Imaging lower limb injuries of the myotendinous junction in elite athletes

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**Purpose**

Myotendinous injuries of the lower limb occur due to excessive tensile forces placed through them, which is common in elite athletes playing sports involving sprinting and kicking. The purpose of this poster is to review the most common muscle groups that are subject to myotendinous injury in elite athletes by describing the myotendinous anatomy, imaging techniques and findings that aid diagnosis, management and prognosis.
Methods and Materials

BACKGROUND:

Myotendinous injuries of the lower limb are common in elite athletes and can lead to withdrawal from competitive sporting activity. The myotendinous junction (MTJ) is the most vulnerable point of the musculotendinous unit and is susceptible to strain injuries. The sports activities that usually lead to strain injuries of the MTJ are those that involve sprinting and kicking due to excessive tensile forces through the musculotendinous unit. The most commonly injured muscle groups include the **hamstrings**, **quadriceps**, and **calf muscles**. A comprehensive understanding of the anatomy, injury patterns and image interpretation is essential for prognostication and appropriate management to expedite return to play.

MTJ strain injuries are clinically classified into first, second, and third-degree strains based on the extent of loss of muscle function.

<table>
<thead>
<tr>
<th>1st degree (stretch injury)</th>
<th>pain on passive muscle stretch with no loss of strength or function</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd degree (partial tear)</td>
<td>moderate/severe pain on passive stretch, causes athlete to stop activity, and mild to moderate loss of function</td>
</tr>
<tr>
<td>3rd degree (complete rupture)</td>
<td>severe pain with possibly a palpable defect and loss of function</td>
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</table>

Clinical classification of MTJ injury

ANATOMY AND BIOMECHANICS

The MTJ is a broad interface transitional zone between the tendon and muscle belly rather than a focal point. The risk of MTJ strain injury is increased due to certain anatomical factors including a high content of fast contracting type 2 fibres, the muscle extending across two joints, fusiform muscle shape and eccentric contraction.

**Hamstrings**

The hamstrings extend the hip and flex the knee and are at most risk of MTJ injury during the *swing phase* of sprinting and kicking.
There are 3 muscles that comprise the hamstrings:

a) **Biceps femoris** has two heads. The direct head arises form the anterior inferior iliac spine and the indirect arises from the superolateral acetabular ridge. The two heads join to form the conjoint tendon, which has an anterior superficial component and a more deep posterior component. The anterior component is mainly formed from direct fibres and blends with the anterior fascia below the level of the hip joint. The posterior component is formed mainly from indirect head fibres and forms a long, deep MTJ that extends to the distal 1/3 of the muscle.

b) **Semitendinosus** arises from the ischial tuberosity via the conjoint tendon with the long head of Biceps femoris. The distal part of the myotendinous unit is predominantly tendinous and inserts on to the medial proximal tibia, along with sartorius and gracilis, to form the pes anserinus configuration.

c) **Semimembranosus** arises from the ischial tuberosity and runs deep to semitendinosus and the long head of biceps femoris. At the level of the knee joint, it divides into five insertion arms with the dominant arm inserting into the posteromedial tibial plateau.

**Quadriceps**

The quadriceps are the main knee extensors and are at most risk of injury during forceful hip extension and knee flexion whilst sprinting or kicking. The quadriceps are comprised of 4 muscles:

a) **Rectus femoris** has two heads. The direct head arises form the anterior inferior iliac spine and the indirect arises from the superolateral acetabular ridge. The two heads join to form a conjoint tendon, which has an anterior superficial component and a more deep posterior component. The anterior component is mainly formed from direct fibres and blends with the anterior fascia below the level of the hip joint. The posterior component is formed mainly from indirect head fibres and forms a long, deep MTJ that extends to the distal 1/3 of the muscle.

b) **Vastus lateralis** is the largest of the quadriceps muscles and arises from the proximal femoral shaft and descends the thigh anterolaterally thigh, inserting on to the superolateral patella and on to the lateral tibial condyle (via the knee joint capsule).

c) **Vastus intermedius** arises from the proximal femoral shaft and descends the thigh anteromedially, blending into the deep surface of rectus femoris, vastus lateralis and vastus medialis distally.

d) **Vastus medialis** has two components. The vastus medialis longus arises from proximal femoral shaft and descends the thigh anteromedially, inserting on to the medial
tibial condyle. The vastus medialis obliquus arises from the adductor magnus tendon and
descends the thigh anteromedially, inserting on to the superomedial patella.

Calf muscles

The calf muscles flex the knee, stabilise the ankle, and plantar flex the ankle. They are at
most risk of injury during sudden extension of the knee with the foot in dorsiflexion, which
is often seen in tennis players and the injury is therefore referred to as "tennis leg". Other
athletes at risk include those that perform high-speed sports including skiing, sprinting
and kicking. The calf is comprised of 3 muscles:

a) **Gastrocnemius** is the most superficial of the calf muscles and has two heads. The
medial head is larger than the lateral head and they arise from the posterior surface of the
femur just proximal to the femoral condyles and unite, descending the calf before forming
a flat tendon in the midcalf. This flat tendon joins the soleus tendon to become the Achilles
tendon, which descends posterior to the ankle and inserts on to the posterior calcaneum.

b) **Soleus** arises from the soleal line on the posterior surface of the upper tibia and
from the posterior surface of the upper fibula. It descends the calf and joins the flat
gastrocnemius tendon in the midcalf to become the Achilles tendon, which descends
posterior to the ankle and inserts on to the posterior calcaneum.

c) **Plantaris** arises from the posterior surface of the distal femur, proximal to the lateral
condyle just superomedial to the lateral gastrocnemius head origin, and also from the
oblique popliteal ligament. The muscle descends for a relative short distance before
reaching the MTJ at the level of the origin of soleus at the upper tibia. The plantaris tendon
continues between the medial head of gastrocnemius and soleus and then parallels the
medial edge of the Achilles tendon, on to which it inserts or on to the calcaneus.
Results

IMAGING MODALITIES:

MRI and Ultrasound are the usual imaging modalities of choice for evaluating MTJ injuries with each having their advantages.

<table>
<thead>
<tr>
<th>MRI</th>
<th>Ultrasound</th>
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<tbody>
<tr>
<td>• Better lesion detection</td>
<td>• Worse lesion detection</td>
</tr>
<tr>
<td>• High spatial resolution</td>
<td>• Highest spatial resolution</td>
</tr>
<tr>
<td>• Images easy to interpret by non-radiologists</td>
<td>• Images difficult to interpret by non-radiologists</td>
</tr>
<tr>
<td>• non-dynamic</td>
<td>• Dynamic</td>
</tr>
<tr>
<td>• Expensive and time-consuming</td>
<td>• Relatively inexpensive and quick</td>
</tr>
<tr>
<td>• Operator independent</td>
<td>• Operator dependent</td>
</tr>
<tr>
<td>• First line investigation</td>
<td>• Problem-solving investigation</td>
</tr>
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</table>

The advantages and limitations of MRI vs Ultrasound

MRI protocol

• *Axial T1* - assess anatomy, haemorrhage, muscle atrophy
• *Triplanar fluid sensitive sequence (STIR, FatSat T2, FatSat PD)* - detect oedema in injury. Coronal and saggital sequences permit longitudinal length measurements.
• Surface marker at point of maximal tenderness.

Ultrasound protocol

• High frequency linear probe (9-17Hz).
• Doppler imaging to assess chronicity.

IMAGING FINDINGS:

<table>
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<th>GRADE</th>
<th>MRI</th>
<th>US</th>
<th>Interpretation</th>
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PROGNOSTICATION

1. The greater the cross-sectional area of involvement MTJ injuries, the longer the recovery time and the greater the risk of re-injury later.
2. Injuries involving a greater length of the MTJ, have longer recovery times.
3. The presence of haemorrhage, fluid collections, and distal MTJ involvement is associated with longer recovery times.
4. Follow-up MRI or US can reveal persisting abnormalities and may predict the likelihood of re-injury in those that are symptom-free and have thus returned to competitive sport.
5. Quadriceps MTJ injuries - Vastus injuries have shorter recovery times compared with rectus femoris injuries which may be due to vastus muscles crossing only one joint, being composed of mainly type 1 fibres, and the large synergistic muscle bulk surrounding the injury.
6. Healing of calf muscle injuries is slow and can take up to 4 months for recovery.
Fig. 1: Feathery oedema seen at the MTJ of Biceps femoris is consistent with a Grade 1 injury.

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Fig. 2: Feathery oedema seen at the MTJ of Rectus femoris is consistent with a Grade 1 injury.

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**Fig. 3:** Oedema and intramuscular haematoma formation in the Biceps femoris is consistent with a Grade 2 injury.

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**Fig. 4:** Oedema and intramuscular haematoma formation in Biceps femoris, is consistent with a Grade 2 injury.
Fig. 5: Oedema and intramuscular haematoma formation in the Rectus femoris is consistent with grade 2 injury

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**Fig. 6:** Complete discontinuity at the MTJ of Semimembranosus with haematoma is consistent with Grade 3 injury.

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Fig. 7: Injury to the medial head of gastrocnemius commonly termed "Tennis Leg"

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Conclusion

Myotendinous injuries of the lower limb are common in elite athletes and can lead to withdrawal from competitive sporting activity. A comprehensive understanding of the anatomy, injury patterns and image interpretation is essential for prognostication and appropriate management to expedite return to play.
References

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