Advanced Imaging of Hamstring Injuries in Athletes and Active Patients

Mayo Clinic Sports Symposium 2016

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Rochester, MN
Hamstring Injury Objectives

- Anatomic Pearls/Pitfalls
- MR imaging protocol
- MR anatomy tips/tricks
- Pathoanatomy as related to age and location
- What the orthopedic surgeon needs to know
- Case Examples
- Conclude
Anatomic Hints
where are they going?

- **SMbr deeper/anterior to BF/ST.** Mostly tendon proximally, muscle belly distally

- **Conjoint tendon = BF tendon, ST muscle belly**
  - “*I really just see one defined tendon (BF)*”
  - ST mostly muscle proximally and tendon distally

- Where are they going?
  - ST **medial** (pes anserine)
  - SMbr **middle** (tibia)
  - BF **lateral** (fibular head)
Conjoint tendon (ST/BF)

ST/BF Muscle bellies split 10cm below origin
Sciatic Nerve

12mm from lateral ischial tuberosity

Miller SL et al. JBJS 2007
Proximity of Sciatic Nerve to Hamstrings has Treatment Implications

“one-two fingerbreadths lateral to ischial tuberosity….do no harm”

Requires tedious intraoperative neurolysis due to scar tissue especially with large cystic hematoma cavities, and chronic tears with significant scarring
Sacrotuberosous Ligament: Relationship to Normal, Torn, and Retracted Hamstring Tendons on MR Images

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Figure 6: Schematic drawing of sagittal sections shows the relationship between STL (arrows) and BF-ST tendon. The osseous attachment site of STL (arrowheads) is also shown. TUB = ischial tuberosity. Left: Normal BF-ST tendon. Middle: Detached BF-ST tendon with continuous STL. Right: Detached BF-ST tendon with discontinuous STL. There is less BF-ST tendon retraction with STL continuity and more retraction with STL discontinuity.
Oblique-Axial Hip
MRI Hamstring Protocol

Bilateral exam vs. higher resolution unilateral study?
Possible Advantages of Bilateral Exam

- Direct comparison with unaffected side
  - Complex surgical anatomy
  - Baseline tendon appearance (tendinopathy)
  - Sciatic nerve appearance
  - Muscular atrophy/denervation

Higher Resolution Unilateral Studies are Prettier
Axial

Anatomic Sequence

Fluid-sensitive Sequence
Coronal

Anatomic Sequence

Fluid-sensitive Sequence
Sagittal Fluid-sensitive Sequence
Coronal and Sagittal Images Are Key to Assess Degree of Inferior Retraction of Proximal Avulsions
The adductor magnus “mini-hamstring”: MRI appearance and potential pitfalls

Stephen M. Broski¹ · Naveen S. Murthy¹ · Aaron J. Krych² · Mitchel R. Obey³ · Mark S. Collins¹

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Materials and methods An IRB-approved retrospective review of patients undergoing “hamstring protocol” MRI between March 2009 and June 2014 was performed. Two musculoskeletal radiologists recorded multiple AMMH anatomic characteristics and involvement in cases of hamstring avulsion.

Results Seventy-six AMMHs were analyzed in 66 patients [35 females and 31 males, mean age 49.3 ± 15.2 years (range 17–81)]. Eleven percent of AMMHs were poorly visualized, 51 % visualized, and 37 % well visualized. Seven percent demonstrated round, 73 % ovoid, and 21 % flat/lenticular tendon morphologies. Most (88 %) demonstrated typical origins. Average cross-sectional area (CSA) was 22.4 ± 10.6 mm² (range 6–56), diameter was 7.2 ± 2.5 mm (range 2.9–15), medial distance from the semimembranosus tendon was 7.5 ± 2.5 mm (range 3–14), and tendon length was 6.8 ± 3.3 cm (range 1.2–14.1). There was no gender difference in AMMH anatomic measurements or correlation between age
and CSA or diameter. Of 17 complete hamstring avulsion cases, the AMMH was intact in 13, partially torn in 3, and completely torn in 1.

Conclusion The AMMH is a constant finding with variable anatomic characteristics. It is visualized or well visualized by MRI in 88% of cases and is a sizable tendon located in close proximity to the semimembranosus tendon. Because it is uncommonly completely torn (6%) in cases of complete hamstring avulsion, radiologists should be aware of its presence and appearance to avoid diagnostic confusion.
Sizable Tendon which could easily be confused with SMbr (if SMbr avulsed and retracted)!
Where do injuries occur in the kinematic chain of the hamstring?
...The Weakest Link...

Depends on age and activity of patient
Apophysis

Teno-osseous junction

Tendon Critical Zone

Myotendinous junction

MRI
May not close until early 20’s
Carefully Compare The Ischial Apophyses
Ischial Apophyseal Avulsion Injuries
Information the Orthopedic Surgeon Needs From MR Imaging

- What tendons are torn
- Partial vs. Full thickness
- Exact amount of inferior retraction
- Is there a residual tendon stump
- Degree of apophyseal avulsion in younger pts
- Status of the Sciatic Nerve
  - Post-traumatic edema
  - Large cystic hemorrhagic cavity
  - Evidence of muscle denervation
  - Reminder of close proximity
Clinical Sports Medicine Cases
Case #1

41M with sudden proximal posterior thigh pain while waterskiing
History

  - Felt a “pop” in back of left thigh.
  - Immediate pain and inability to flex knee.
- Seen by local orthopedist, MRI performed.
- Subsequently referred to Mayo Sports Medicine.
  - Evaluated approximately 6 weeks after injury.
- Previous similar injury on right in 2000 (softball). Treated nonoperatively, with persistent weakness.
Physical Examination

- **LEFT:**
  - No ecchymosis or swelling in posterior thigh.
  - Palpable defect in thigh, palpable mass ~15cm distal to ischial tuberosity.
  - Significant weakness with hip extension and knee flexion.
  - Mild medial leg hypoesthesia; NV status otherwise normal.
Patient photograph at time of initial injury
posterior-anterior
Companion Case

...what happens if you don’t do immediate surgery....
HPI: 49F who did the splits while running on treadmill 1-19-06. Significant ecchymosis. Had outside evaluation and MRI showing complete Hamstring avulsion. Treated conservatively with PT, massage, US, leg curls, lunges and stationary bike. Unhappy with the lack of progress, limited strength, and persistent pain.

PHYSICAL EXAMINATION
She shows full active range of motion of her hip joint. She does have mild pain to palpation of her left ischial tuberosity with marked defect in the hamstring lateral musculotendinous attachment to the tuberosity. She shows 4/5 loss of strength to manual muscle testing of her hamstrings prone. However this increases to 3+/5 with her lower leg externally rotated and stays at 4+/5 with her lower leg
Clinical Information
4-13-06

IMPRESSION/REPORT/PLAN
Patient's goals are as noted above. To this end, she was placed on a home exercise program consisting of stretching for her hamstrings and gastroc-soleus groups following application of heat. She will then progress to autoresistive flexion and extension exercises using her right leg; to wall squats; toe raises; standing leg curls off a machine with her lower leg internally rotated and then externally rotated; stool scoots, both forward and backwards; biking with toe clips; swimming or walking in water; and four-way hip exercises using green then blue Thera-Band. She was given permission to use a treadmill or an elliptical running machine as long as she maintained letting pain be her guide. She was instructed in use of ice after activities. She satisfactorily demonstrated all the exercises and appears to be in agreement with our program. I will see her back again in the Sports Medicine Center in six weeks for further evaluation and advancement of her aggressive hamstring program.
Patient returns 6 months later and is unhappy with her lack of progress. Now wants to pursue operative treatment.

MRI ordered.
Management

• Due to amount of hamstring muscular atrophy and edema, EMG ordered to rule out sciatic nerve compromise.

• EMG “Normal”

• Atrophy thought to be due to chronic avulsion/disuse.
Operative Findings

…..”The sciatic nerve was identified and found to be scarred to the ruptured retracted hamstring tendons. Dr. XXXX and I performed a sciatic neurolysis in order to free up the scarred hamstring tendons which were retracted 10 cm distal to the ischial tuberosity. The sciatic nerve was carefully protected throughout the procedure. The ischial tuberosity was then exposed, and the surface was cleaned with an elevator. Two corkscrew suture anchors were then inserted into the tuberosity. A No. 5 FiberWire locking whipstitch was placed in the scarred retracted hamstring tendon ends. The hamstrings were freed of all adhesions and then could be brought up to the ischial tuberosity with the hip in neutral extension and the knee flexed 90 degrees”....
Recent Companion Case

Sciatic Nerve Involvement in acute rupture
Sciatic Nerve thickened, hyperintense, laterally displaced in by large hematoma/edema and avulsed tendon stump.
66M with sciatic nerve dysfunction following outside hamstring repair. Initially injured while playing soccer.
Referred to Mayo Clinic Neurology For Persistent Sciatic Nerve Dysfunction 2nd Opinion
Additional Case Examples
Is MRI clinically indicated/necessary and cost effective in the evaluation of hamstring MTJ strains/partial tears?
Is MRI clinically indicated/necessary and cost effective in the evaluation of hamstring MTJ strains/partial tears?

*Best reserved for professional athletes with financial and performance consequences requiring rapid return to play in-season*
# NFL Week 4 Injury Report

## INDIANAPOLIS COLTS

<table>
<thead>
<tr>
<th>DATE</th>
<th>POS</th>
<th>PLAYER</th>
<th>INJURY</th>
<th>NFL STATUS</th>
<th>FANTASY NEWS</th>
</tr>
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<tr>
<td>09/09/16</td>
<td>DL</td>
<td>Ron Thompson</td>
<td>Undisclosed</td>
<td>QUESTIONABLE</td>
<td>Questionable for Week 4 at Jacksonville</td>
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<tr>
<td>08/21/16</td>
<td>TE</td>
<td>Michael Miller</td>
<td>Undisclosed</td>
<td>OUT</td>
<td>Out for Week 4 at Jacksonville</td>
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<tr>
<td>07/29/16</td>
<td>DL</td>
<td>Arthur Jones</td>
<td>Suspension</td>
<td>SUSPEND</td>
<td>Suspended until Week 5 at Houston</td>
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## JACKSONVILLE JAGUARS

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<th>POS</th>
<th>PLAYER</th>
<th>INJURY</th>
<th>NFL STATUS</th>
<th>FANTASY NEWS</th>
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<td>Questionable for Week 4 vs. Indianapolis</td>
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<td>09/09/16</td>
<td>WR</td>
<td>Tony Washington</td>
<td>Hamstring</td>
<td>QUESTIONABLE</td>
<td>Questionable for Week 4 vs. Indianapolis</td>
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<tr>
<td>09/08/16</td>
<td>DB</td>
<td>Earl Wolff</td>
<td>Hamstring</td>
<td>QUESTIONABLE</td>
<td>Questionable for Week 4 vs. Indianapolis</td>
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<tr>
<td>07/29/16</td>
<td>WR</td>
<td>Justin Blackmon</td>
<td>Suspension</td>
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<td>Suspended indefinitely</td>
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<tr>
<td>07/29/16</td>
<td>DB</td>
<td>Aaron Colvin</td>
<td>Suspension</td>
<td>SUSPEND</td>
<td>Suspended until Week 6 at Chicago</td>
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Diagnostic and Prognostic Value of Clinical Findings in 83 Athletes with Posterior Thigh Injury

Comparison of Clinical Findings with Magnetic Resonance Imaging Documentation of Hamstring Muscle Strain*

Geoffrey M. Verrall,‡ MBBS, John P. Slavotinek,§ FRANZCR, Peter G. Barnes,‡ MBBS, and Gerald T. Fon,‖ FRANZCR

From the †SPORTSMED•SA Sports Medicine Clinic, the §Department of Medical Imaging, Flinders Medical Centre, and ‖Perrett Medical Imaging, Adelaide, Australia

Background: Little is known about the clinical features of posterior thigh injuries and their contribution to accurate diagnosis and prognostic assessment of hamstring muscle strain injury.

Hypotheses: The clinical features of posterior thigh injury can be used to diagnose hamstring muscle strain and to predict duration of absence from competition.

Study Design: Prospective clinical study.

Methods: For two playing seasons, the clinical features of posterior thigh injury, timing of injury, and playing days lost were recorded for Australian Rules football players. Magnetic resonance imaging was used to confirm hamstring muscle injury.

Results: Posterior thigh injuries associated with pain and tenderness were recorded for 83 players, with magnetic resonance imaging confirming hamstring injury in 68 (82%). Most of the hamstring injuries were sudden onset (62; 91%) and occurred after a significant warm-up period (57; 84%). Of the patients whose injuries were sudden onset and occurred after the warm-up period (N = 59), 57 (97%) had hamstring muscle strain detected on magnetic resonance imaging. Hamstring muscle injury confirmed by magnetic resonance imaging was associated with a longer absence from competition (mean, 27 days) than injuries where no hamstring injury was detected (mean, 16 days).

Conclusions: The clinical features of hamstring injury typically include sudden onset, pain, and tenderness, although exceptions do occur. Muscle fatigue may be important in the pathogenesis of hamstring injury.
Hamstring Injuries in Professional Football Players: Magnetic Resonance Imaging Correlation With Return to Play

Steven B. Cohen, MD,*† Jeffrey D. Towers, MD,‡ Adam Zoga, MD,§ Jay J. Irrgang, PhD,‡ Junaid Makda, MD,§ Peter F. Deluca, MD,† and James P. Bradley, MD‡

Background: Magnetic resonance imaging (MRI) allows for detailed evaluation of hamstring injuries; however, there is no classification that allows prediction of return to play.

Purpose: To correlate time for return to play in professional football players with MRI findings after acute hamstring strains and to create an MRI scoring scale predictive of return to sports.

Study Design: Descriptive epidemiologic study.

Methods: Thirty-eight professional football players (43 cases) sustained acute hamstring strains with MRI evaluation. Records were retrospectively reviewed, and MRIs were evaluated by 2 musculoskeletal radiologists, graded with a traditional radiologic grade, and scored with a new MRI score. Results were correlated with games missed.

Results: Players missed 2.6 ± 3.1 games. Based on MRI, the hamstring injury involved the biceps femoris long head in 34 cases and the proximal and distal hamstrings in 25 and 22 cases, respectively. When < 50% of the muscle was involved, the average number of games missed was 1.8; if > 75%, then 3.2. Ten players had retraction, missing 55 games. By MRI, grade I injuries yielded an average of 1.1 missed games; grade II, 1.7; and grade III, 6.4. Players who missed 0 or 1 game had an MRI score of 8.2; 2 or 3 games, 11.1; and 4 or more games, 13.9.

Conclusions: Rapid return to play (< 1 week) occurred with isolated long head of biceps femoris injuries with < 50% involvement and minimal perimuscular edema, correlating to grade I radiologic strain (MRI score < 10). Prolonged recovery (missing > 2 or 3 games) occurs with multiple muscle injury, injuries distal to musculotendinous junction, short head of biceps injury, > 75% involvement, retraction, circumferential edema, and grade III radiologic strain (MRI score > 15).

Clinical Relevance: MRI grade and this new MRI score are useful in determining severity of injury and games missed—and, ideally, predicting time missed from sports.

Keywords: hamstring strain; magnetic resonance imaging; professional football; return to sports
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Clinical Relevance: MRI grade and this new MRI score are useful in determining severity of injury and games missed—and, ideally, predicting time missed from sports.
<table>
<thead>
<tr>
<th>Points</th>
<th>Age, y</th>
<th>Muscles Involved, n</th>
<th>Location</th>
<th>Insertion</th>
<th>Muscle Injury, %</th>
<th>Retraction, cm</th>
<th>Long Axis T2 Signal Length, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>0</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>≤ 25</td>
<td>1</td>
<td>Proximal</td>
<td>Yes</td>
<td>25</td>
<td>&lt; 2</td>
<td>1-5</td>
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<tr>
<td>2</td>
<td>26-31</td>
<td>2</td>
<td>Middle</td>
<td>Yes</td>
<td>50</td>
<td>≥ 2</td>
<td>6-10</td>
</tr>
<tr>
<td>3</td>
<td>≥ 32</td>
<td>3</td>
<td>Distal</td>
<td></td>
<td>≥ 75</td>
<td></td>
<td>&gt; 10</td>
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Table 3. Positions of injured players.

<table>
<thead>
<tr>
<th>Position</th>
<th>n (%)</th>
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<tr>
<td>Defensive back</td>
<td>11 (28.9)</td>
</tr>
<tr>
<td>Wide receiver</td>
<td>9 (23.7)</td>
</tr>
<tr>
<td>Defensive line</td>
<td>6 (15.8)</td>
</tr>
<tr>
<td>Linebacker</td>
<td>5 (13.2)</td>
</tr>
<tr>
<td>Offensive line</td>
<td>4 (10.5)</td>
</tr>
<tr>
<td>Tight end</td>
<td>2 (5.3)</td>
</tr>
<tr>
<td>Kicker</td>
<td>1 (2.6)</td>
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Table 5. Results of games missed by MRI score.

<table>
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<th>Games Missed</th>
<th>Average Points</th>
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<tr>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>3-4</td>
<td>11</td>
</tr>
<tr>
<td>5+</td>
<td>16</td>
</tr>
</tbody>
</table>
Figure 1. MRI of player with prolonged return to play: multiple muscles, high percentage of muscle involvement, and retraction. A, coronal T2-weighted view; B, axial T2-weighted view.
Figure 2. MRI of player with rapid return to play: single muscle and low percentage of muscle involvement. A, coronal T2-weighted view; B, axial T2-weighted view.
Case #6

23M FB player with distal thigh pain

(Case courtesy of Naveen Murthy MD, Bruce Levy MD)
Full Thickness Tear of Distal BF MTJ, Involves SH BF; > 75% of muscle; Retracted > 2cm; Long Axis T2SI 7.5cm = Prolonged Recovery Time (13points/4+weeks)
Objectives – what did we learn?

- Understand pathoanatomy as related to patient age
- Review radiographs carefully, especially in younger patients
- MRI is indicated in apophyseal injuries and proximal hamstring avulsions for surgical planning
- MRI may help predict return to play in professional athletes with MTJ injuries
- Be familiar with challenging MRI findings:
  - Sciatic nerve
  - Adductor Magnus Mini-hamstring
  - STL relationship to CJT
Thank You For Your Attention

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