Imaging of Injuries to the muscle-tendon-bone complex in children, adolescents and young adults

Poster No.: P-0231
Congress: ESSR 2017
Type: Educational Poster
Authors: D. Howarth, K. A. Kingston; York/UK
Keywords: Paediatric, Musculoskeletal soft tissue, Musculoskeletal joint, Conventional radiography, Ultrasound, MR, Education, Trauma, Athletic injuries
DOI: 10.1594/essr2017/P-0231

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Learning objectives

Injuries to the muscle-tendon-bone complex may be acute or chronic. The effect of acute intrinsic, forced muscle contraction on the muscle-tendon-bone complex changes with increasing skeletal maturity, whilst extrinsic blunt trauma will produce similar appearances across all age groups.

The appearance of chronic overuse injuries will also vary depending on whether the apophysis has fused.

During the course of this presentation we will explore the imaging features of injury to the muscle-tendon bone complex in the paediatric population.
Background

York Hospital catchment population is around 350 000 with 56 000 <16 years. Musculoskeletal injuries are a common reason for imaging in all age groups but the pattern of injury and imaging approach will vary with patient age and skeletal maturity.

Plain films are often the initial imaging modality employed. In young children, ultrasound is often used before MRI as the procedure is well tolerated, quick and does not require sedation or GA which may be necessary to prevent movement artefact in MRI evaluation.

In adults the use of US or MRI for initial evaluation of injury will usually be decided with regard to the mechanism of injury, the structures to be examined and whether dynamic assessment will be helpful. CT is used sparingly in children to limit radiation exposure.

With increasing skeletal maturity the nature of injuries to the muscle-tendon-bone complex will change.

Acute and chronic traction apophyseal injuries can present across a range of commonly injured joints, we will discuss the US and MRI appearances and the relative benefits of each modality.

Occasionally injury may involve only cartilaginous structures and be occult on plain film or extend to include the whole physeal plate and CT may need to be employed. In adolescents and young adults, the injury is more likely to involve the myotendinous junction or occur along intermuscular planes, both US and MR assessment may be of value. Pure tendon injuries are rare in these age groups usually occurring in older adults once the tendons begin to degenerate.
Imaging findings OR Procedure Details

In general skeletal muscle attaches to bone via a muscle tendon bone complex (figure 1), the type of injury varies with age, muscle and skeletal maturity, type of sporting activity and mechanism of injury.

Intrinsic or Distraction Injuries:

Intrinsic or distraction injuries occur with forced muscle contraction and are common in running sports requiring sudden acceleration, weightlifters and gymnasts (ref). Injury occurs from sudden eccentric contraction while the muscle is being lengthened during activity. Predisposing factors which increase risk of this type of injury include: muscle origin and insertion across two joints, eg rectus femoris, biceps femoris and medial gastrocnemius muscles: perform eccentric contraction and have a high percentage of fast twitch, type II muscle fibres used in rapid acceleration. The injury occurs at the myotendinous junction or along the internal aponeuroses. There maybe a strain injury, partial tear or complete muscle rupture. (figure 2)

Apophyseal Injuries:

In children and adolescents the weakest link in the muscle-tendon-bone complex is the attachment of the tendon to the non-ossified cartilage of the apophysis. (figure 3)

Sudden acute apophyseal injuries occur with violent traction tension applied to apophysis from sudden muscle contraction. The apophysis can partially or completely detach, occasionally with complete functional loss. These injuries are most common in the adolescent pelvis and the majority involve the ischial tuberosity, anterior inferior iliac spine (AIIS) or anterior superior iliac spine (ASIS). Pelvic hip apophysitis most commonly affects adolescents between 14 and 18 years of age and usually affects runners, sprinters, dancers and football players. Diagnosis usually apparent on XR (figure 4) but can be diagnosed on US, especially if occurring at an unexpected site (figure 5). MRI may be helpful if the XR appearances are unusual (figure 6) or require further clarification (figures 7 & 8). Occassionally CT may be employed if the injury is deemed to be more complex (figure 9).

Chronic Traction apophysitis results from repetitive traction trauma on the attachment of the tendon to the apophysis, with no time for recovery from the insult before it happens again. This leads to progressive insertional tendinopathy and microtears within the cartilage, progressing to osteochondral fragmentation. The knee is the most common site for traction apophysitis in adolescents, with Osgood-Schlatter's occuring at the distal
patella tendon insertion (figure 10) on the tibial tuberosity apophysis and Sinding-Larsen Johansson syndrome at the proximal origin of the tendon form the patella.

The pelvis is also a common location for chronic traction apophysitis, which may follow non union of the avulsed bone (figure 11).

**Tendon Injuries:**

These injuries usually occur once the tendon attachment to the apophysis has fused, frequently in older adults and acute tears are common in racquet sports.

Acute injury results in partial or full thickness tears that almost exclusively occur in tendons that are abnormal and tendinopathic with mucoid degeneration. Partial thickness tears demonstrate incomplete disruption of tendon fibres and often extend to the tendon surface. Complete full thickness tears involve the entire cross section of the tendon with retraction and a tenon gap filled with haematoma and debris. (figure 12). Chronic overuse tendinopathy is also more common in adults but may occasionally be seen in sporting children (figures 12 &13).
Fig. 1: Muscle-Tendon-Bone Complex

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Fig. 2: (A) Normal muscle tissue has a 'feather like' appearance as the fibroadipose septae between muscle fascicles converge on the aponeuroses. (yellow arrow) (B) Grade 2 gastrocnemius tear. (C) Grade 3 quadriceps injury with retraction of the rectus femoris muscle (arrow) leaving a tendon gap filled with haematoma(*).

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**Fig. 3:** Normal apophyseal appearance: Left: The triceps tendon TT is attached to a thin layer of cartilage surrounding the apophysis (yellow arrow) which is in turn separated from the underlying olecranon by a growth plate (red arrow). Right: Distal Achilles attachment: Yellow arrow = cartilage surrounding apophysis, red arrow = growth plate cartilage.

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**Fig. 4:** Acute Apophyseal Avulsion fracture of the right AIIS (arrow).

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**Fig. 5:** 11 yo with right elbow pain following hockey injury. Medial LS & TS: normal appearance of common flexor CFO attachment to medial epicondyle apophysis.( arrow = growth plate cartilage) Lateral LS & TS: Acute avulsion of the lateral epicondyle apophysis following traction at common extensor CEO attachment. Note widening of growth plate (arrow)

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**Fig. 6:** 15yo with sudden posterior thigh pain during a sprint. XR: irregular lucency in right ischium MRI: confirms avulsion of hamstring apophysis from ischium. This is cartilaginous, hence the slightly unusual plain film appearance.

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Fig. 7: Acute patella tendon avulsion from tibial tuberosity. XR shows soft tissue swelling and a thin strip of bone adjacent to the tibial tuberosity apophysis. MR confirms a partial avulsion at this site.

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**Fig. 8:** Avulsion injury to distal pole of patella: Difficult to appreciate on the XR, the injury is well seen on Sagittal MR.

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**Fig. 9:** 10 yo unable to straight leg raise following football injury: US (A) shows a widened tibial tuberosity growth plate and further fragment of bone adjacent to tibia (yellow arrows) confirmed on CT sagittal reformat (F). (B) a large medial subperiosteal haematoma (long red arrows) was seen on US and subsequent MR (C). (D) the proximal tibial epiphyseal growth plate appeared widened (short red arrow) prompting rare CT evaluation which confirmed a thin metaphseal fracture line making this a more complex injury.

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**Fig. 10:** 13 yo with painful right distal patella tendon. (a) Normal insertion of patella tendon PT onto tibial tuberosity TT. Note the fibrillar pattern of the tendon and the thin layer of
cartilage separating tendon from apophysis (arrow). (b) chronic repetitive traction trauma results in insertional tendinopathy and osteochondral fragmentation with loss of fibrillar pattern and foci of heterotopic ossification (*). (c) Doppler US hypervascularity in distal PT.

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Fig. 11: Chronic apophyseal Avulsion: The red arrows show the left rectus femoris tendon to be thickened, hypoechoic and tendinopathic in comparison to the right. In addition there is elongation of the left AIIS apophysis and a widened growth plate (yellow arrows). This appearance is confirmed on XR and MRI.

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Fig. 12: (A) LS US Normal Achilles tendon: fibrillar pattern of parallel echogenic tendon fibrils. (B) Extended FOV US shows fusiform thickening and hypoechogenicity of the mid Achilles tendon with disruption of the normal fibrillar pattern consistent with tendinopathy. (C) Full thickness tear of mid Achilles with a measured tendon gap containing haematoma and herniation of Kager’s fat pad.

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**Fig. 13:** Achilles Tendinopathy in 11 yo boy. Although less common in children, tendinopathy can occur with altered biomechanics, connective tissue diseases and overuse and has a similar appearance to that seen in adults. There is mild disruption of the fibrillar pattern (yellow arrow), a small fluid collection in the retrocalcaneal bursa (red arrow) and hypervascularity seen on Doppler (B).

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Conclusion

The pattern of injury to the muscle-tendon-bone complex and the imaging algorithm will change with increasing skeletal maturity. It is important that radiologists are aware of these changes and the common imaging findings so that the best method of imaging can be employed.
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Personal Information

Dr Howarth is a final year resident on the Leeds Bradford Training scheme, UK, the work was carried out whilst at York Hospital. Dr Kingston is a Consultant Radiologist at York Hospital, Wigginton Road, York, YO31 8HE, UK.