INTRODUCTION

Groin injuries are one of the most common injuries in high intensity team sports. Despite their high incidence there is very little literature on imaging and diagnosis in acute groin injuries. The available evidence is mainly composed of case studies and older epidemiological studies. Epidemiological studies can guide us with regard to an overview of injury distribution, but studies including hip and groin injuries often group the injuries together, regardless of their onset. This means they include both acute and long-standing injuries for analysis on distribution and severity. Additionally, the majority of epidemiological studies rely on clinical examination alone, and lack specification of the specific structures injured. Some studies even lack differentiation between hip adductor, hip flexor and lower abdominal injuries. This leaves uncertainty on the distribution and importance of the exact muscles injured, as well as the severity of injury.

This article provides an overview of the available literature on acute groin injuries, focusing on studies involving a more detailed description of injuries including imaging. Additionally, we provide illustrations with current experiences from the ongoing research at Aspetar – Orthopaedic and Sports Medicine Hospital.

EPIDEMIOLOGY

One of the first studies, which includes imaging of a subset of acute groin injuries, is a retrospective review of muscle strains between 1982-1991. Fifty patients with acute lower extremity muscle strains were investigated with computerised tomography (CT) or magnetic resonance imaging (MRI). There were 13 injuries to the adductor group and 10 to the quadriceps. Imaging showed involvement of the adductor longus muscle only in all adductor injuries. The majority of the adductor injuries were, however, distally located and could therefore be considered more thigh than groin injuries. For the quadriceps, the injuries were all located in the rectus femoris only, and it is described that the MRI generally showed linear disruptions with intervening high signal indicating injury at the myotendinous junction.

One of the first prospective studies focusing specifically on acute groin injuries and including imaging followed two male soccer leagues for 1 year. They described a total of 25 groin injuries. The injuries were diagnosed using clinical examination, radiography and sonography, however, only half of these injuries were clinically related to the muscle-tendon unit and only one of these could be confirmed on imaging. Despite the large scale, the study left many questions on acute groin injuries unanswered.

A better overview of the distribution can be extracted from a retrospective study investigating all muscle injuries occurring in a soccer team over a 5-year period. Ultrasound examinations and in some cases MRI, was used to confirm the clinical diagnosis. Researchers recorded 103 muscle
strains with 20 of these being adductor and 3 abdominal muscle strains. The quadriceps were involved in 33 cases, however, a further division of structural location of these injuries is not provided. Very few (2 to 4) injuries involved the sartorius and/or iliopsoas.

The largest study focusing on the hip and groin includes 628 hip/groin injuries recorded through seven soccer seasons, accounting for 12 to 16% of all injuries per season. This study shows that the hip/groin diagnoses, including both acute and chronic injuries, varied between 18 entities with adductor injuries being by far the most common (64%), followed by iliopsoas injuries (8%).

Another recent large scale prospective study on groin injuries followed 998 Danish soccer players for a full season. All groin injuries were diagnosed clinically using a clinical entity approach by a physiotherapist allocated to each of the 44 participating clubs. During the study, 58 injuries occurred, of which 39% were acute. Looking at the data we can see that 52% of the acute injuries included the adductor entity, 28% the iliopsoas and 27% abdominal, which shows a higher level of involvement of entities other than the adductors compared to other studies, and also indicates a degree of overlap of entities in some of the cases.

The available epidemiological research in this area shows that adductor injuries, specifically adductor longus muscle strains, appear to be the most common acute groin injury. To get a more detailed description of the subtypes of acute groin injuries through radiological investigations, we have to look into the reported case studies as there are no higher quality studies reporting this.

**ACUTE GROIN INJURY STUDIES**

**Adductor injuries**

Case series involving acute adductor injuries focus primarily on complete tears. The largest case series of adductor ruptures includes a few previously published smaller case series, and reports a total of 19 adductor longus ruptures from the National Football League (NFL). Data was collected retrospectively, including history, physical examination and MRI findings for

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all injuries in the NFL over a 12-year period. Fourteen players (74%) had adductor longus tendon involvement and five players (26%) had both adductor longus and brevis tendon involvement. Tendon retraction varied and was categorised into <1 cm, 1 to 3 cm and >3 cm (2, 10 and 7 injuries, respectively). No statistical significant association was noted between size of the tear on MRI and outcomes. This is, however, most likely due to the small numbers, as the data presented shows that the two injuries with a retraction less than 1 cm had a much shorter time to return to play (4 weeks), compared to almost all the injuries with a retraction greater than 3 cm (3 to 16 weeks). From a clinical perspective it can also be noted that a palpable defect could only be felt in all cases when retraction of the tendon was greater than 3 cm. All players returned to the NFL, and the time to return to play was significantly shorter (P=0.001) for the 14 non-operatively treated players, 6.1±3.1 weeks (range 3 to 12 weeks) compared to 12±2.5 weeks (range 10 to 16 weeks) for the 5 operated players. This large difference might primarily be explained by the difference in the rehabilitation protocols, as the operated players did not start with strengthening exercises until 6 to 8 weeks after surgery, which is longer than the mean for the non-operated players. Randomised controlled studies are therefore still lacking to provide better evidence to the choice between conservative treatment and surgery after complete adductor tears. Additionally, prospective studies on lower grade adductor injuries are needed to contribute to the knowledge about differences in treatment and prognoses on return to play.

Abdominal and iliopsoas injuries

There are reports of abdominal muscle strains, but these usually focus on injuries more cranially located than the groin region. For the rectus abdominis this is just below the umbilical line, and more laterally around the lower costal region for oblique abdominal injuries. These injuries are often related to sports which involve overhead arm movement, such as a service or smash as in tennis and volleyball or throwing in handball and baseball. It can be suspected that distal abdominal injuries, located in the groin region, are more likely to occur with lower limb movement instead, such as kicking. There are however, no studies on these injuries including imaging. The literature focusing on acute iliopsoas injuries is almost non-existent, however, descriptions of other pathological conditions can assist when evaluating the radiological features of the iliopsoas. A case study of four soccer players showed that acute inguinal pain can also be related to the iliopectinal bursa.

Figure 1: Grade II strain of the proximal musculotendinous junction of the adductor longus muscle. MRI axial T2FS image (a) shows a grade II strain involving the proximal musculotendinous junction of the right adductor longus muscle. The ultrasound image of the same patient (b) also shows the strain with haematoma (star) in the gap (arrows).

Figure 2: Avulsion with retraction of the adductor longus tendon. MRI coronal image T2FS shows a complete avulsion of the proximal adductor longus tendon with retraction (arrow).

Figure 3: Avulsion without retraction of the adductor longus tendon. MRI sagittal image T2FS shows a complete avulsion of the proximal adductor longus tendon without retraction due to the integrity of the superficial aponeurosis (arrow).
Rectus femoris injuries

There is more research available about rectus femoris injuries. The importance of distinguishing between injuries involving the proximal direct and indirect tendon, also known as the straight and reflected head of the rectus femoris, was first described in 1995. A more recent study of quadriceps strains in Australian Rules football included 15 rectus femoris injuries and demonstrated that injuries involving the central tendon/aponeurosis, which is the extension of the indirect head, have a significantly longer rehabilitation time (26.9 days) than peripheral injuries (9.2 days). In another study injuries involving the central aponeurosis were described as having a longer time to return to play for soccer players if there is involvement of the proximal part, defined on ultrasound as being located proximal to lateral edge of the sartorius and the medial edge of the rectus femoris (45.1 vs 32.9 days for proximal and distal injuries, respectively). Furthermore, the time until full team training for this type of injury appears to increase with the length of the injury (4.2 days per cm increase). Grade 3 injuries are less common, but both non-operative and surgical treatment of these injuries has been described in a number of studies. The studies appear in favour of conservative management as the RTP time is described to be anywhere from 3 to 10 months after surgical repair\textsuperscript{14-16}, compared to 6 to 12 weeks with conservative treatment\textsuperscript{17}.

It has also been described that pain after a rectus femoris injury can be due to an associated labral tear, which could occur as a result of traction of the indirect head of the rectus femoris on its insertional connection with the superior labrum\textsuperscript{18,19}. Clear evidence of this is, however, still missing and the cause-and-effect relationship remains unconfirmed\textsuperscript{20}.

ASPETAR SPORTS GROIN PAIN CENTRE: ACUTE GROIN PAIN PROJECT

The above overview highlights the need for further knowledge on acute groin injuries. Thanks to the National Sports Medicine Programme, we have an extraordinary opportunity at Aspetar to follow a large cohort of athletes from various sports shortly after injury occurrence. Since the summer of 2012, we have prospectively...
Figure 6: Grade I strain of the iliacus muscle. Axial oblique ultrasound view (a) and MRI axial T2FS image (b) show a grade I strain of the iliacus muscle (arrowheads) involving intermuscular fascia of the iliacus muscle. Note the psoas major tendon is preserved (arrow).

Figure 7: Grade II strain of the iliacus muscle. Axial oblique ultrasound view (a) and MRI axial T2FS image (b) show a grade II strain of the iliacus muscle involving the medial fibres of the iliacus muscle (arrows) along the accessory tendon. Note the psoas major tendon is preserved (arrowheads).

Figure 8: Partial tear of the distal iliopsoas tendon. MRI axial T2FS image shows a partial tear of the distal iliopsoas tendon (arrow) with significant soft-tissue oedema.

Figure 9: Grade I strain of the deep musculotendinous junction of the rectus femoris muscle. Axial ultrasound view shows a 'bullseye' sign of the right rectus femoris muscle with oedema along the central aponeurosis (arrowheads). Comparison with normal appearance of the left central aponeurosis (arrow).
studied all adult male athletes (age >18 years) presenting with acute groin pain at the hospital within 7 days of injury occurrence.

All patients undergo a standardised history, including the type of sport, when the injury occurred and injury mechanism. They also receive a standardised clinical examination and imaging with ultrasound and MRI. The ultrasound is performed in a structured way, where all muscles on the affected side are investigated, and the MRI includes a number of specifically selected standardised sequences. Specific muscle involvement is registered and severity is classified into four grades:

1. Grade 0 injuries (clinical acute groin injury with no radiological abnormality),
2. Grade I (oedema without architectural disruption),
3. Grade II (oedema with architectural disruption/partial tear) and
4. Grade III injuries (complete tear).

So far 70 athletes with an acute groin injury have been included representing a variety of sports. The majority of the athletes are football players, followed by futsal, handball and basketball. The most common injury mechanism is kicking, followed by injuries occurring in various stretch situations or during change of direction. The majority of the injuries have so far occurred in the dominant leg, and the injuries have occurred during training and matches in almost equal proportions.

The preliminary results will soon be reported, and confirm that adductor injuries are most frequent. Of the adductor injuries, the adductor longus is the muscle that has been involved most often, but injuries located in the adductor brevis and pectineus are not uncommon. Injuries involving the proximal rectus femoris and iliopsoas are also frequent, whereas the majority of abdominal groin injuries appear to occur only in connection with adductor injuries.

A detailed description of the pathoanatomical features of all injuries is too extensive for the present article, so we have chosen a few examples of images (Figures 1 to 12), which represent some common findings and differences.

In addition to the current diagnostic procedures, the injured players are now receiving a standardised criteria-based active treatment programme with specialised physiotherapists at Aspetar. This will allow an evaluation of the baseline measures in relation to the time to return to play and re-injury rates. Furthermore players are being followed with various tests during the treatment phases as well as on discharge. At return to play, they also receive an additional MRI and US investigation to examine the healing and the importance of possible remaining radiological findings.

SUMMARY

For such a common injury there is remarkably little evidence on acute groin injuries. The current literature shows that most acute injuries are adductor-related and our preliminary results support the belief that the adductor longus muscle is most frequently injured. Kicking is the most commonly reported injury mechanism in our cohort. As the project at Aspetar develops, we can provide further knowledge on these injuries including more details on time to return to play and possible prognostic factors.
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References