

# Proximal Rectus Femoris Avulsion in an Elite, Olympic-Level Sprinter

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## Abstract

Quadriceps injuries, ranging from simple strains to disabling muscle ruptures, are common athletic injuries. The rectus femoris is the most commonly injured portion of the quadriceps musculature.

This article is, to our knowledge, the first report of a proximal rectus femoris avulsion in an elite, Olympic-level 100-meter sprinter, acutely managed with surgical repair.

Several key factors must be considered and carefully assessed when determining the appropriate course of management (ie, deciding between operative and nonoperative treatment): amount of distal retraction of the tendon, severity of associated soft-tissue trauma, physical examination, and postoperative goals (eg, return to elite-level competitive sports involving running or kicking vs resuming basic activities of daily living). We believe that these factors in our elite, high-performance athlete dictated an operative course of management.

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Quadriceps injuries, ranging from simple strains to disabling muscle ruptures, are common among athletes who participate in sports, such as football, basketball, rugby, and soccer.<sup>1</sup> The rectus femoris is the most commonly injured portion of the quadriceps musculature because of its anterior location, high percentage of type II muscle fibers, and biarticular span

mal rectus femoris avulsion in an elite, Olympic-level 100-meter sprinter, acutely managed with surgical repair. We have obtained the patient's informed written consent for print and electronic publication of this case report.

## CASE REPORT

The patient was a 24-year-old elite-level sprinter who had been training for the 2008 Summer Olympics

“...proximal avulsions of the rectus femoris in skeletally mature athletes are rare.”

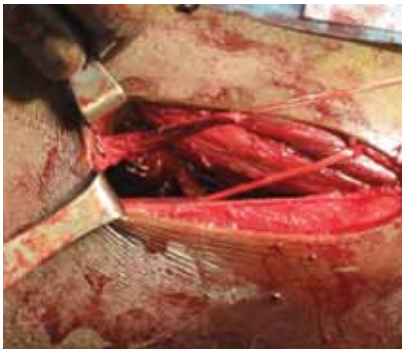
across the hip and knee joints.<sup>2</sup> Diagnoses are made for specific areas of the quadriceps. The classic quadriceps strain (jumper's knee) occurs at the conjoined muscle-tendon junction.<sup>2-4</sup> A partial tear of the quadriceps most commonly affects the indirect distal head of the rectus femoris.<sup>2-4</sup> Unlike these more common clinical entities, proximal avulsions of the rectus femoris in skeletally mature athletes are rare.<sup>5-7</sup> Case reports document the surgical repair of a chronic proximal rectus femoral rupture at the myotendinous junction in a soccer player,<sup>7</sup> the natural history and clinical outcome of rectus femoral avulsions treated nonoperatively in 2 National Football League (NFL) kickers,<sup>5</sup> and the surgical repair of 5 proximal rectus femoris avulsions (4 in soccer players and 1 in a 110-meter hurdler).<sup>6</sup>

This article is, to our knowledge, the first report of a proxi-

mal rectus femoris avulsion in the left thigh at the 50-meter mark of his qualifying 100-meter dash. He was unable to continue running. He was referred from an outside institution after being told he had a quadriceps muscle tear, specifically of the rectus femoris, and was initially treated with a knee immobilizer, crutches, and rehabilitation. He was otherwise healthy, with no pertinent past medical or surgical



**Figure 1.** Twelve-centimeter exposure extending from anterior inferior iliac spine.

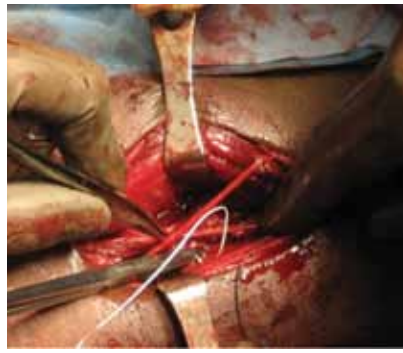


**Figure 2.** Lateral femoral cutaneous nerve identified and preserved. Rectus avulsion tagged.

history, and there was no steroid use or recent account of use of quinolone antibiotics.

Physical examination did not reveal an abnormal swelling, mass, or defect in the groin. In fact, there appeared to be a palpable defect approximately 4 cm proximal to the quadriceps tendon insertion into the patella. The patient was unable to perform a straight-leg raise. He had mild swelling of the left thigh, a normal neurovascular examination, and a stable knee.

The report of the patient's original magnetic resonance imaging (MRI) study from the outside institution documented a grade 2 muscle tear of the rectus femoris muscle with a likely partial tear of the rectus femoris tendon and a focal hematoma within the proximal rectus femoris muscle. According to the report, there was no evidence of complete disruption of the rectus femoris muscle or retraction of any muscular segments. Yet, we believed the findings of the patient's physical examination at our institution 8 days later, specifically his inability to extend the knee against gravity, warranted further investigation. Therefore, we ordered MRI for the knee, thigh, and hip. These studies showed a complete tear in the proximal rectus femoris tendon. The tear appeared to have a longitudinal split component involving a small tuft of tendon tissue that was still attached to the left anterior inferior iliac spine.



**Figure 3.** Side-to-side repair of rectus performed proximal to distal.

The majority of the tendon was retracted approximately 8 cm, and there was a large (10-cm) hemorrhagic fluid collection encasing the retracted tendon edge and the rectus muscle–tendon junction. Fairly extensive hemorrhage and edema also was found extending throughout the proximal half to two-thirds of the rectus femoris muscle in the anterior left thigh. There was associated prominent anterior and lateral soft-tissue edema. Less severe edema, compatible with muscle strain injury, was seen in the mid to



**Figure 4.** Repair of proximal rectus femoris tendon.

also was medial soft-tissue edema along the knee. A small longitudinal tear was seen in the superior fibers of the lateral patellar retinaculum. This tear minimally extended into the distal muscle–tendon junction of the vastus lateralis.

After thorough discussion of the surgical and nonsurgical risks and benefits of treatment, the patient was brought to surgery 11 days after injury. The patient, an elite, Olympic-level 100-meter sprinter, wanted to return to competitive track. Given the significant (8-cm)

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distal vastus lateralis muscle. There was overlying anterolateral subcutaneous hematoma extending down the mid and distal portions of the left thigh. Mild edema, compatible with mild muscle strain injury, also was found in the mid to distal fibers of the semimembranosus muscle. Additional fluid and edema, indicating strain injury, surrounded the sartorius muscle in the medial aspect of the left thigh. Distally, the quadriceps tendon was intact at its insertion onto the patella. Prominent soft-tissue edema was seen anteriorly and laterally along the distal quadriceps tendon. There

retraction of the proximal rectus femoris tendon, the large (10-cm) hemorrhagic fluid collection encasing the retracted tendon edge and the rectus muscle–tendon junction providing an interpositional barrier to potential healing and/or scar formation, and the massive edema in the entire rectus femoris muscle, which extended distally to a point just proximal to the knee joint, we felt that surgical repair afforded the best chance for a return to competitive running and sports.

After initial exposure through a 12-cm longitudinal incision, which extended distally from the anterior

inferior iliac spine, the lateral femoral cutaneous nerve was identified, and then was preserved throughout the procedure (Figures 1, 2). The interval between the sartorius and the tensor fascia lata was identified and developed. Subsequently, a very large hematoma was evacuated from the proximal to middle third of the thigh. This area was copiously irrigated. The rectus femoris tendon was noted to be completely torn and retracted approximately 8 cm. A longitudinal split in the tendon had left approximately 3 cm of the proximal tendon still attached to the anterior inferior iliac spine. The tendon tissue was in fair (shredded) condition. Edges were débrided of this non-optimal tendon tissue. After appropriate tensioning was established, side-to-side repair was performed, proximal to distal, with interrupted figure-of-8 sutures (Ethibond No. 2) (Figure 3). Excellent repair was noted (Figure 4).

At this point, a bioabsorbable suture anchor (BioROC; Innovasive Devices, Marlborough, Massachusetts) was placed in the anterior inferior iliac spine, and a circumferential suture was weaved into the proximal rectus femoris tendon to relieve any tension on the side-to-side repair of the longitudinal split



**Figure 5.** Bioabsorbable suture anchor (BioROC; Innovasive Devices, Marlborough, Massachusetts) placed in anterior inferior iliac spine. Circumferential suture was weaved into proximal rectus femoris tendon.

(Figure 5). After copious irrigation, the fascia was approximated with interrupted sutures (Vicryl No. 2), and the surgical wound was closed in standard fashion. The operative extremity was placed in a knee immobilizer, which was maintained for 6 weeks before initiation of a rehabilitation program. During this time, the patient was restricted to toe-touch weight-bearing precautions. The postoperative protocol

Rectus femoris strain has been shown to occur most commonly in either the distal musculotendinous junction or in the mid-muscle belly as a lesion of the intramuscular indirect head tendon.<sup>2-4</sup>

Various factors predispose the rectus femoris to strain injuries and eventual failure in sports such as sprinting. Anatomy plays a large role. The direct head of the rectus femoris originates on the anterior

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used was that described by Straw and colleagues,<sup>7</sup> who reported surgical repair of a chronic rupture of the rectus femoris muscle at the proximal musculotendinous junction in a soccer player. They believed that hip immobilization was both impractical and detrimental to the outcome, that hip immobilization alone was insufficient for protection of the repair, and that, even with hip immobilization, knee immobilization would still be needed where the arc of movement of the rectus femoris was larger than that of the hip. Therefore, we felt that knee immobilization alone would satisfactorily protect the repair.

### DISCUSSION

The quadriceps femoris, the largest muscle of the body, is the main extensor of the knee joint. It has 4 parts: the rectus femoris and 3 vastus muscles (lateralis, intermedius, medialis). Forty years ago, Ryan<sup>8</sup> described the seriousness of a quadriceps muscle strain injury. A previous radiologic study found the rectus femoris to be the site of clinical quadriceps strains,<sup>9</sup> confirming clinical suspicion.<sup>10</sup> Multiple authors have presented series of quadriceps muscle strain injuries, and all have described rectus femoris injuries, the most common and serious of quadriceps strains.<sup>2-4</sup>

inferior iliac spine, proximal to the hip joint, while its reflected head begins on the groove on the upper brim of the anterior acetabulum and anterior joint capsule.

The rectus femoris combines with the vastus muscle groups to become the extensor mechanism, which inserts distal to the knee joint at the tibial tubercle. It is the only quadriceps muscle that is biarticular. Clinical sports medicine asserts that 2-joint muscles strain during sprint activities when undergoing eccentric contractions<sup>10,11</sup>; muscle strain injuries occur when the muscle is either stretched passively or activated during stretch.<sup>10-12</sup> This paradigm suggests that hamstring muscles are prone to strain injury in the late swing phase (eccentric phase) rather than during early ground contact, when hamstring contraction is concentric.<sup>13</sup> This model also would suggest that the rectus femoris is prone to strain in the early swing phase of sprinting and in the early backward swing of the kicking motion. These phases are when the rectus femoris is eccentrically contracting.<sup>14</sup> To summarize, in real-life activities (eg, sprinting, kicking), the largest lengths (stretches or strains) of the hamstring and rectus femoris muscles occur during swing phases

es. Clinical teaching that stretch (strain) is most responsible for muscle strain injuries<sup>11</sup> suggests that the hamstring and rectus femoris muscles are most prone to failure when most stretched, which is when they are contracting eccentrically during the swing phases. Almost all laboratory-simulated muscle strain injury experiments have found that strain (amount of lengthening of muscle or muscle fiber, expressed in millimeters per millimeter) is

as the hip assumes a significantly hyperextended position, such as at the start of the forward swing phase of sprinting and the early backward swing of the kicking motion. This provides the sport-specific biomechanical explanation for the proximal rectus femoris avulsion sustained by our elite, Olympic-level 100-meter sprinter and for those sustained by NFL kickers,<sup>5</sup> soccer players,<sup>6,7</sup> and a 110-meter hurdler.<sup>6</sup>

ity 8 days after injury. We felt that surgical repair afforded this sprinter the best chance to return to competitive running.

Favorable outcomes of acute surgical treatment of this rare injury have been documented.<sup>6</sup> The proximal rectus femoris avulsions of 5 patients<sup>6</sup> (4 soccer players, a 110-meter hurdler) were repaired using Super Quick Anchors (Mitek, Raynham, Massachusetts). All 5 patients returned to preinjury level

**“...strain (amount of lengthening of muscle or muscle fiber, expressed in millimeters per millimeter) is the property that correlates most with muscle damage.”**

the property that correlates most with muscle damage. Muscle damage has been found to correlate more with strain than with muscle force,<sup>15</sup> velocity,<sup>16</sup> strain rate,<sup>17</sup> or muscle contraction status.<sup>18</sup> These findings suggest that amount of strain (muscle length) should be the property that correlates most with risk for muscle strain injury *in vivo*.

Muscle strain and tears occur most commonly at the myotendinous junction.<sup>19-21</sup> The structural design of the proximal myotendinous rectus femoris junction consists of the anterior, superficial tendon from its direct head, which travels down the proximal third of the muscle, and an intramuscular, deep tendon from the reflected head, which travels down the proximal two-thirds of the muscle.<sup>2,5</sup> Unipennate muscle fibers arise from the tendon of the direct head. Muscle fibers arising from both the medial and lateral surfaces of the tendon of the deep reflected head create a bipennate structure. The more common distal quadriceps ruptures occur during squatting, jumping, or lunging<sup>5</sup> with the hip in a flexed position during maximal quadriceps exertion. Proximal avulsions, on the other hand, occur when the rectus femoris is eccentrically contracting<sup>14</sup>

Surgical repair was recommended for this sprinter in view of the significant (8-cm) retraction of the avulsed proximal rectus femoris tendon, the large (10-cm) hemorrhagic fluid collection encasing the retracted tendon edge and the rectus muscle-tendon junction providing an interpositional barrier to potential healing and/or scar formation, and the massive edema in the entire rectus femoris muscle spreading distally to a point just proximal to the knee joint. The notable differences between this case and the cases of the 2 nonoperatively treated NFL kickers<sup>5</sup> are amount of tendon retraction, severity of soft-tissue injury, and the physical examination. The NFL kickers presented with 1 cm and 3.5 cm of distal retraction of the rectus femoris tendon from the anterior inferior iliac spine. In addition, within the kickers' first week after injury, their acute pain had resolved, and they were able to extend their knees against resistance and walk with a moderately antalgic gait.<sup>5</sup> In our patient's case, the tendon was distally retracted 8 cm, a massive amount of soft-tissue trauma was seen on repeat MRI, and the patient, unlike the NFL kickers, was unable to perform a straight-leg raise (extend knee against gravity) or place any weight on the extrem-

of activity 5 to 10 months after surgery. Similar to our patient, all 5 patients had notable pain, weakness, and inability to extend the knee against gravity. In addition, as in our case, all 5 avulsions involved the direct head of the rectus femoris. Yet, contrary to our case, the maximum amount of tendon retraction in these 5 athletes was only 3 to 4 cm. All 5 avulsed tendons were repaired to restore the normal anatomy, as insufficient healing in the bone-tendon interface is believed to lead to decreased strength and abnormal function.

The principal actions of the rectus femoris muscle are knee extension and hip flexion. Given that the retracted edge of the avulsed rectus femoris tendon in our patient was 2 times the maximal distance previously reported,<sup>5,6</sup> we felt surgical treatment was imperative, as this sprinter depends on being able to maximize the function of this muscle in his explosive sport.

### SUMMARY

We have presented the first report of a proximal rectus femoris avulsion injury in an elite, Olympic-level 100-meter sprinter and of the immediate outcome of acute surgical treatment. Given the rarity

of this injury, several key factors must be considered and carefully assessed when determining the appropriate course of management (ie, deciding between operative and nonoperative treatment): amount of distal retraction of the tendon, severity of associated soft-tissue trauma, physical examination, and postoperative goals (eg, return to elite-level competitive sports involving running or kicking vs resuming basic activities of daily living). We believe that these factors in our elite, high-performance athlete dictated an operative course of management.

### AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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