



A proposed algorithm for the treatment of core muscle injuries

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ABSTRACT

In recent years, there has been increased awareness and treatment of groin injuries in athletes. These injuries have been associated with various terminologies including sports hernia, core muscle injury (CMI), athletic pubalgia and inguinal disruption, among others. Treatment of these injuries has been performed by both orthopaedic and general surgeons and may include a variety of procedures such as rectus abdominis repair, adductor lengthening, abdominal wall repair with or without mesh, and hip arthroscopy for the treatment of concomitant femoroacetabular impingement. Despite our increased knowledge of these injuries, there is still no universal terminology, diagnostic methodology or treatment for a CMI. The purpose of this review is to present a detailed treatment algorithm for physicians treating patients with signs and symptoms of a CMI. In doing so, we aim to clarify the various pathologies involved in CMI, eliminate vague terminology, and present a clear, stepwise approach for both diagnosis and treatment of these injuries.

INTRODUCTION

Core muscle injury (CMI), otherwise known as athletic pubalgia (AP), sports hernia or inguinal disruption, represents any of a number of musculotendinous injuries in the peripubic region affecting the structures which insert on the pubis [1, 2]. As a result of the ambiguity in its definition, there is no current consensus on the terminology, appropriate diagnostic work-up or surgical treatment for core muscle injuries [1]. CMI may include multiple pathologies such as rectus abdominis (RA) tendinopathy [3–6], adductor contracture [4–6] or an inguinal hernia [7–9]. Furthermore, although not directly related, additional pathologies have been found to be associated with CMI, including femoroacetabular impingement (FAI) [2, 10–12] and osteitis pubis (OP) [13, 14]. Because core muscle injuries may include both orthopaedic and general surgical pathologies, it is necessary to treat a CMI through a team approach, with a sports medicine-trained orthopaedic surgeon, general surgeon and experienced radiologist involved throughout the care of these patients [1].

As our knowledge of CMI continues to evolve, there is a need to standardize the work-up and treatment of these injuries based on the symptomatic pathologies involved in each individual patient. The Doha agreement [15] previously categorized various types of groin pain in athletes (adductor-, iliopsoas-

pubic-, hip-related, etc.) but did not provide a specific treatment algorithm to accompany this classification scheme. Surgical outcomes, including return to sports, are affected by the type of groin pain in patients diagnosed with a CMI [16]. In a systematic review, Hatem et al. [16] found that 92% of athletes were able to return to preinjury activity levels after surgery to the inguinal region compared to only 75% after surgery to the adductors. This places further emphasis on a need to distinguish between the various pathologies involved in athletic groin injuries. The purpose of this review is to present a detailed treatment algorithm for physicians treating patients with signs and symptoms of a CMI (Fig. 1).

ANATOMY AND INJURY MECHANISM

It is important to understand the anatomy of the peripubic structures in order to help guide physical diagnosis and appropriate treatment recommendations. The RA and adductor longus (AL) are intimately involved in most core muscle injuries, with the RA tendon inserting just anterolateral to the pubic symphysis and the AL tendon inserting distal and lateral to this (Fig. 2) [5]. The transversus abdominis and internal oblique muscles merge to form the conjoint tendon which blends with fibres of the rectus sheath external oblique aponeurosis as they attach to the pubic tubercle [17]. The adductor brevis (AB) tendon inserts distal

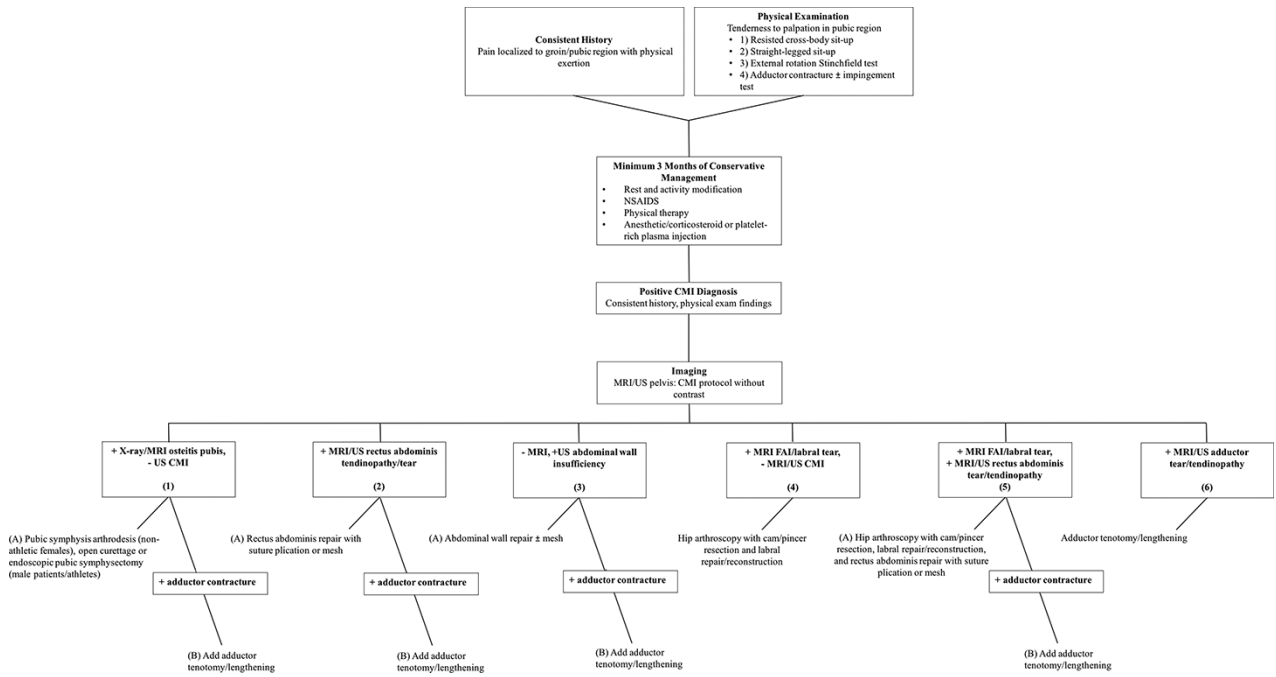


Fig. 1. Proposed algorithm for the treatment of core muscle injury. The different types of CMI are numbered 1–6. CMI: core muscle injury, FAI: femoroacetabular impingement, MRI: magnetic resonance imaging, NSAIDs: non-steroidal anti-inflammatory drugs, US: ultrasound.



Fig. 2. Anatomy of core muscle injuries. Blue = rectus abdominis tendon origin, yellow = adductor longus tendon origin, red = adductor brevis tendon origin, green = gracilis tendon origin, orange = pubic symphysis.

and medial to the AL tendon, and the gracilis tendon inserts distal and medial to the AB [5]. The ‘aponeurotic plate’ is formed by the coalescence of the proximal fibres of the conjoint tendon/rectus sheath and the origins of the AL and gracilis tendons anterior to the pubic symphysis [17]. The genital branch of the genitofemoral nerve lies an average of 4.3 cm lateral to the insertion of the inguinal ligament, and the obturator nerve can be found an average of 2.5 cm lateral to the AL attachment [5].

CMI typically occur in athletes involved in cutting/pivoting activities or lateral acceleration, such as in ice hockey, soccer, football and rugby [2]. These types of movements may place excess stress on the various structures which insert on the pubic symphysis. In some patients, this may result in an ‘imbalance’ between the RA and adductors as they insert on the pubic symphysis [17]. Other theories as to the mechanism of CMI include either a defect or weakness in the posterior inguinal canal which in some cases may result in compression of the genital branch of the genitofemoral nerve [17, 18]. Patients may complain of gradually increasing activity-related lower abdominal and/or proximal adductor-related pain [2]. Following initial injury, pain may be further exacerbated by trunk hyperextension or hip hyperabduction [2].

NON-OPERATIVE MANAGEMENT

As outlined in the sections below, patients with suspected CMI should undergo a thorough work-up to test for various pathologies. If CMI remains the most likely differential diagnosis following work-up, first-line treatment is non-operative for a minimum of 3–6 months [4, 19]. This includes rest and activity modification, nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy, and anaesthetic/corticosteroid or platelet-rich plasma (PRP) injections [4, 13, 20]. The focus of physical therapy in patients initiating non-operative management consists of maintaining pain and oedema control prior to developing coordination and strength of the hip adductors, flexors, internal rotators, extensors, core stabilizers and lumbopelvic spinal musculature [19]. In essence, the goal of physical therapy is to target strengthening and neuromuscular reeducation with regard to timing and recruitment patterns during functional movements [19].

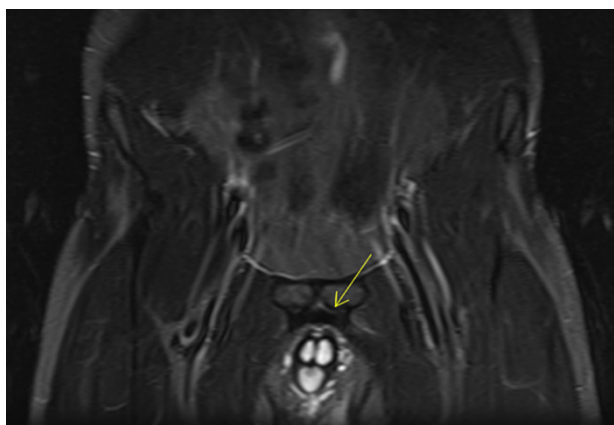


Fig. 3. MRI demonstrating core muscle injury. Coronal T2 fat-suppressed sequence demonstrating linear fluid signal extending to the midline, consistent with left adductor aponeurosis. Example of cleft sign (yellow arrow) indicating a core muscle injury.

While corticosteroid injections may provide fast pain relief, this is often just temporary and may even cause further damage by progressing any tendon tears involved. PRP injections, on the other hand, take longer to exert their effect but in some cases result in complete resolution of a patient's symptoms. Anaesthetic injections may be diagnostic and therapeutic, directed at the adductor tendon insertion [21], pubic symphysis/pubis tubercle or associated aponeuroses [22], hip joint [23] or psoas bursa [23].

RA TENDINOPATHY

RA tendinopathy and tears are among the most common pathologies involved in patients with CMI. Physical examination findings include pain over the RA insertion or pain with resisted sit-ups [4, 8, 24]. Imaging should include magnetic resonance imaging (MRI) of the pelvis. The CMI MRI protocol at our institution consists of coronal short tau inversion recovery (STIR) and T1 large field of view (FOV) (38 cm) sequences and axial T2 fat-saturation, coronal proton density and sagittal STIR small FOV (24 cm) sequences [25]. MRI is considered positive if a tear along the RA-adductor aponeurosis is visualized (Fig. 3) [25]. Other findings associated with an aponeurotic lesion include abnormal marrow signal intensity and a secondary cleft sign [26]. Ultrasound may be useful as well and demonstrates hypoechoic areas along the distal rectus insertion on transverse and linear views [4]. Surgical treatment of a type 2 CMI (Fig. 1) involves RA repair with suture plication or mesh [6, 27, 28].

ADDUCTOR CONTRACTURE AND TENDINOPATHY

In addition to RA tendinopathy, patients with CMI often present with adductor contracture or tendinopathy. Chronic damage to the adductors in cutting sports such as soccer, football and ice hockey may lead to tendon contracture, which may lead to abnormal forces on the pubis resulting in CMI. This may be elicited on physical examination by pain to palpation of the adductor tendons [7, 29] or the presence of an adductor contracture [4]. The adductor squeeze test (Fig. 4) has also been used to



Fig. 4. Adductor squeeze test. The patient lays supine with the hips flexed to 45 degrees and knees flexed to 90 degrees. The cuff of a sphygmomanometer is placed between the knees and the patient is asked to squeeze the cuff as hard as possible. Pressure values may be measured and groin pain with this test is concerning for adductor tendinopathy.

test for adductor tendinopathy [30–32]. As mentioned above, MRI of the pelvis will demonstrate a tear or cleft sign along the RA-adductor aponeurosis (Fig. 3).

Treatment of an isolated adductor contracture (type 6 CMI, Fig. 1) includes release of the AL and/or brevis tendons. If there is pathologic adductor contracture, consideration to tendon lengthening may help in rebalancing forces at the pelvis and potentially decreasing recurrence. Adductor contracture may also occur in conjunction with the other pathologies discussed in this review, and adductor tenotomy/release may be performed in conjunction with other procedures if indicated (Fig. 1). Meyers et al. [33] demonstrated that several patients who did not undergo adductor release continued to have adductor-related pain for >3 months after surgery for AP. Some authors [32, 34] have advocated for release of the AB and gracilis tendons rather than the AL tendon in order to limit significant weakening of the adductor muscles and possibly a slower recovery. However, no studies have directly compared outcomes between these two techniques.

It is also important to be aware of the pyramidalis-anterior pubic ligament–AL complex (PLAC) [35]. Patients presenting with proximal AL avulsion injuries should undergo MRI to assess for integrity of the PLAC [35], and surgical treatment of the pyramidalis may be considered in future studies on these injuries.

INGUINAL HERNIA

Although the term 'sports hernia' is considered a misnomer as these injuries often involve abdominal wall weakening or tearing with no abdominal hernia [36], an abdominal hernia should be ruled out as the primary pain generator in patients presenting with signs and symptoms of a CMI. Patients may have an insidious inguinal hernia, either direct/indirect or a combination of both, a lipoma of the spermatic cord [37], or 'bowing' of the external oblique muscle due to laxity resulting in nerve compression and a CMI presentation. Physical examination should

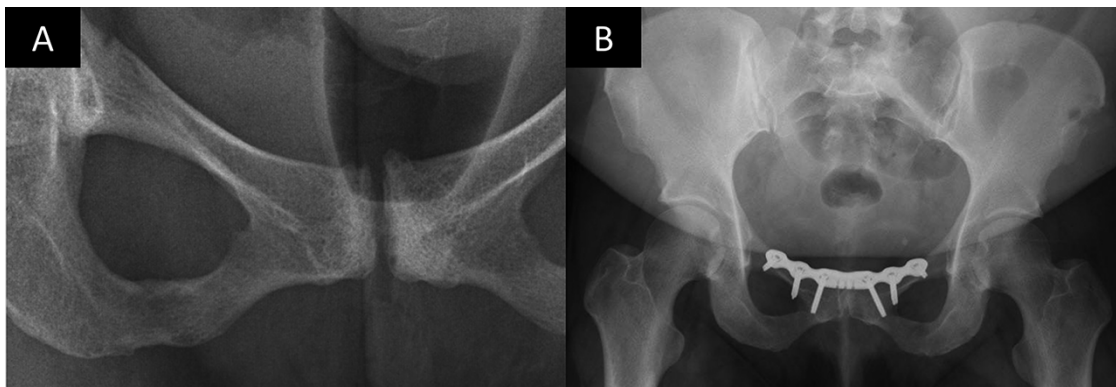


Fig. 5. Osteitis pubis. (A) Close-up anteroposterior (AP) pelvis radiograph demonstrating osteitis pubis with sclerosis and osteophyte formation at the pubic symphysis. (B) AP pelvis radiograph in the same patient following pubic symphysis arthrodesis.

include palpation of the inguinal canal [38, 39], a cough impulse test [29, 39] and the presence of a localized bulge in the abdominal wall with Valsalva manoeuvre [32, 40]. Imaging may include a groin ultrasound or MRI of the pelvis. Treatment of the pathologies mentioned above should be performed by a general surgeon and may include open or laparoscopic abdominal wall repair with or without mesh (type 3 CMI, Fig. 1) [41].

FEMOROACETABULAR IMPINGEMENT

In a subset of patients, CMI is a consequence of reduced hip range of motion (ROM) due to FAI, thereby leading to compensatory stresses on the lumbar spine, pubic symphysis and sacroiliac joint [2, 10, 12, 23, 36]. Thus, the orthopaedic surgeon should test hip ROM and perform impingement tests such as the FADIR (flexion, adduction, internal rotation) and FABER (flexion, abduction, external rotation) tests [42]. Imaging should include plain radiographs of the pelvis to evaluate for cam-, pincer- or mixed-type FAI as well as magnetic resonance arthrogram of the hip to evaluate for labral pathology [23, 27]. The diagnosis of FAI may be confirmed by the presence of an anterior or lateral cam lesion on imaging (cam-type), or by focal acetabular over-coverage indicated by a lateral centre edge angle $>40^\circ$ or Tönnis angle $<0^\circ$ [43]. Surgical treatment includes hip arthroscopy with cam and/or pincer resection and labral repair/reconstruction. Patients presenting with CMI secondary to FAI (type 5 CMI, Fig. 1) may benefit from concomitant treatment of both disorders rather than addressing one at a time, although some patients may experience symptom resolution with hip arthroscopy alone if CMI symptoms are mild/non-limiting [23, 44].

OSTEITIS PUBIS

Another issue that is often present in a patient presenting with CMI symptoms is OP, an overuse stress injury to the pubic symphysis [13, 14, 36, 45]. Injury to any of the core muscles or adductors may increase stress across the pubic symphysis, ultimately causing a stress reaction of the pubic bone [36]. Similar to a CMI, several studies have described a correlation between FAI and OP thought to be due to restricted hip motion resulting in a secondary stress transfer to the pubic symphysis [46–48]. Physical examination includes pain with direct palpation of the pubic symphysis as well as a spring test, in which a positive test

is indicated by pubic symphysis pain with direct pressure lateral to the symphysis [36]. Imaging should include plain radiographs and MRI of the pelvis (Fig. 5). For patients who fail conservative management consisting of NSAIDs and physical therapy, surgical treatment of OP (type 1 CMI, Fig. 1) may include pubic symphysis arthrodesis for non-athletic females versus open curettage or endoscopic pubic symphysectomy in male patients or athletes [49–51].

OTHER CONSIDERATIONS

During surgery for a CMI, some surgeons have advocated for resection of the genital branch of the genitofemoral nerve and ilioinguinal nerve neurolysis as nerve entrapment may be a cause of postoperative groin pain [38, 52].

In addition to the pathologies described in the above sections, other causes of groin pain should be ruled out in patients with atypical symptoms or negative imaging findings. The lumbar spine should be ruled out as a cause of referred pain [29]. Hip osteoarthritis (OA) is a rare cause of groin pain in athletes but should be considered and can be evaluated on plain radiographs [53]. Painful internal snapping reproduced on examination is often due to the iliopsoas tendon snapping over the anterior femoral head or iliopectineal ridge [54]. Urological or gynaecological referrals should be considered for some patients, especially males with testicular tenderness or females with ovarian pathology identified on imaging [33, 55]. Pelvic floor dysfunction should also be considered, especially in patients presenting with incontinence [56].

CONCLUSIONS

A variety of diagnostic methods and surgical procedures have been used in the treatment of a CMI/AP/sports hernia/inguinal disruption. The detailed treatment algorithm for CMI outlined in this review (Fig. 1) should be used by clinicians evaluating patients presenting with athletic-related groin pain. In addition to the physical examination manoeuvres described here, the patient's history should be emphasized. Detailed questions should be asked regarding the timing of the injury, duration and onset of symptoms, worsening and alleviating factors, and response to conservative management, physical therapy and

injections. We believe that both an orthopaedic surgeon and general surgeon should be involved in the care of these patients, with an experienced radiologist involved to critically review appropriate preoperative imaging. We also believe that treatment should be individualized to each patient's specific pathology, rather than treating all patients with the same procedure(s) regardless of individual pathology noted on preoperative work-up.

CONFLICT OF INTEREST STATEMENT

None declared.

FUNDING

The authors report no funding for this study.

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