MRI OF THE ATHLETE WITH ELBOW PAIN

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INTRODUCTION

MRI is commonly used to evaluate athletes with elbow pain. MRI can acquire high resolution images with excellent tissue contrast in multiple planes. It is therefore well-suited for assessing the bones, ligaments, tendons and nerves of the elbow which may all be sources of pain in athletes. MRI is particularly helpful for evaluating athletes with non-localisable elbow pain and athletes with a history of acute trauma to the elbow superimposed on chronic injury from repetitive micro-trauma. Even when the cause of elbow pain in athletes can be diagnosed clinically, MRI can assess the severity of the injury and thereby provides useful information for determining the most appropriate treatment option and estimating recovery time. This article will review the role of MRI in evaluating a wide spectrum of elbow injuries in athletes.

OSSEOUS INJURIES

Osteochondral lesions

Osteochondral lesions comprise the vast majority of osseous injuries in young athletes. Osteochondral lesions typically occur in adolescent baseball pitchers, tennis and squash players and gymnasts who have a history of chronic repetitive micro-trauma to the elbow. Most osteochondral lesions are located within the anterolateral capitellum although there are rare reports of lesions involving the trochlea, radial head and olecranon. Although the exact aetiology of osteochondral lesions is currently unknown, most authors believe that the condition is primarily due to chronic repetitive micro-trauma to the poorly vascularised capitellum. Athletes with osteochondral lesions typically present with pain, tenderness and swelling over the lateral aspect of the elbow. Radiographs may show rarefaction, non-displaced fragmentation or focal defect of the subchondral bone of the capitellum[1].

MRI is commonly used to evaluate athletes with osteochondral lesions of the elbow. MRI is superior to radiographs for detecting early osseous injuries and can determine the exact size and location of the osteochondral lesion. MRI can also be used to assess the stability of the osteochondral lesion which is the single most important prognostic factor that determines its likelihood to heal with conservative therapy. Osteochondral lesions have variable signal intensity on T1-weighted and T2-weighted images. Stable lesions are surrounded by patchy bone marrow oedema or show no surrounding T2 signal abnormality. Unstable lesions are surrounded by a high T2-signal rim or cysts (Figure 1). Displacement of an unstable osteochondral

Figure 1: 16-year-old baseball pitcher with chronic lateral elbow pain who had a surgically confirmed unstable osteochondral lesion of the capitellum. Sagittal fat-suppressed T2-weighted fast spin-echo image of the elbow shows a low signal intensity osteochondral fragment (large arrow) separated from the cancellous bone of the anterior capitellum by a thin, well-defined rim of high signal intensity (small arrow).

Figure 2: 25-year-old baseball pitcher with acute onset of posterior elbow pain. Sagittal fat-suppressed T2-weighted fast spin-echo image of the elbow shows extensive high signal intensity bone marrow oedema within the olecranon process (arrows) consistent with a severe stress injury.

lesion may lead to a focal defect within the articular surface with an associated loose body within the elbow joint[1].

NON-DISPLACED FRACTURES

MRI is commonly used to detect and characterise non-displaced fractures in athletes. MRI is especially useful for detecting non-displaced radial head fractures following acute injury and avulsion fractures of the sublime tubercle due to chronic repetitive micro-trauma which are often difficult to identify on radiographs. MRI can also detect 'little leaguers elbow', a repetitive stress injury of the physis at the medial epicondyle apophysis, during the early stage of the injury before radiographic changes become apparent. MRI is also useful for identifying and assessing the severity of stress injuries to the olecranon process and other bones of the elbow which are especially common in elite baseball pitchers who generate high forces across the elbow joint during the throwing motion (Figure 2)[2].

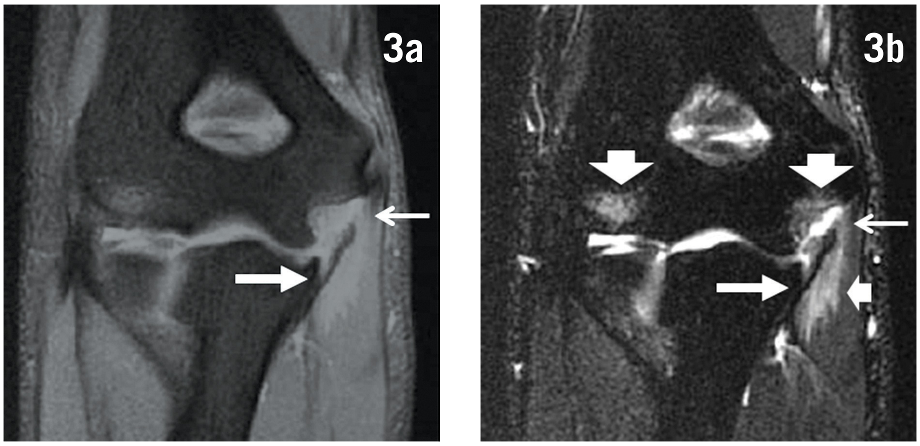
LIGAMENT INJURIES

Ulnar collateral ligament tears

Tears of the ulnar collateral ligament in athletes may occur following acute valgus injury but are more commonly the result of chronic repetitive stress to the elbow elicited by overhead throwing activities. Most athletes with ulnar collateral ligament tears present with medial elbow pain which is most severe during the acceleration phase of the throwing motion. Individuals may also describe a sensation of elbow 'opening' while throwing or decreased ability to maximise velocity or distance during the throwing motion. Most tears of the ulnar collateral ligament involve the anterior bundle which is the primary stabiliser of the elbow joint against valgus and internal rotatory stress. Most anterior bundle tears involve the mid-portion of the ligament although complete soft tissue avulsion of the proximal and distal attachments may also occur. Partial thickness tears of the deep fibre of the distal attachment of the anterior bundle have also been described and are especially common in elite baseball pitchers[3].

MRI may be used to evaluate the ulnar collateral ligament in athletes. MRI has 100% sensitivity for detecting full-thickness tears but only 57% sensitivity for detecting partial-thickness tears of the anterior bundle of the ulnar collateral ligament. The normal anterior bundle of the ulnar collateral ligament appears as a thin band of low signal intensity on coronal T1-weighted and T2-weighted images that extends along the medial joint line of the elbow. The MRI findings of a torn anterior bundle of the ulnar collateral ligament include redundancy, irregularity and poor definition of the ligament and abnormal signal intensity within and surrounding the ligament (Figure 3). The abnormal morphology and signal intensity of the torn ligament is thought to be due to the presence of oedema and haemorrhage. Chronic tears of the anterior bundle of the ulnar collateral ligament are often difficult to detect on MRI due the absence of surrounding soft tissue oedema and haemorrhage[3].

> ***Individuals may describe a sensation of elbow 'opening' while throwing***



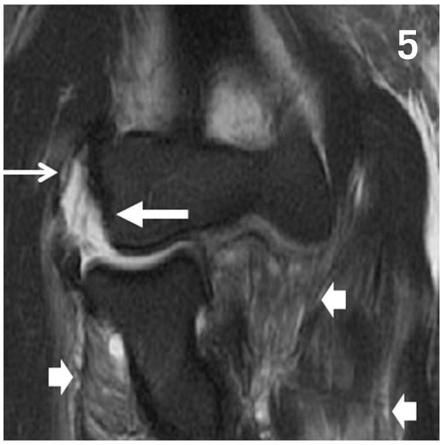


Figure 3: 22-year-old baseball pitcher with acute onset of medial elbow pain who had a surgically confirmed tear of the proximal and distal attachments of the ulnar collateral ligament. a) Coronal fat-suppressed intermediate-weighted fast spin-echo image and b) corresponding coronal fat-suppressed T2-weighted fast spin-echo image of the elbow shows disruption of the proximal (small arrows) and distal (large arrows) attachments of the anterior bundle of the ulnar collateral ligament. Also note the high signal intensity oedema surrounding the torn ligament (small arrowhead) and within the bone marrow of the medial and lateral humeral condyles (large arrowheads).

Figure 4: 26-year-old baseball pitcher with chronic medial elbow pain and decreased throwing velocity who had a surgically confirmed partial-thickness undersurface tear of the distal attachment of the ulnar collateral ligament. a) Coronal fat-suppressed T1-weighted fast spin-echo image of the elbow shows high signal intensity intra-articular contrast extending below the attachment of the anterior bundle of the ulnar collateral ligament at the sublime tubercle (arrow).

Figure 5: 19-year-old American football player with acute onset of lateral elbow pain following varus extension injury who had a surgically confirmed tear of the proximal attachment of the lateral collateral ligament. Coronal fat-suppressed T2-weighted fast spin-echo image of the elbow shows complete disruption of the proximal attachment of the ulnar band of the lateral collateral ligament (large arrow) and partial disruption of the overlying common extensor tendon origin (small arrow). Also note the high signal intensity oedema within the musculature of the elbow (arrowheads).

MR arthrography of the elbow using saline or gadolinium intra-articular contrast can also be used to evaluate the ulnar collateral ligament in athletes. The presence of intra-articular contrast allows for better delineation of the under surface of the anterior bundle of the ulnar collateral ligament and significantly improves the sensitivity for detecting partial-thickness tears. On MR arthrography, the distal insertion of the anterior bundle attaches within 1 mm of the articular margin of the coronoid process of the ulna. Any intra-articular contrast extending below the attachment of the anterior bundle to the base of the coronoid process is abnormal and indicates a partial-thickness tear of the ulnar collateral ligament (Figure 4). A full-thickness tear of the ulnar collateral ligament results in contrast extravasation into the medial soft tissue of the elbow. This finding may be especially useful for detecting chronic tears of the ulnar collateral ligament[4].

Valgus extension overload syndrome

Valgus extension overload syndrome is a condition seen in overhead throwing athletes who have an intact but attenuated ulnar collateral ligament due to chronic repetitive micro-trauma. Attenuation of the anterior bundle of the ulnar collateral ligament allows the posteromedial olecranon tip to impinge against the medial aspect of the olecranon fossa during the throwing motion which results in formation of olecranon tip osteophytes and damage to the articular cartilage of the posteromedial trochlea. Subtle valgus laxity may also lead to excessive tension on the medial soft tissue of the elbow which may cause chronic repetitive injury to the common flexor tendon origin and ulnar nerve. Athletes with valgus extension overload syndrome typically present with chronic vague posteromedial elbow pain. MRI may be useful for diagnosis and for determining the extent of injury to the ulnar collateral ligament, trochlear cartilage, common flexor tendon origin and ulnar nerve[5].

Lateral collateral ligament tears

Tears of the lateral collateral ligament are relatively uncommon in athletes and are typically caused by an acute varus extension injury to the elbow. Lateral collateral ligament injuries primarily consist of full-thickness tears of the

Figure 6: 46-year-old tennis player with chronic lateral elbow pain and a clinical diagnosis of lateral epicondylitis. Coronal fat-suppressed intermediate-weighted fast spin-echo image of the elbow shows thickening and high signal intensity within the common extensor tendon origin (small arrows). Note that the underlying proximal attachment of the ulnar band of the lateral collateral ligament (large arrow) is intact but is thickened and irregular.

Figure 7: 55-year-old golfer with chronic medial elbow pain and a clinical diagnosis of medial epicondylitis. Coronal fat-suppressed intermediate-weighted fast spin-echo image of the elbow shows thinning and high signal intensity within the common flexor tendon origin (small arrow). Note the intact underlying proximal attachment of the anterior bundle of the ulnar collateral ligament (large arrow).

proximal attachment of the ulnar band of the lateral collateral ligament which is the primary stabiliser of the elbow joint against varus and external rotatory stress. Tears of the ulnar band of the lateral collateral ligament result in posterolateral rotatory instability of the elbow. Athletes with posterolateral rotatory instability usually present with a long history of lateral elbow pain and a catching or snapping sensation during movement of the elbow. MRI plays an important role in diagnosis since the condition is often difficult to detect using physical examination and radiographs. The normal ulnar band of the lateral collateral ligament appears as a thin band of low signal intensity on coronal T1-weighted and T2-weighted images that extends along the lateral joint line of the elbow and then crosses posterior to the radial head to insert onto the proximal ulna. The MRI findings of a torn lateral collateral ligament include redundancy, irregularity and poor definition of the ligament and abnormal signal intensity within and surrounding the ligament (Figure 5)[6].

TENDON INJURIES

Lateral epicondylitis

Lateral epicondylitis is a pathologic condition of the common extensor tendon at its origin from the lateral epicondyle. The condition is primarily seen in athletes between 40 and 60 years of age. Lateral epicondylitis is also known as tennis elbow since over 50% of tennis players develop the condition at one time or another. Athletes with lateral epicondylitis present with chronic lateral elbow pain exacerbated by activities that require resisted extension of the wrist. The condition is thought to represent an incomplete healing response to an initial microscopic or macroscopic avulsion injury of the common extensor tendon origin. Lateral epicondylitis typically involves the tendon origins of the extensor carpi radialis brevis muscle and occasionally extensor digitorum communis and extensor carpi radialis longus muscles from the lateral epicondyle[7].

Most athletes with lateral epicondylitis are easily diagnosed using clinical history and physical examination. However, MRI may be useful for determining the extent of tissue damage to the common extensor tendon origin and to exclude other causes of lateral elbow pain in patients who do not respond well to conservative treatment. The normal common extensor tendon origin shows homogenous low signal intensity on both T1-weighted and T2-weighted images. The common extensor tendon origin in athletes with lateral epicondylitis is usually thickened and shows increased T1 and T2 signal intensity. In individuals with severe lateral epicondylis, the common extensor tendon origin may be thinned and show areas of intense fluid-like signal intensity on T2-weighted images (Figure 6). Additional MRI findings include bone marrow oedema of the lateral epicondyle, anconeus muscle oedema and fluid within the radial head bursa[7].

Medial epicondylitis

Medial epicondylitis is a pathologic condition of the common flexor tendon at its origin from the medial epicondyle and is much less common than lateral epicondylitis. The condition is typically seen in athletes between 40 and 60 years of age who are involved in sports activities which generate repetitive valgus and flexion forces at the elbow. Athletes with lateral epicondylitis present with chronic medial elbow pain exacerbated by activities that require resisted flexion of the wrist and pronation of the forearm. The condition is thought to represent an incomplete healing response to an initial microscopic or macroscopic avulsion injury of the common flexor tendon. Medial epicondylitis most commonly involves the tendon origins of the flexor carpi radialis and pronator teres muscles from the medial epicondyle. On MRI, the origin of the common flexor tendon in athletes with medial epicondylitis is usually thickened and shows increased signal intensity on both T1-weighted and T2-weighted images. However, the common flexor tendon origin may be thinned and show areas of intense fluid-like signal intensity on T2-weighted images especially in the advanced stages of the disease process (Figure 7). In contrast, the normal common flexor tendon origin shows homogenous low signal on both T1-weighted and T2-weighted images[8].

Biceps tendon injuries

Distal biceps tendon tears most commonly occur in the dominant extremity of male athletes between 40 and 60 years of age. Tears of the biceps tendon may be partial or complete and typically occur at the insertion site of the tendon into the radial tuberosity. Biceps tendon tears are almost always caused by a single traumatic event in which a sudden extension force is applied to the arm with the elbow flexed 90°. Athletes usually present with an acute onset of pain and swelling in the antecubital fossa of the elbow following a single traumatic event. The exact aetiology of distal biceps

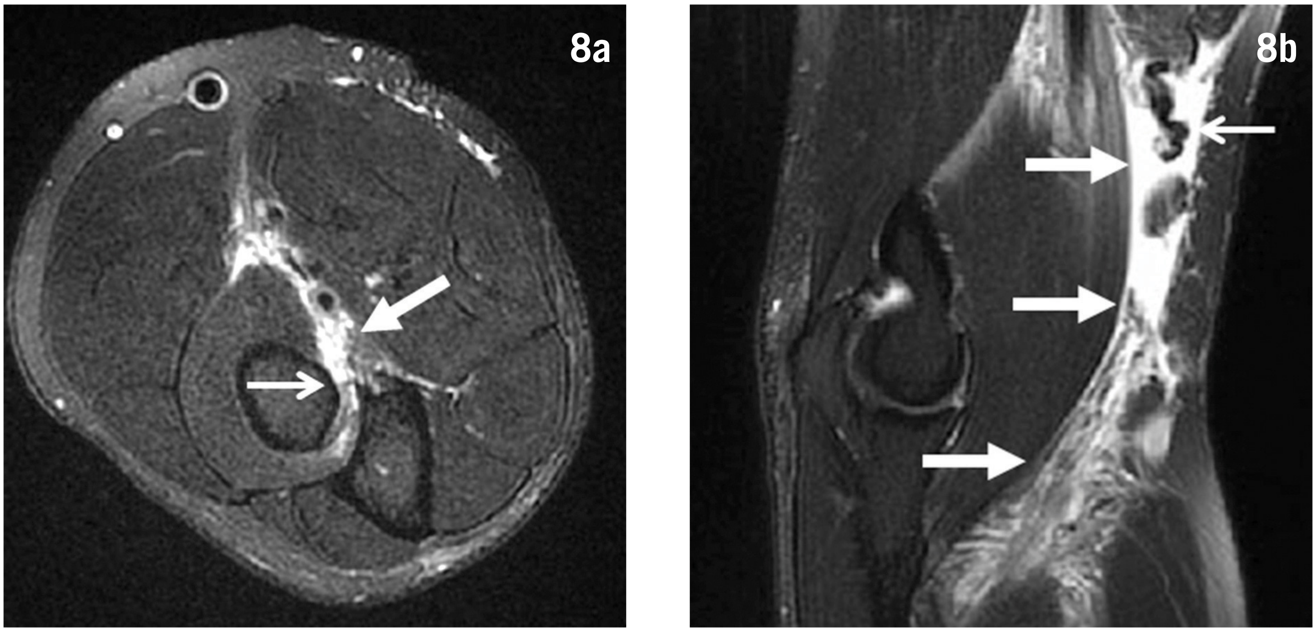


Figure 8: 46-year-old weightlifter with acute onset of anterior elbow pain following injury who had a surgically confirmed full-thickness biceps tendon tear. a) Axial fat-suppressed T2-weighted fast spin-echo image of the elbow shows absence of the low signal intensity distal biceps tendon at its insertion site on the radial tuberosity (small arrow) with surrounding soft tissue oedema within the antecubital fossa (large arrow). b) Corresponding sagittal fat-suppressed T2-weighted fast spin-echo image of the elbow shows proximal retraction of the torn biceps tendon (small arrow) with surrounding soft tissue oedema within the antecubital fossa (large arrows).

tendon tear is currently unknown. However, degenerative factors are thought to play a major role in the pathogenesis as almost all torn biceps tendons show evidence of tendinopathy on histopathologic analysis[9].

MRI may be useful for evaluating athletes with distal biceps tendon tears, especially individuals with partially torn or completely torn but non-retracted tendons which are often difficult to clinically diagnose. The distal biceps tendon is best evaluated on axial T1-weighted and T2-weighted images. Complete tendon tear is characterised by the absence of the low signal intensity distal biceps tendon at its insertion site on the radial tuberosity and by the presence of soft tissue oedema within the antecubital fossa. A variable amount of retraction of the distal biceps tendon is usually noted on sagittal images (Figure 8). Partial tendon tear is characterised by the presence of increased signal intensity within an abnormally thickened or thinned distal biceps tendon. Secondary findings of a partially torn distal biceps tendon include bone marrow oedema within the radial tuberosity and fluid within the bicipitoradial bursa[9].

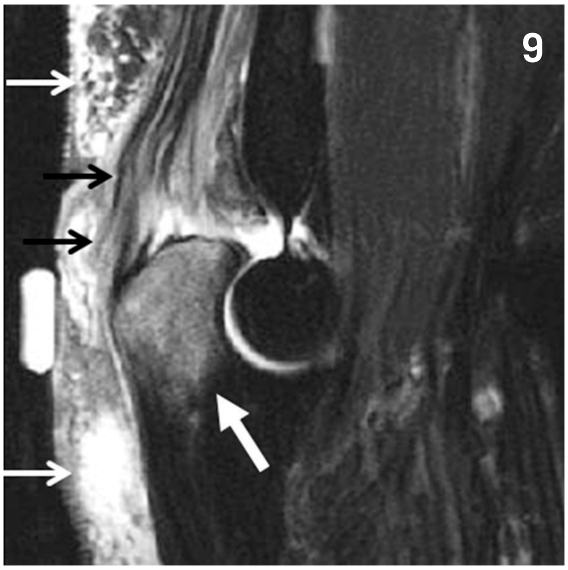
> ***athletes involved in overhead throwing can experience nerve injuries***

Triceps tendon injury

Triceps tendon tears are a rare injury in athletes and occur in both males and females and in individuals of all ages. Tear of the triceps tendon is almost always the result of a single traumatic event such as a fall on an outstretched hand, a direct blow to the posterior elbow or a forceful eccentric contraction of the triceps muscle with the elbow flexed. Most tears occur at the insertion site of the triceps tendon into the olecranon process of the proximal ulna. Individuals with triceps tendon tear usually present with an acute onset of pain and swelling in the posterior elbow following a single traumatic even. MRI may be useful for distinguishing between partial and complete tear of the triceps tendon and for determining the amount of retraction of a completely torn tendon. The triceps tendon is best visualised on sagittal T1-weighted and T2-weighted images. Partial tendon tear is characterised by irregular contour and increased signal intensity within the distal triceps tendon with oedema within the surrounding subcutaneous soft tissue (Figure 9). Complete tear of the triceps tendon is characterised by a large fluid filled gap between the distal triceps tendon and the olecranon process with a large amount of surrounding soft tissue oedema[10].

NERVE INJURIES

Athletes place forceful repetitive stress on the elbow joint which results in chronic traction and compression of the ulnar, radial and median nerves. Compression of the ulnar nerve within the cubital tunnel is by far the most common sports-related neuropathy about the elbow and is typically seen in athletes involved in overhead throwing activities. Athletes with cubital tunnel syndrome usually complain of aching pain and discomfort on the medial aspect of the elbow and proximal forearm. Numbness and paraesthesia in the distribution of the ulnar nerve is commonly present. The ulnar nerve lies within a groove in the posterior aspect of the medial epicondyle with the floor of the cubital tunnel formed by the posterior bundle of the ulnar collateral ligament and the roof formed by the cubital tunnel retinaculum. The ulnar nerve in athletes is spontaneously compressed within the cubital tunnel during forceful elbow flexion



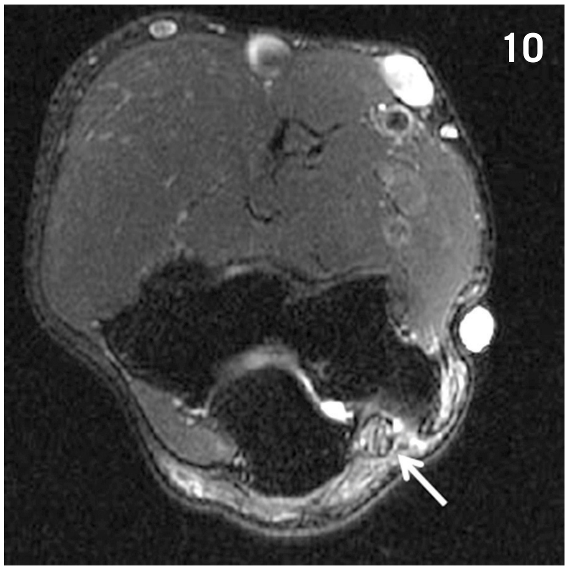


Figure 9: 46-year-old weightlifter with acute onset of posterior elbow pain following injury who had a surgically confirmed partial-thickness triceps tendon tear. Sagittal fat-suppressed T2-weighted fast spin-echo image of the elbow shows irregular contour and increased signal intensity within the distal triceps tendon (black small arrows). Note the high signal intensity oedema within the adjacent bone marrow of the olecranon process (large arrow) and posterior subcutaneous soft tissue (white small arrows).

Figure 10: 25-year-old tennis player with chronic medial elbow pain and a clinical diagnosis of ulnar neuropathy. Axial fat-suppressed T2-weighted fast spin-echo image of the elbow shows focal thickening and increased signal intensity of the ulnar verve within the cubital tunnel (arrow).

which reduces the cross-sectional area of the cubital tunnel. The cubital tunnel retinaculum may also be replaced by the anconeus epitrochlearis muscle in up to 28% of individuals which may further reduce the capacity of the cubital tunnel and cause greater compression of the ulnar nerve[11].

MRI may be useful in evaluating athletes with cubital tunnel syndrome. Inflammatory changes within the ulnar nerve caused by long-standing compression may alter its morphology and signal characteristics. The normal ulnar nerve is of intermediate to low signal intensity on T1-weighted and T2-weighted images. Inflammation may cause increased signal intensity within the compressed nerve which is best visualised on T2-weighted images. Inflammation may also lead to focal or diffuse thickening of the ulnar nerve which may be present both proximal to and at the site of compression (Figure 10). Chronic inflammation of the ulnar nerve in athletes may lead to denervation of the muscle groups which it innervates. While MRI is not reliable at detecting acute denervation, increased signal intensity on T2-weighted images is seen in denervated muscle after approximately one month. Chronically denervated muscle demonstrates atrophy and fatty infiltration which is best visualised on T1-weighted images[11].

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