.74</td>
</tr>
<tr>
<td>Cranial-caudal</td>
<td>Askling et al</td>
<td>0.51</td>
</tr>
<tr>
<td>Medial-lateral</td>
<td>Askling et al</td>
<td>0.55</td>
</tr>
<tr>
<td>Anterior-posterior</td>
<td>Askling et al</td>
<td>0.39</td>
</tr>
<tr>
<td>Volume</td>
<td>Askling et al</td>
<td>0.61</td>
</tr>
<tr>
<td>Cross-sectional area (%)</td>
<td>Askling et al</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Reported associations between MRI parameters and time to return to sport in hamstring injuries.5-9
painful area, identified by the athlete and marked by the physi-
cian. Axial and coronal proton density with fat saturation along
the longitudinal axis of the thigh (TR/TE 3490/27 and a
512×326 matrix for the coronal images and TR/TE 3000/32
and a 512×333 matrix for the axial images) with one signal
average each were obtained. The field of view used on the cor-
nals was 25 cm and 24 cm with the axial images and a 3.5 mm
section thickness with no gap.

MRI assessment
Prior to the study, two radiologists were familiarised with the
MRI scoring protocol, in a trial involving 10 patients. Each radi-
ologist scored the MRIs in random order between May 2012
and January 2013. Radiologist one (EA), who was also involved
in other hamstring diagnostic studies, scored 128 MRIs in this
period. During this process, MRIs were randomly allocated each
week in sets of 3–5 with at least 2 months between the first and
second evaluations of the same MRI. Radiologist two (BR)
scored sets of 3–5 MRIs on a weekly basis in the same manner.

The radiologists, each with more than 9 years of experience
in musculoskeletal radiology and blinded to the clinical status
of the injury, independently interpreted the MRIs, scoring them
according to a modified Peetrons classification system,10 11
grade 0: no abnormalities; grade I: oedema without architec-
tural distortion; grade II: oedema with architectural distortion;
and grade III: complete tear.

Additional prognostic MRI parameters measured were: cra-
niocaudal, transverse and anteroposterior dimensions (cm)
of identified oedema, and distance from the most proximal site of
oedema to the ischial tuberosity (cm). We subsequently calcu-
lated the volume (cm3) of muscle involved and the maximum
involved cross-sectional area as a percentage of the total muscle
cross-sectional area in the transversal plane.

When more than one muscle was involved, the muscle with
the most extensive oedema or tear was scored.

Data analysis
Interobserver and intraobserver reliability was calculated with
a one-way random model. For the categorical variable of overall
grade, a scoring system (with choices of 0, 1, 2 or 3) per obser-
ver per hamstring injury was recorded.10 11 The interobserver
reliability was calculated with a one-way random model. For the categorical variable of overall


good if 0.4<ICC<0.75 and poor if ICC is <0.4.12 The SDD
was calculated from the inter-rater reliability analysis.

RESULTS
A total of 316 patients met the inclusion criteria, and all
selected 25 MRIs were included in the analysis. Patient charac-
teristics are presented in table 2. There were 3 Grade 0 (12%),
11 Grade 1 (44%); biceps long head (BLH) injuries), 9 grade 2
(36%); 6 BLH 2 semitendinosis (ST) and 1 semimembranosus
(SB) injury) and 2 grade 3 (8%) injuries. The mean values of the
prognostic MRI parameters, reliability and SDD data are pre-

DISCUSSION
In this study, the interobserver and intraobserver reliability
for MRI grading and prognostic parameters in acute hamstring
injuries was excellent. When experienced radiologists report
MRI data on hamstring strain injuries, we can be confident that
the detailed assessment of MRI for injuries in these muscles will
be a reproducible finding. This is an important and clinically
relevant finding when one considers the increased use of MRIs
in the diagnosis and prognosis of hamstring injuries, which has
not been reported previously.

Values for SDDs are critical for our understanding of com-
parative prognosis between patients and continuous evaluation
of individual patients. Despite this, the SDDs for hamstring
muscle evaluation with MRI have not been reported previously.

Table 2 Patient characteristics (N=25)

<table>
<thead>
<tr>
<th>Sports</th>
<th>Football</th>
<th>Handball</th>
<th>Volleyball</th>
<th>Futsal</th>
<th>Athletics</th>
<th>Weightlifting</th>
<th>Waterski</th>
<th>Level of sports</th>
<th>Professional</th>
<th>Competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (min–max)</td>
<td>27.3 years (19–40)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sports</td>
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<td>Level of sports</td>
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<td>Volleyball</td>
<td>Futsal</td>
<td>Athletics</td>
<td>Weightlifting</td>
<td>Waterski</td>
<td>Level of sports</td>
<td>Professional</td>
<td>Competitive</td>
</tr>
<tr>
<td>Professional</td>
<td>24</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Competitive</td>
<td>1</td>
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</tbody>
</table>

Table 3 Mean values (SD), interobserver and intraobserver reliability, 95% CI and SDD of prognostic parameters and grading in 25 acute hamstring injuries

<table>
<thead>
<tr>
<th>Prognostic parameters</th>
<th>Mean (SD)</th>
<th>Inter-rater</th>
<th>Intra-rater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICC</td>
<td>95% CI</td>
<td>ICC</td>
</tr>
<tr>
<td>Distance from ischial tuberosity (cm)</td>
<td>11.0 (6.9)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Extent of oedema</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cranial-caudal (cm)</td>
<td>15.5 (6.2)</td>
<td>0.79</td>
<td>0.62 to 0.89</td>
</tr>
<tr>
<td>Anterionposterior (cm)</td>
<td>2.5 (1.4)</td>
<td>0.92</td>
<td>0.84 to 0.96</td>
</tr>
<tr>
<td>Medial-lateral (cm)</td>
<td>2.5 (1.3)</td>
<td>0.77</td>
<td>0.58 to 0.88</td>
</tr>
<tr>
<td>Volume (cm³)</td>
<td>73.0 (75.3)</td>
<td>0.97</td>
<td>0.93 to 0.98</td>
</tr>
<tr>
<td>Cross-sectional area (%)</td>
<td>23.2 (20.6)</td>
<td>0.97</td>
<td>0.94 to 0.99</td>
</tr>
<tr>
<td>Grading</td>
<td>1.0*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For all ICCs, p value was <0.05. For Grading, Cronbach’s α is presented.
* Cronbach’s α.
ICC, intraclass correlation coefficients; SDD, smallest detectable difference.
The SDD for oedema measurement of approximately 1.0–1.5 cm for three planes highlights that very small differences may accurately reflect true variation in oedema in these planes. The SDDs presented here may be used both when comparing between different patients (for the assessment of relative prognosis), and for serial imaging of the same patient to clarify if the reported changes in MRI parameters (eg, in the length of tear, extent of oedema) are potentially due to measurement error (changes less than the SDD) or not (changes greater than the SDD).

Categorical scales for grading muscle injuries are pragmatic and popular with clinicians and patients. However, the ultimate significance of many of the imaging findings described remains to be determined and, as such, the importance of a clear history and examination must not be lost.

While these data suggest good levels of reliability, it is important to note that this was between two experienced musculoskeletal radiologists, after a familiarisation trial involving 10 patients, using 1.5 Tesla field strength and high-resolution MRI (3.5 mm slices). One should be cautious about extrapolating these data to less experienced radiologists, who may not have such an opportunity for familiarisation and appraisal. In any future research, although our reported ICC was excellent, this may not translate to other studies and use of this reliability finding should be considered essential in any research or analysis of radiological MRI grades sub-groups. However, future research may utilise this reliability and the SDD data to clarify the nature of the relations between MRI parameters and clinical outcomes.

Similarly, future technical developments may deem 1.5 Tesla MRI to have inadequate sensitivity for specific variables of interest in muscle injury diagnosis, as 3.0 Tesla MRI already appears to be clinically more sensitive. However, in all recently published high-level studies, 1.5 Tesla MRI was used to classify the hamstring injury (Ekstrand et al, Askling et al, and Silder et al). Future research may utilise reliability studies on 3.0 Tesla MRI.

In conclusion, this is the first study to evaluate the interobserver reliability and SDD in assessing the MRI grading, location and extent of hamstring injuries. An excellent interobserver and intraobserver reliability was found. The SDDs presented allow clinically meaningful inferences to be made when comparing within-subjects and between-subjects with hamstring muscle injuries.

Contributors BH designed the study, monitored the data collection, interpreted the data, and drafted and revised the paper. RW analysed and interpreted the data and revised the paper. EA and BR analysed the MRIs, interpreted the data and revised the paper. CG interpreted the data and revised the paper. JT designed the study, monitored the data collection, interpreted the data, and drafted and revised the paper.

Competing interests None.

Ethics approval Approval was obtained from the Ethics Committee of Aspetar, Qatar Orthopaedics and Sports Medicine Hospital.

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