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Diagnosis and management of quadriceps strains and contusions

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Abstract Injuries to the quadriceps muscle group occur frequently in sports and athletic activities. Muscle strains and contusions constitute the majority of these injuries. The clinical presentation and assessment of quadriceps strains and contusions are reviewed along with discussion of appropriate imaging used in diagnosis. Treatment protocols for acute injuries are reviewed including rehabilitation techniques frequently utilized during recovery. Special consideration is given to discussing the criteria for return to sports for athletes after injury. Myositis ossificans is a potentially disabling complication from quadriceps contusions and risk factors, prevention, and treatment are reviewed.

Keywords Quadriceps · Muscle strain · Contusion · Myositis ossificans

Introduction

Injury to the quadriceps muscle group can be painful and debilitating. Strains and contusions of the quadriceps are common in athletics and result in lost time from training and competition. This article will review the presentation, physical examination, diagnostic testing, and treatment of these injuries. In addition, rehabilitation techniques and factors to consider when returning athletes to play after injury will be discussed.

Functional anatomy

The quadriceps muscle group is composed of the rectus femoris, vastus medialis, vastus lateralis, and vastus intermedius. The rectus femoris originates at the ilium, thus crossing both the hip and knee joint along its course. This anatomy allows for hip flexion and knee extension. The remaining muscles originate on the femur and function solely as knee extensors. Innervation of these muscles is by the femoral nerve. The quadriceps are primarily active in kicking, jumping, and running.

Quadriceps strains

Acute strain injuries of the quadriceps commonly occur in athletic competitions such as soccer, rugby, and football. These sports regularly require sudden forceful eccentric contraction of the quadriceps during regulation of knee flexion and hip extension. Higher forces across the muscle–tendon units with eccentric contraction can lead to strain injury. Excessive passive stretching or activation of a maximally stretched muscle can also cause strains. Of the quadriceps muscles, the rectus femoris is most frequently strained [1–5]. Several factors predispose this muscle and others to more frequent strain injury. These include muscles crossing two joints, those with a high percentage of Type II fibers, and muscles with complex musculotendinous architecture [1, 2, 6, 7]. Muscle fatigue has also been shown to play a role in acute muscle injury [8].

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Classification of quadriceps strains

Various ways of grading muscle strains have been proposed [4, 6, 9]. Factoring in pain, loss of strength, and physical exam findings in a grading system helps provide guidance for treatment, rehabilitation, and eventual return to play. Table 1 provides an outline of a clinical grading system for muscle strains.

Grade 1 strains represent minor tearing of muscle fibers with only minimal or no loss in strength. Pain is usually mild to moderate with no palpable defect in the muscle tissue on exam.

Grade 2 strains involve more severe disruption to the muscle fibers with significant pain and loss of strength. A defect in the muscle tissue may sometimes be felt.

Grade 3 strains are a result of complete tearing of the muscle with associated severe pain and complete loss of strength. A palpable defect in the muscle tissue can frequently be felt, especially if examined at onset of injury prior to hematoma formation.

History

An accurate history should be obtained in patients presenting with anterior thigh pain. Patients who suffer an acute quadriceps strain will usually know right away. They are typically involved in kicking, jumping, or initiating a sudden change in direction while running. Frequently a sharp pain is felt associated with a loss in function of the quadriceps. Sometimes pain would not fully develop until the end of a game, practice, or sporting activity. Pain may be associated with localized swelling and loss of motion. Location of pain can be anywhere along the quadriceps muscles, but is classically described along the distal portion of the rectus femoris at the musculotendinous junction. However, several studies have shown quadriceps strains commonly occur at the mid to proximal portion of the rectus femoris [1, 2, 5].

Physical examination

After obtaining a thorough history, a careful examination should ensue including observation, palpation, strength testing, and evaluation of motion. Strain injuries of the quadriceps may present with an obvious deformity such as a bulge or defect in the muscle belly. Ecchymosis may not develop until 24 h after the injury. Palpation of the anterior thigh should include the length of the injured muscle, locating the area of maximal tenderness and feeling for any defect in the muscle. Strength testing of the quadriceps should include resistance of knee extension and hip flexion. Adequate strength testing of the rectus femoris must include resisted knee extension with the hip flexed and extended. Practically, this is best accomplished by evaluating the patient in both a sitting and prone-lying position. The prone-lying position also allows for optimum assessment of quadriceps motion and flexibility. Pain is typically felt by the patient with resisted muscle activation, passive stretching, and direct palpation over the muscle strain. Assessing tenderness, any palpable defect, and strength at the onset of muscle injury will determine grading of the injury and provide direction for further diagnostic testing and treatment.

Imaging

Most acute injuries to the quadriceps musculature can be diagnosed with an adequate history from the patient and a thorough examination. Imaging can be a useful adjunct in those cases where the diagnosis is uncertain or further detail is needed regarding the type and location of the muscle strain. Radiographs, ultrasound (US), and magnetic resonance imaging (MRI) are the commonly used imaging tools for this area. Radiographs are routinely normal in acute muscle strains, but may be helpful in differentiating between bony (femoral stress fracture, tumor, or myositis ossificans) and muscular etiologies of quadriceps pain in chronic cases. US is an excellent imaging modality for visualizing the quadriceps muscles and tendons, but is highly operator dependent and requires a skilled and experienced clinician [6, 10, 11]. US has the ability to image the muscles dynamically and assess for bleeding and hematoma formation via Doppler. MRI provides detailed images of muscle injury and can be quite helpful in characterizing quadriceps injuries [5, 12, 13]. It can sometimes be difficult to distinguish between muscular contusion and strain on MRI, which simply re-enforces the importance of

Table 1 Clinical grading system for quadriceps strains

Grade	Pain	Strength	Physical exam
1	Mild	None or minimal loss of strength	No palpable muscle defect
2	Moderate	Moderate loss of strength	May feel a small palpable muscle defect
3	Severe	Usually complete loss of strength	Often feel a palpable muscle defect

clinical history and examination in injury assessment [12]. Prognostically, Cross et al. found strains of the central tendon of the rectus femoris, identified on MRI, correlated with a significantly longer rehabilitation period [5].

Treatment

Treatment of muscle strain injuries has not changed greatly over the years and there is little scientific basis for the majority of treatment protocols. Despite the relative paucity of literature specific to treatment of muscle injuries, there are certain principles which provide a basis for the currently accepted methods of treatment. When muscle is acutely damaged by strain, contusion, or laceration, there is bleeding and hematoma formation among the ruptured muscles cells followed by an inflammatory reaction [6, 14]. Acute phase treatment of quadriceps strains is focused on minimizing bleeding into the muscles by following the RICE principle (rest, ice, compression, and elevation). Allowing the muscle to rest prevents worsening of the initial injury. Ice or cold application is thought to lower intra-muscular temperature and decrease blood flow to the injured area. This may help facilitate faster healing and return to athletics, but has not been proven in the scientific literature [15]. This same review did show that cryotherapy is effective in decreasing pain associated with muscle injury [15]. Compression may help decrease blood flow and accompanied by elevation will serve to decrease both blood flow and excess interstitial fluid accumulation. Practically, the first 24–72 h after quadriceps strain should be focused on the RICE principles. Cryotherapy, accompanied by compression, should be applied for 15–20 min at a time with 30–60 min between applications. During this time period, the quadriceps should be kept relatively immobile to allow for appropriate healing and prevent further injury [6]. A grade 2 or 3 strain may necessitate the use of crutches initially to facilitate rest and immobilization of the quadriceps. Nonsteroidal anti-inflammatory drugs (NSAIDs) can be useful for reducing pain and allowing earlier return to activity. The long-term effects of NSAIDs in muscle strains are unknown and a recent review recommends only a short 3–7 day course after muscle strains [16]. In contrast, the use of corticosteroids is definitely discouraged based on research demonstrating delayed healing and reduced biomechanical strength of injured muscle [6, 17, 18].

The acute phase of treatment is subsequently followed by an active phase of management once the injured leg is recovering well. This phase usually begins approximately 3–5 days after the initial injury depending on its severity. Stretching, strengthening, range of motion, maintenance of aerobic fitness, proprioceptive exercises, and functional training are the primary components of this phase. Stretching should be done carefully and always to the point of discomfort, but not pain. Various techniques can be utilized including passive, active–passive, dynamic, and proprioceptive neuromuscular facilitation stretching. Generally, ballistic stretching is discouraged due to the risk of re-tearing muscle fibers. An active warm-up should always precede any type of rehabilitation exercises as it has been shown to activate neural pathways in the muscle and reduce muscle viscosity [6]. Strengthening exercises can begin gradually and should progress sequentially through isometric, isotonic, isokinetic, and functional exercises. Table 2 provides definitions of these various strengthening techniques.

All strengthening exercises should be performed through a pain-free range of motion. Advancement through each type of strengthening depends on the level of soreness and pain created by each type of exercise. For example, once isometric straight leg raises at 0°, 20°, and 40° can be completed without any pain or subsequent soreness, isotonics can then be initiated. Maintaining aerobic fitness during rehabilitation is important and can be accomplished by using activities like swimming and biking. Once again, these activities should not increase pain in the injured quadriceps and should be performed in a pain-free range of motion.

Return to sports

Consideration of return to sports criteria is important when managing quadriceps strains in athletic patients. There are no established consensus guidelines or criteria for safe return to sports following muscle strains [19]. Practically, athletes should have normal knee range of motion, be pain free, demonstrate near normal strength compared to the contralateral side and perform well on functional field tests [13]. Isokinetic muscle strength testing can be a useful tool for assessing strength and guiding return to sports.

Quadriceps contusions

Contusion injuries to the quadriceps are common in athletics. In fact, next to muscle strains, traumatic muscle contusions have been reported as the most frequent type of quadriceps injury in sports [20]. A direct blow to the quadriceps causing significant muscle damage is the usual mechanism of this injury. In comparison to strains, contusions will cause rupture to the muscle fibers at or directly adjacent to the area of impact [6]. This typically leads to hematoma formation within the muscle causing pain and loss of motion. A contracted muscle will absorb force

Table 2 Strengthening techniques

Isometric	Muscle contraction against a fixed object resulting in no change in muscle length
Isotonic	Muscle contraction against a constant resistance, with uncontrolled speed of movement, resulting in muscle shortening or lengthening through a range of motion
Isokinetic	Muscle contraction through a range of motion at a constant angular velocity
Functional	Sport or activity specific strengthening exercises such as sprinting, jumping, or agility drills

better and result in a less severe injury [6, 18]. Improved protective equipment seems to be decreasing the frequency of this injury in many sports; however, there is no research to support this apparent trend. In sports without padding for the thigh and upper leg, such as soccer and rugby, quadriceps contusions continue to be a major disabling injury.

History and physical examination

Perhaps more so than with muscle strains, athletes will usually report a definite mechanism associated with a contusion injury. A direct blow from an opponent's knee or other piece of equipment frequently is recalled as the traumatic force causing their thigh pain. Localized pain at the site of injury, swelling, decreased range of motion, and tenderness to palpation are usual findings. Depending on the severity of injury, some athletes may be able to continue their activity and present after competition or training for evaluation. Upon examination, the area of injury should be inspected for obvious deformity, swelling, or ecchymosis. Palpation along the injured muscle will help localize the exact site of muscle damage and determine if there is any associated injury. Strength testing of the quadriceps, by resisting knee extension and hip flexion, compared to the uninjured side will aid in assessing severity of injury. Measurement of knee flexion has been used as a prognostic indicator in quadriceps contusions. Jackson and Feagin originally described a classification system, which was further modified by Ryan et al. [21, 22]. Mild contusions are characterized by a normal gait, localized tenderness, and active knee flexion of greater than 90°. Moderate contusions are characterized by antalgic gait, swollen, tender mass in the quadriceps, and 45–90° of active knee flexion. Severe contusions are characterized by a severely antalgic gait, noticeably swollen and tender muscle mass, and less than 45° of active knee flexion [21]. Table 3 summarizes this classification.

Table 3 Classification of quadriceps contusions adapted from Jackson and Feagin [21]

Pain	Active knee flexion	Gait
Mild	>90°	Normal
Moderate	45–90°	Antalgic
Severe	<45°	Severely antalgic

The prognostic value of this classification system has been demonstrated as the average disability time is longer for subsequently more severe contusions. Ryan et al. found average disability times of 13 days for mild contusions, 19 days for moderate contusions, and 21 days for severe contusions [22].

Imaging

The diagnosis of a quadriceps contusion is, by and large, a clinical diagnosis made by obtaining an accurate history from the patient and completing an appropriate examination. Diagnostic imaging is typically not necessary, but is helpful in a few instances. Occasionally, a patient will present subacutely with anterior thigh pain without a known mechanism of injury. Ultrasound and MRI can be useful in this case to provide additional information regarding the nature of muscle injury. It may help distinguish between strain, contusion, or avulsion injuries [12]. Ultrasound can be used to identify a localized hematoma formation caused from a contusion and provide real-time imaging for needle aspiration. If there is concern for bony involvement, radiographs will evaluate for bony injury. Subsequently, radiographs are useful in identifying heterotopic bone formation, known as myositis ossificans (MO), which is a delayed complication of severe muscle contusions.

Treatment

The principles of treatment for quadriceps contusions are essentially the same as for quadriceps strains, with one major exception. It is recommended the injured leg be placed in a position of flexion for the first 24 h post-injury to limit hematoma formation. Practically, this can be done by placing the patient in a hinged knee brace at 120° of knee flexion or using elastic compression wrap to maintain this position of flexion. This needs to be done as soon as possible after injury. Besides maintaining this position of flexion, ice and compression should be applied during this time. Several military studies have demonstrated the

efficacy of this acute phase treatment of quadriceps contusions [21–23]. After 24 h, the brace or wrap should be removed and gentle, active, pain-free range of motion at the knee should be instituted along with stretching and isometric quadriceps strengthening. The active phase of treatment, including functional rehabilitation, can begin when pain-free, active knee flexion of at least 120° is attained.

NSAIDs can be useful short term for decreasing pain, but their long-term effect on muscle healing is not known [16]. Long-term use of NSAIDs for contusions is usually not necessary and is discouraged. However, NSAIDs have been promoted for prevention of myositis ossificans after severe quadriceps contusions. Evidence for this use is inferred from studies showing a decrease in heterotopic bone formation after total hip replacement in those patients given indomethacin for at least 7 days [24]. Similar to muscle strains, corticosteroids are not recommended in the treatment of contusion injuries.

Return to sports

Criteria are similar to muscle strains for return to sports in contusions of the quadriceps. The athlete should be pain free, attain 120° of knee flexion with hip extended, and perform all aspects of functional field testing without limitations [13]. Protective thigh padding is recommended prior to resuming sports in order to reduce recurrence.

Myositis ossificans

A complication associated with severe quadriceps contusions; this is a non-neoplastic proliferation of bone and cartilage in the area of contusion injury. In contusions, the reported incidence is between 9 and 17% [18, 22]. MO should be suspected if symptoms worsen after 2–3 weeks accompanied by loss of knee flexion and persistent swelling. Ryan et al. identified several risk factors associated with development of MO in their study of West Point cadets. They included knee flexion less than 120°, injury occurring during football, previous quadriceps injury, delay in treatment greater than 3 days, and ipsilateral knee effusion [22]. Diagnosis is made by radiographs demonstrating new bone formation in the area of contusion. Radiographic findings may be present within 3 weeks of injury, but frequently lag behind clinical symptoms [18]. As mentioned previously, indomethacin is often given for 7 days after severe contusions to prevent development of MO despite lack of direct evidence supporting this treatment. Treatment otherwise consists of stretching, range of motion, and strengthening. Athletes can still participate in sports with MO present, but may find their range of motion restricted with occasional flare-ups of pain and swelling. Unfortunately, many cases do not resolve requiring definitive surgical treatment. Surgical excision should not be performed until the ectopic bone formation has fully matured, which is usually in a range of 12 to 24 months [6, 13, 18]. Early excision while bone formation is still active can result in more severe local recurrence [18].

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