

Thigh Injuries in American Football

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Abstract

Quadriceps and hamstring injuries occur frequently in football and are generally treated conservatively. While return to competition following hamstring strains is relatively quick, a high rate of injury recurrence highlights the importance of targeted rehabilitation and conditioning. This review describes the clinical manifestations of thigh-related soft-tissue injuries seen in football players. Two of these—muscle strains and contusions—are relatively common, while a third condition—the Morel-Lavallée lesion—is a rare, yet relevant injury.



American football has the highest injury rate of any team sport in the United States at the high school, collegiate, and professional levels.¹⁻³ Muscle strains and contusions constitute a large proportion of football injuries. For example, at the high school level, muscle strains comprise 12% to 24% of all injuries;² at the collegiate level, they account for approximately 20% of all practice injuries, with nearly half of all strains occurring within the thigh.^{1,4} Among a single National Football League (NFL) team, Feeley and colleagues⁵ reported that muscle strains accounted for 46% of practice and 22% of preseason game injuries. The hamstrings, followed by the quadriceps, are the most commonly strained muscle groups among both professional and amateur athletes,^{5,6} with hamstring and quadriceps injuries making up approximately 13% of all injuries among NFL players.⁷ Given the relatively large surface area and muscle

volume of the anterior and posterior thigh, as well as the activities and maneuvers necessitated by the various football positions, it is not surprising that the thigh is frequently involved in football-related injuries.

The purpose of this review is to describe the clinical manifestations of thigh-related soft-tissue injuries seen in football players. Two of these conditions—muscle strains and contusions—are relatively common, while a third condition—the Morel-Lavallée lesion—is a rare, yet relevant injury that warrants discussion.

Quadriceps Contusion

Pathophysiology

Contusion to the quadriceps muscle is a common injury in contact sports generally resulting from a direct blow from a helmet, knee, or shoulder.⁸ Bleeding within the musculature causes swelling, pain, stiffness, and limitation of quadriceps excursion, ultimately resulting in loss of knee flexion and an inability to run or squat. The injury is typically confined to a single quadriceps muscle.⁸ The use of thigh padding, though helpful, does not completely eliminate the risk of this injury.

History and Physical Examination

Immediately after injury, the athlete may complain only of thigh pain. However, swelling, pain, and diminished range of knee motion may develop within the first 24 hours depending on the severity of injury and how quickly treatment is instituted.⁸ Jackson and Feagin⁹ developed an injury grading system for quadriceps contusions based on the limitation of knee flexion observed (**Table 1**). Fortunately, the majority of contusions in these athletes are of a mild to moderate severity.^{9,10}

Imaging

A quadriceps contusion is a clinical diagnosis based on a typical history and physical examination; therefore, advanced imaging usually does not need to be obtained except to gauge the

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severity of injury, to rule out concurrent injuries (ie, tendon rupture), and to identify the presence of a hematoma that may necessitate aspiration. Plain radiographs are typically unremarkable in the acute setting. Appearance on magnetic resonance imaging (MRI) varies by injury severity, with increased signal throughout the affected muscle belly and a diffuse, feathery appearance centered at the point of impact on short T1 inversion recovery (STIR) and T2-weighted images reflecting edema and possibly hematoma (**Figures 1A-1C**).^{8,11} Resolution of these MRI findings may lag behind functional recovery.⁸ Therefore, the athlete is often able to return to competition once he has recovered full lower extremity motion and function despite the persistence of abnormal findings on MRI.

Treatment

Treatment of a quadriceps contusion is nonoperative and consists of a 3-phase recovery.¹⁰ The first

phase lasts approximately 2 days and consists of rest, ice, compression, and elevation (RICE) to limit hemorrhage. The knee should be rested in a flexed position to maintain quadriceps muscle fiber length in order to promote muscle compression and limit knee stiffness. For severe contusions in which there is a question of an acute thigh compartment syndrome, compression should be avoided with appropriate treatment based on typical symptoms and intra-compartmental pressure measurement.¹² Nonsteroidal anti-inflammatory drugs (NSAIDs) may be administered to diminish pain as well as the risk of myositis ossificans. While there is no data on the efficacy of NSAIDs in preventing myositis ossificans following quadriceps contusions, both COX-2 selective (ie, celecoxib) and nonselective (ie, naproxen, indomethacin) COX inhibitors have been demonstrated to significantly reduce the incidence of heterotopic ossification following hip surgery—a condition occurring from a similar

Table 1. **Quadriceps Contusion Classification**⁹

Grade	Physical Examination	Knee Motion	Gait	Activity
1 (mild)	Localized tenderness	>90°	No alteration	Able to deep knee bend
2 (moderate)	Swollen, tender muscle mass	≤90°	Antalgic	Unable to deep knee bend, climb stairs, or rise from chair without severe pain
3 (severe)	Markedly swollen, tender thigh; contour of muscle cannot be defined by palpation; frequent knee effusion	≤45°	Severe limp	Prefers to walk with crutches

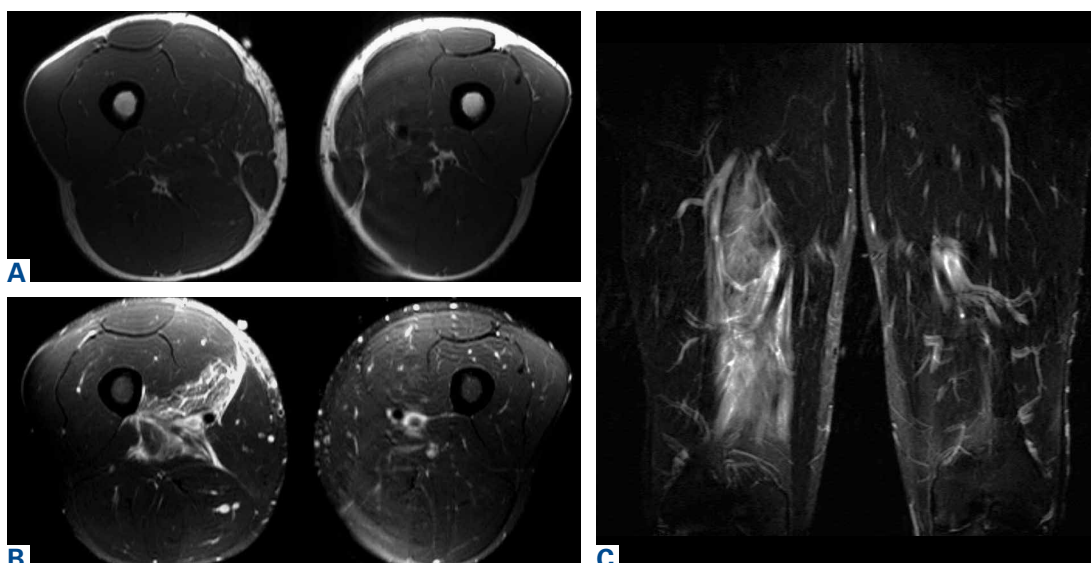


Figure 1. Magnetic resonance imaging of the thigh following a quadriceps contusion. (A) Axial T1-weighted image. (B) Axial T2-weighted image with fat saturation. (C) Coronal short T1 inversion recovery (STIR) image.



Figure 2. Lateral radiograph of the left thigh showing early myositis ossificans following a contusion to the quadriceps.

pathophysiologic process as myositis ossificans.¹³⁻¹⁷ However, this class of drugs should not be given any sooner than 48 to 72 hours after injury to decrease further bleeding risk, given its inhibitory effect on platelet function.¹⁸ Narcotic pain medications are rarely required.

The second phase focuses on restoring active and passive knee and hip flexion and begins when permitted by pain.⁸ Icing, pain control, and physical therapy modalities are also continued in order to reduce pain and swelling as knee motion is progressed. The third phase begins once full range of knee and hip motion is restored and consists of quadriceps

strengthening and functional rehabilitation of the lower extremity.^{8,19} Return to athletic activities and eventually competition should take place when a full, painless range of motion is restored and strength returns to baseline. Isokinetic strength testing may be utilized to more accurately assess strength and endurance. Noncontact, position-specific drills are incorporated as clinical improvement allows. A full recovery should be expected within 4 weeks of injury, with faster resolution and return to play seen in less severe contusions depending on the athlete's position.⁸ Continued quadriceps stretching is recommended to prevent recurrence once the athlete returns to play. A protective hard shell may also be utilized both during rehabilitation as well as once the athlete returns to play in order to protect the thigh from reinjury, which may increase the risk of myositis ossificans.⁸

Complications

A prolonged recovery or persistent symptoms should alert the treating physician to the possibility of complications, including myositis ossificans.^{8,20} Myositis ossificans typically results from moderate to severe contusions, which may present initially as a painful, indurated mass that later becomes quite firm. This mass may be seen on plain radiographs as early as 2 to 4 weeks following injury if the athlete complains of persistent pain or a palpable thigh mass (**Figure 2**).⁹ The risk of myositis ossificans increases in proportion to the severity of injury.¹⁸ Among US military academy members, the incidence of myositis ossificans following quadriceps contusions ranges from 9% to 20%.^{9,10} These masses often masquerade as a neoplasm

that results in an unnecessary biopsy which reveals an "aggressive" lesion leading to an incorrect diagnosis of a soft-tissue sarcoma. MRI and/or computed tomography scanning may confirm the diagnosis of a benign process in these questionable cases as the lesion matures, with ossification demonstrated on both T1- and T2-weight imaging.²¹ Even in the presence of myositis ossificans, most patients regain full knee and hip motion and return to sports without residual weakness or pain.²⁰ Very rarely, persistent symptoms and limitation of motion may warrant consideration for surgical excision of the symptomatic mass once it is considered mature, which generally occurs within 6 months to 1 year, in order to avoid the risk of recurrence resulting from the surgical trauma.^{9, 22}

Mani-Babu and colleagues²³ reported a case of a 14-year-old male football player who sustained a quadriceps contusion after a direct blow from an opponent's helmet to the lateral thigh. Persistent pain and limitation of motion at 2 months follow-up prompted imaging studies that demonstrated myositis ossificans. The patient was treated with intravenous pamidronate (a bisphosphonate) twice over a 3-month period and demonstrated a full recovery within 5 months.

Acute compartment syndrome of the thigh has also been reported following severe quadriceps contusions, with the majority occurring in the anterior compartment.^{12,24-28} When injury from blunt trauma extends into and disrupts the muscular layer adjacent to the femur, vascular disruption can cause hematoma formation, muscle edema, and significant swelling, thereby increasing intracompartmental pressure. The relatively large volume of the anterior thigh compartment and lack of a rigid deep fascial envelope may be protective from the development of compartment syndrome compared to other sites.²⁸ It can be difficult to distinguish a severe contusion from a compartment syndrome, as both can occur from the same mechanism and have similar presenting signs and symptoms. Signs of a compartment syndrome include pain out of proportion to the injury that is aggravated by passive stretch of the quadriceps muscles, an increasingly firm muscle compartment to palpation, and neurovascular deficits.²⁹ Both acute compartment syndrome and a severe contusion may present with significant pain, inability to bear weight, tense swelling, tenderness to palpation, and pain with passive knee flexion.²⁴ While the successful conservative treatment of

athletes with acute compartment syndrome of the thigh has been reported, it is important to closely monitor the patient's condition and consider intracompartmental pressure monitoring if the patient's clinical condition deteriorates.¹² An acute fasciotomy should be strongly considered when intracompartmental pressures are within 30 mm Hg of diastolic pressure.²⁴⁻²⁷ Fortunately, it is highly uncommon for thigh compartment pressure to rise to this level. Percutaneous compartment decompression using liposuction equipment or a large cannula has been described to decrease intracompartmental pressure, potentially expediting recovery and minimizing morbidity.¹⁸ Interestingly, reports of fasciotomies for acute thigh compartment syndrome following closed athletic injuries have not described necrotic or non-contractile muscle typical of an acute compartment syndrome, calling into question the need for fasciotomy following closed blunt athletic trauma to the thigh.¹⁸

Quadriceps Strain

Pathophysiology

Acute quadriceps strains occur during sudden forceful eccentric contraction of the extensor mechanism. Occasionally, in the absence of a clear mechanism, these injuries mistakenly appear as a contusion resulting from a direct blow to the thigh.^{30,31} The rectus femoris is the most frequently strained quadriceps muscle due, in part, to its superficial location and predominance of type II muscle fibers, which are more likely to be strained.^{11,32} Although classically described as occurring along the distal portion of the rectus femoris at the musculotendinous junction, quadriceps strains most commonly occur at the mid to proximal aspect of the rectus femoris.^{30,33} The quadriceps muscle complex crosses 2 joints and, as a result, is more predisposed to eccentric injury than mono-articular muscles.³⁴ We have had a subset of complete myotendinous tears of the rectus femoris that occur in the plant leg of placekickers that result in significant disability.

Risk Factors

Quadriceps and thigh injuries comprise approximately 4.5% of injuries among NFL players.⁷ Several risk factors for quadriceps strains have been described. In a study of Australian Rules football players, Orchard³⁵ demonstrated that for all muscle strains, the strongest risk factor was a recent history of the same injury, with the next strongest risk factor being a past history of the same injury. Increasing age was found to be a risk factor for hamstring strains but not quadriceps strains. Muscle fatigue may also contribute to injury susceptibility.³⁶

History and Physical Examination

Injuries typically occur during kicking, jumping, or a sudden change in direction while running.³⁰ Athletes may localize pain anywhere along the quadriceps muscle, although strains most commonly occur at the proximal to mid portion of the rectus femoris.^{30,33} The grading system for quadriceps strains described by Kary³⁰ is based on level of pain, quadriceps strength, and the presence or absence of a palpable defect (**Table 2**). In high-grade strains, a sharp pain occurs immediately following the injury and often causes variable degrees of functional loss to the quadriceps.³⁰

The athlete typically walks with an antalgic gait. Visible swelling and/or ecchymosis may be present depending on when the athlete is seen, as ecchymosis may develop within the first 24 hours of injury. The examiner should palpate along the entire length of the injured muscle. High-grade strains or complete tears may present with a bulge or defect in the muscle belly, but in most cases no defect will be palpable. There may be loss of knee flexion similar to a quadriceps contusion. Strength testing should be performed in both the sitting and prone position with the hip both flexed and extended to assess resisted knee extension strength.³⁰ Loss of strength is proportional to the degree of injury.

Table 2. **Muscle Strain Classification**³⁰

Grade	Pain	Strength	Physical Examination
1 (minor muscle fiber tearing)	Mild to moderate	None or minimal loss	No palpable defect
2 (severe disruption to muscle fibers)	Moderate to severe	Moderate loss	May feel palpable muscle defect
3 (complete tearing of muscle)	Severe	Complete loss	Generally palpable muscle defect and/or hematoma

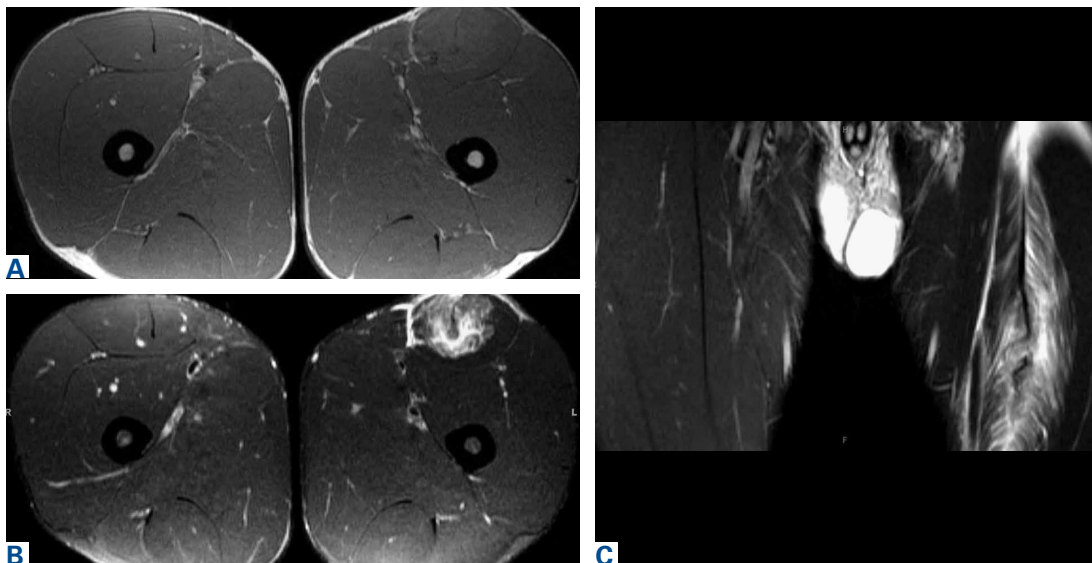


Figure 3. Central rectus femoris strain. (A) Axial T1-weighted magnetic resonance imaging (MRI). (B) Axial T2-weighted fat saturation MRI. (C) Coronal short TI inversion recovery (STIR) image.

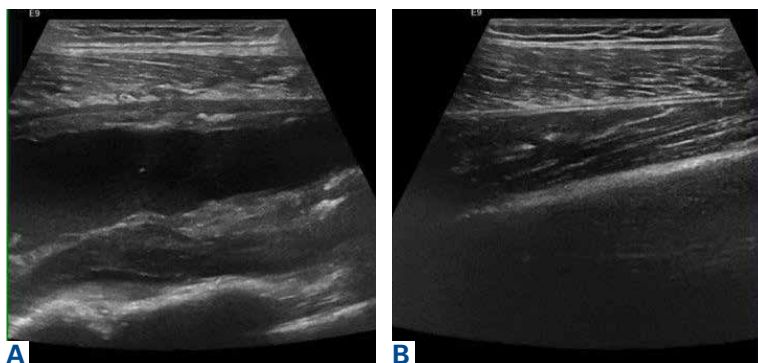


Figure 4. Right rectus femoris strain on sagittal ultrasound. (A) Mid-sagittal image showing hypoechoic region consistent with a hematoma with adjacent muscle fiber disruption, and early myositis ossificans along the anterior femoral cortex. (B) Mid-sagittal image of normal left thigh for comparison.

Imaging

While most quadriceps strains are adequately diagnosed clinically without the need for imaging studies, ultrasound or MRI can be used to evaluate for partial or complete rupture.^{30,33} In milder cases, MRI usually demonstrates interstitial edema and hemorrhage with a feathery appearance on STIR and T2-weighted imaging (**Figures 3A-3C**).¹¹ Myotendinous strains can be classified based on the extent of fiber disruption.^{11,32} Cross and colleagues³³ demonstrated that strains of the central tendon of the rectus femoris seen on MRI correlated with a significantly longer rehabilitation period than those occurring at the periphery of the rectus or within other quadriceps muscles. Ultrasound is a more economical imaging modality that can

dynamically assess the quadriceps musculature for fiber disruption and hematoma formation but is user-dependent, requiring a skilled technician (**Figures 4A, 4B**).³⁰

Treatment

Acute treatment of quadriceps strains focuses on minimizing bleeding using the principles of RICE treatment.³⁷ NSAIDs may be used immediately to assist with pain control.³⁰ COX-2-specific NSAIDs are preferred due to their lack of any inhibitory effect on platelet function in order to reduce the risk of further bleeding within the muscle compartment. For the first 24 to 72 hours following injury, the quadriceps should be maintained relatively immobilized to prevent further injury.³⁸ High-grade injuries might necessitate crutches for ambulatory assistance.

Depending on injury severity, the active phase of treatment usually begins within 5 days of injury and consists of stretching and knee/hip range of motion. An active warm-up should precede rehabilitation exercises to activate neural pathways within the muscle and improve muscle elasticity.³⁸ Ballistic stretching should be avoided to prevent additional injury to the muscle fibers. Strengthening should proceed when the athlete recovers a pain-free range of motion. When isometric exercises can be completed at increasing degrees of knee flexion, isotonic exercises may be implemented into the rehabilitation program.³⁰ Return to football can be considered when the athlete has recovered



knee and hip range of motion, is pain-free, and has near-normal strength compared to the contralateral side. The athlete should also perform satisfactorily in simulated position-specific activities in a noncontact fashion prior to return to full competition.³⁰

Hamstring Strain

Pathophysiology

Hamstring strains are the most common noncontact injuries in football resulting from excessive muscle stretching during eccentric contraction generally occurring at the musculotendinous junction.^{5,39} Because the hamstrings cross both the hip and knee, simultaneous hip flexion and knee extension results in maximal lengthening, making them most vulnerable to injury at the terminal swing phase of gait just prior to heel strike.^{39,42} The long head of the biceps femoris undergoes the greatest stretch, reaching 110% of resting length during terminal swing phase and is the most commonly injured hamstring muscle.^{43,44} Injury occurs when the force of eccentric contraction, and resulting muscle strain, exceeds the mechanical limits of the tissue.^{42,45} It remains to be shown whether hamstring strains occur as a result of accumulated microscopic muscle damage or secondary to a single event that exceeds the mechanical limits of the muscle.⁴²

Epidemiology and Risk Factors

The majority of hamstring strains are sustained during noncontact activities, with most athletes citing sprinting as the activity at the time of injury.³ Approximately 93% of injuries occur during noncontact activities among defensive backs and wide receivers.³ Hamstring strains are the second-most common injury among NFL players, comprising approximately 9% of all injuries,^{5,7} with 16% to 31% of these injuries associated with recurrence.^{3,5,35,46} Using the NFL's Injury Surveillance System, Elliott and colleagues³ reported 1716 hamstring strains over a 10-year period (1989-1998). Fifty-one

percent of hamstring strains occurred during the 7-week preseason, with a greater than 4-fold increased injury rate noted during the preseason compared to the 16-week regular season. An increased incidence in the preseason is partially attributable to relative deconditioning over the offseason. Defensive backs, wide receivers, and special teams players accounted for the majority of injured players, suggesting that speed position players and those who must "backpedal" (run backwards) are at an increased risk for injury.

Several risk factors for hamstring strain have been described, including prior injury, older age, quadriceps-hamstring strength imbalances, limited hip and knee flexibility, and fatigue.^{39,42,47} Inadequate rehabilitation and premature return to competition are also likely important factors predisposing to recurrent injury.^{39,48}

History and Physical Examination

The majority of hamstring strains occur in the acute setting when the player experiences the sudden onset of pain in the posterior thigh during strenuous exercise, most commonly while sprinting.³⁹ The injury typically occurs in the early or late stage of practice or competition due, in part, to inadequate warm-up or fatigue. The athlete may describe an audible pop and an inability to continue play, depending on injury severity.

Physical examination may demonstrate palpable induration and tenderness immediately or shortly after injury. In the setting of severe strains, there can be significant thigh swelling and ecchymosis, and in complete ruptures, a palpable defect.³⁹ The affected muscle should be palpated along its entire length, and is best performed prone with the knee flexed to 90° as well as with the knee partially extended to place it under mild tension. Injury severity can be assessed by determining the restriction of passive knee extension while the athlete is lying supine with the hip flexed to 90°. The severity of hamstring strains varies from minor damage of a

Table 3. **Hamstring Strain Classification**⁴⁹

Grade	Musculotendinous unit disruption	Strength	Physical Examination
1 (mild)	<5%	None or minimal loss	No palpable defect
2 (moderate)	Partial/incomplete tear	Moderate loss	May feel palpable muscle defect
3 (severe)	Complete rupture	Complete loss	Generally palpable myotendinous defect and/or hematoma

few myofibers without loss of structural integrity to complete muscle rupture. Hamstring strains are classified into 3 groups based on the amount of myotendinous disruption (**Table 3**).⁴⁹

Imaging

Similar to other muscle strains, hamstring strains are a clinical diagnosis and generally do not necessitate advanced imaging studies except to assess the degree of damage (ie, partial vs complete rupture) and to rule out other injuries, especially if the athlete fails to respond to treatment. Plain radiographs in acute cases are usually unremarkable. However, more severe injuries may go on to develop myositis ossificans similar to quadriceps soft tissue injuries (**Figure 5**). The MRI appearance of hamstring strains shows increased signal within and surrounding the affected muscle belly on T2-weighted imaging as well as the degree of muscle fiber disruption (**Figures 6A, 6B**). MRI can also be beneficial to confirm the diagnosis of myositis ossificans in chronic cases with a palpable mass.



Figure 5. Lateral radiograph showing mature myositis ossificans in the mid-hamstring musculature. Note the well-defined borders indicative of a mature, benign lesion.

Treatment

Most hamstring strains respond to conservative treatment, with operative intervention rarely indicated except for proximal or distal tendon avulsions.³⁹ Like other muscle strains, initial management con-

sists of RICE. COX-2-selective NSAIDs are preferred initially following injury. During a brief period of immobilization, the leg should be extended as much as tolerated to maximize muscle length, limit hematoma formation, and reduce the risk of contracture.³⁹ Controlled mobilization should begin as soon as tolerated by the athlete.³⁹ Isometric exercises and a stretching program should be started early in the rehabilitation period, with isotonic exercises added as motion and pain improve. Active stretching should be initiated and progressed to passive, static stretching as guided by pain.

The late phase of rehabilitation and long-term conditioning protocols should incorporate eccentric training once the athlete is pain-free, performing isotonic and isokinetic exercises. Eccentric exercises best strengthen the hamstrings at their most susceptible point, prepares the athlete for functional activities, and minimizes the risk of reinjury.^{3,50,51} Elliot and colleagues³ reported an order of magnitude decrease in hamstring injuries in high-risk athletes with identifiable hamstring muscle weakness after implementing an eccentric strengthening program and progressive sprint training. Similarly, in a large cohort of elite soccer players, correction of strength deficits in players with prior hamstring injuries led to similar rates of injury compared to athletes without strength deficits or prior injury.⁵² Those athletes with persistent weakness who did not undergo rehabilitation had significantly higher rates of reinjury.

Various injections containing local anesthetics, corticosteroids, platelet-rich plasma (PRP), and other substances have been administered to football players following acute muscle strains in an effort to alleviate pain and safely return the athlete

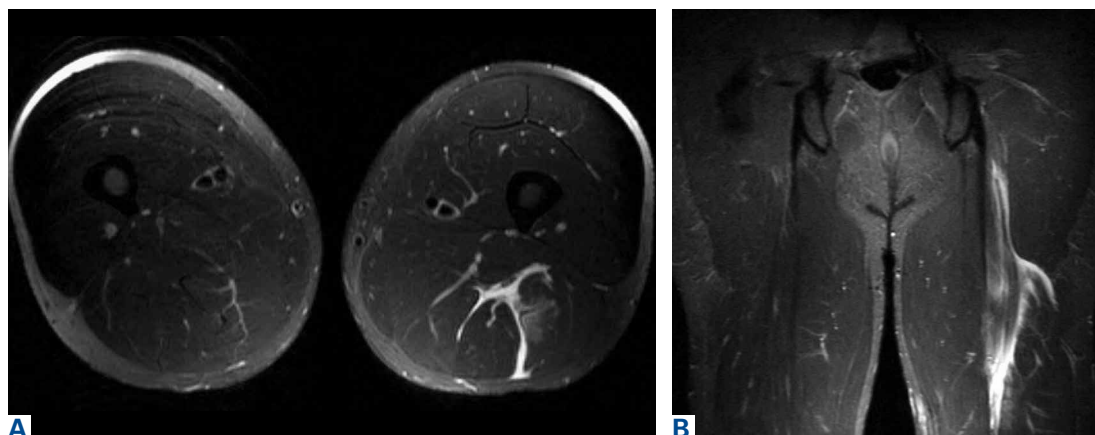


Figure 6. Magnetic resonance imaging of a proximal hamstring strain in a professional football player sustained while trying to make a tackle. (A) Axial T2-weighted fat saturation image. (B) Coronal shortTI inversion recovery (STIR) image.

to competition. Some practitioners have been reluctant to administer injections (especially those containing corticosteroids) due to a potentially increased risk of tendinopathy or rupture.³¹ Drakos and colleagues⁵³ reported their outcomes following muscle and ligament strains treated with combined corticosteroid and local anesthetic injections on one NFL team. While quadriceps and hamstring strains were associated with the most missed games among all muscle strains, these injections resulted in no adverse events or progression of injury severity. Similarly, Levine and colleagues⁵¹ administered intramuscular corticosteroid injections to 58 NFL players with high-grade hamstring injuries that had a palpable defect within the muscle belly. They reported no complications or strength deficits at final examination. In a case-control study, Rettig and colleagues⁴⁶ administered PRP injections under ultrasound guidance in 5 NFL players with hamstring injuries. Compared to players treated with a focused rehabilitation program only, there were no significant differences in recovery or return to play.

The decision to return to play should be based on a clinical assessment considering pain, strength, motion, and flexibility. Player position should also be considered. Return-to-play guidelines describing the appropriate progression through rehabilitation and return to sport have been described and can be

used as a template for the rehabilitation of football players.⁵⁴ It should be noted that primary hamstring strains are associated with decreased athletic performance and an increased risk of more severe reinjury after return to sport.^{55,56}

Morel-Lavallée Lesion

Pathophysiology

Morel-Lavallée lesions (MLLs) are uncommon football injuries, but often occur in the thigh.^{57,58} An MLL is a posttraumatic soft tissue injury in which deforming forces of pressure and shear cause a closed, soft tissue degloving injury; in this injury, the skin and subcutaneous tissues are separated from the underlying fascia, disrupting perforating blood vessels. The resulting space between the fascia and subcutaneous tissue fills with blood, lymphatics, and necrotic fat, resulting in a hematoma/seroma that can be a nidus for bacterial infection.⁵⁸ The most common anatomic regions are the anterior distal thigh and lateral hip. Both of these areas are commonly involved in both direct contact and shear forces following a fall to the ground.

History and Physical Examination

Athletes with MLLs typically present with the insidious onset of a fluid collection within the thigh following a fall to the ground, usually while sliding

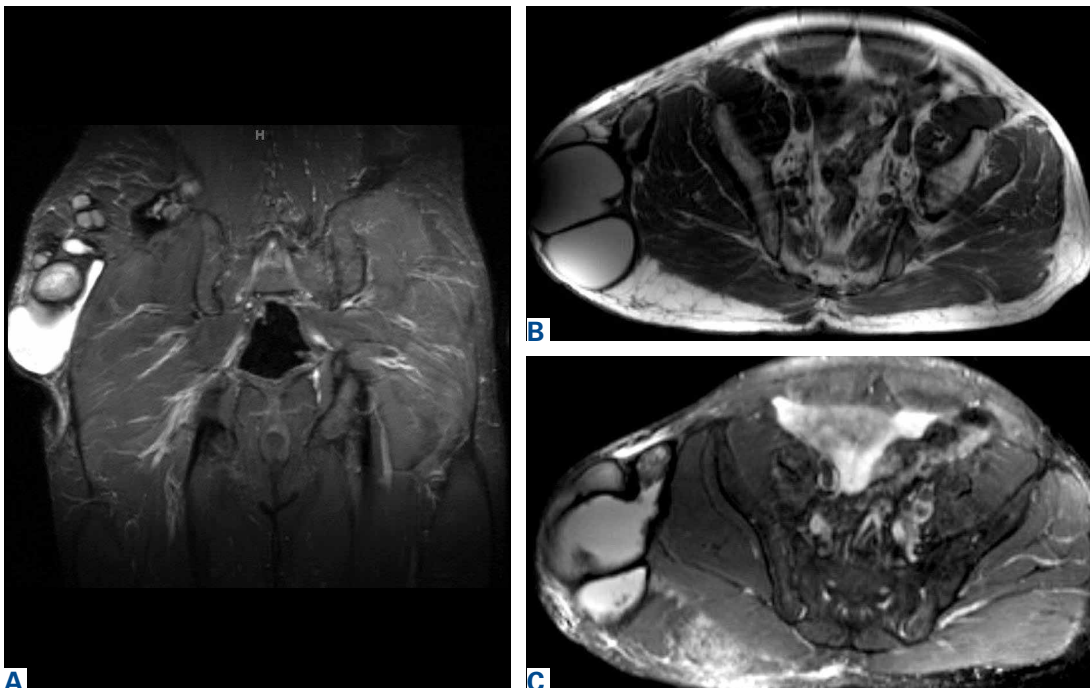


Figure 7. Morel-Lavallée lesion of the proximal right thigh on magnetic resonance imaging. (A) Coronal shortTI inversion recovery (STIR) image. (B) Axial T1-weighted image. (C) Axial T2-weighted fat saturation image.

or diving on the playing surface.^{57,58} The fluid collection can be associated with thigh tightness and may extend distally into the suprapatellar region or proximally over the greater trochanter. Thigh swelling, ecchymosis, and palpable fluctuance are seen in most cases. Progressive increases in pain and thigh swelling may be seen in severe injuries, but thigh compartments generally remain soft and nontender. Signs and symptoms of an MLL do not typically manifest immediately following the athletic event. Tejwani and colleagues⁵⁸ reported a case series of MLLs of the knee in 27 NFL players from a single team over a 14-year period, with an average of 3 days between injury and evaluation by the medical staff. The mechanism of injury was a shearing blow from the knee striking the playing surface in 81% of cases and direct contact to the knee from another player in 19% of cases; all cases occurred in game situations. No affected players were wearing kneepads at the time of injury.

Imaging

Plain radiography may reveal a noncalcified soft tissue mass over the involved area and is not usually helpful except to rule out an underlying fracture. The appearance of an MLL on ultrasound is nonspecific and variable, often described as anechoic, hypoechoic, or hyperechoic depending on the presence of hemolymphatic fluid sedimentation and varying amounts of internal fat debris. MRI is the imaging modality of choice and typically shows a well-defined oval or fusiform, fluid-filled mass with tapering margins blending with adjacent fascial planes. These lesions may show fluid-fluid levels, septations, and variable internal signal intensity depending on the acuity of the lesion (**Figures 7A-7C**).⁵⁹

Treatment

Similar to quadriceps contusions, treatment goals for MLLs are evacuation of the fluid collection, prevention of fluid recurrence, a full range of active knee flexion, and prompt return to play.^{57,58} Initial treatment for smaller lesions consists of cryotherapy, compression wrapping of the involved area, and immediate active and passive range of motion of the hip and knee. While MLLs were traditionally treated with serial open debridements, less invasive approaches—including elastic compression, aspiration, percutaneous irrigation with debridement and suction drainage, or liposuction and drainage followed by suction therapy—have been recently described.^{57,58,60,61} Less invasive approaches

aim to minimize soft tissue dissection and disruption of the vascular supply while accelerating rehabilitation. The presence of a surrounding capsule on MRI makes conservative or minimally invasive approaches less likely to be successful and may necessitate an open procedure.⁶² Antibiotics should be used preoperatively due to the presence of a dead space containing necrotic debris that makes infection a potential complication. While elite contact athletes can expect to return to competition long before complete resolution of an MLL, there is a risk of further delamination and lesion expansion due to re-injury prior to complete healing.

Tejwani and colleagues⁵⁸ performed aspiration at the area of palpable fluctuance in the thigh or suprapatellar region using a 14-gauge needle in those athletes who failed to improve with conservative treatments alone. Mean time to resolution of the fluid collection was 16 days following aspiration. Fifty-two percent of the athletes were successfully treated with cryotherapy, compression, and motion exercises alone; 48% were treated with at least one aspiration, with a mean of 2.7 aspirations per knee. In 11% of cases that failed to resolve after multiple aspirations, doxycycline sclerodesis was performed immediately following an aspiration. Patients treated with sclerodesis had no return of the fluid collection and returned to play the following day.

Matava and colleagues⁵⁷ described the case of an NFL player who sustained a closed MLL of the lateral hip while diving onto an artificial turf surface attempting to catch a pass. Despite immediate thigh pain and swelling, he was able to continue play. Immediately following the game, the player was examined and had a tense thigh with ecchymosis extending into the trochanteric region. Aspiration of the fluctuant area was unsuccessful. Progressive increases in pain and thigh swelling prompted hospital admission. Percutaneous irrigation and debridement was performed as described by Tseng and Tornetta.⁶¹ A suction drain was placed within the residual dead space, and constant wall suction was applied in addition to hip compression using a spica wrap. The player returned to practice 22 days after the injury and missed a total of 3 games without any residual deficit.

Conclusion

Quadriceps and hamstring injuries occur frequently in football and are generally treated conservatively. While return to competition following hamstring strains is relatively quick, a high rate of injury

recurrence highlights the importance of targeted rehabilitation and conditioning. Rarely, complications from quadriceps contusions, including acute compartment syndrome and myositis ossificans, may require operative intervention if unresponsive to conservative treatment. MLLs are rare in sports, but usually involve the thigh when they occur in football players. Team physicians must maintain a heightened degree of awareness of this injury as it may require operative intervention.

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