Technical Note

Open Repair of Acute Proximal Adductor Magnus Avulsion

Ryan J. McNeilan, M.D., Michael Rose, M.D., Omer Mei-Dan, M.D., and James Genuario, M.D.

Abstract: Hip adduction is accomplished through coordinated effort of the adductor magnus, brevis, and longus and the obturator externus and pectineus muscles. Each of these muscles may be injured at its proximal or distal insertion or in its midsubstance. The incidence of injuries to the adductor complex is difficult to determine in sport because of players' underreporting and playing through minor strains. The most commonly injured adductor muscle is the adductor longus muscle. The injury most frequently occurs at the proximal or distal musculotendinous junction, but several case reports of origin and insertional ruptures of the adductor longus exist in the literature. Successful outcomes have been obtained with both operative and nonoperative approaches in these cases. Reports of isolated proximal avulsion of the adductor magnus are less common. This article describes our surgical technique for management of a rare acute proximal adductor magnus avulsion.

Hip adduction is accomplished through coordinated effort of the adductor magnus, brevis, and longus and the obturator externus and pectineus muscles. Because of the proximity of their origins on the pubis and ischium, the adductor musculature is intimately related to the proximal hamstring musculature. Although the adductor brevis and longus attach more anteriorly on the pubis, the adductor magnus tendon has an ischiocondylar portion consistently present just medial to the conjoint tendon at the ischial tuberosity and a pubofemoral portion with extension anteriorly onto the pubis.[1] Because of this proximity on the ischial tuberosity, some even consider the ischial portion of the adductor magnus to be part of the hamstring muscle group.[2]

The etiology of adductor muscle strains/injury is most frequently a forceful eccentric contraction. The incidence of injuries to the adductor complex is difficult to determine in sport because of players' underreporting and playing through minor strains. Adductor strains have been reported to account for up to 10% to 13% of athletic injuries in sports with frequent eccentric loads, particularly hockey and soccer.[3-6] The most commonly injured adductor muscle is the adductor longus muscle.[7] The injury most frequently occurs at the proximal or distal musculotendinous junction, but several case reports of origin and insertional ruptures of the adductor longus exist in the literature.[8-14] A case of a distal adductor magnus rupture has been reported.[15] Satisfactory outcomes have been achieved with both operative and nonoperative management of proximal avulsions of the adductor longus musculature.[8-13] In the single case of distal adductor magnus avulsion, surgical repair resulted in satisfactory outcome.[15] This article describes our technique to manage a rare acute proximal adductor magnus avulsion.

Patient Evaluation/Preoperative Assessment

Presentation of a patient with proximal adductor magnus avulsion mimics that of a patient with a proximal hamstring avulsion. The patient may report an acute onset of pain or tearing sensation in the

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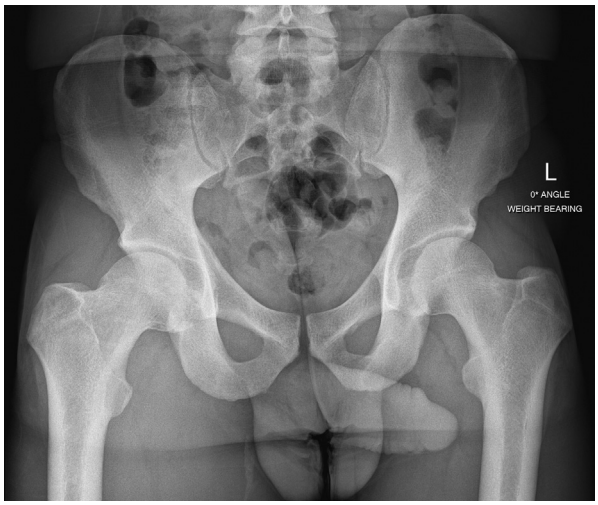

Fig 1. A standing anteroposterior pelvis radiograph is obtained when considering diagnosis of proximal avulsion of the adductor magnus to rule out bony avulsion from the ischial tuberosity. There is no evidence of bony avulsion in the current imaging.

proximal posterior thigh. Significant ecchymosis and a palpable defect may be present at the medial aspect of the ischial tuberosity. Radiographs of the pelvis should be obtained to assess for bony avulsion (Fig 1). A magnetic resonance image (MRI) will confirm the diagnosis of an adductor magnus avulsion (Fig 2).

Surgical Technique

Our surgical technique for open repair of acute proximal adductor magnus avulsion can be seen in detail in Video 1. Pearls and pitfalls of the procedure are noted in Table 1.

Positioning

The patient is placed prone in a superman position on a regular operating table with 2 chest rolls and padding beneath the elbows and knees (Fig 3). The knees are flexed slightly and supported by 2 pillows. The patient is secured to the table with a belt over the proximal torso, and a sequential compression device is applied to the nonoperative leg. No tourniquet is used. A preoperative anesthetic block is avoided to allow postoperative assessment of sciatic nerve function.

Draping

The ischium (in particular, the medialmost extent) is identified with palpation and marked along with the course and location of the sciatic nerve. The planned transverse gluteal crease incision is marked extending medial to the medial edge of the palpation ischium. The operative leg is then prepped and draped fully, paying particular attention to extending the operative field to the gluteal fold as the dissection will require more medial extension than the standard approach for surgical management of a proximal hamstring injury. An antimicrobial incise drape (Ioban 2; 3M, St Paul, MN) is applied to aid in infection prevention and drape seal.

Approach

The procedure is initiated with a 5- to 6-cm incision and sharp dissection through the skin and subcutaneous tissue transversely in the medial gluteal crease while skin tension is applied by an assistant. The inferior border of the gluteus maximus is identified, freed, and retracted superiorly with a Richardson retractor. Visualization of the medial hamstring and adductor magnus musculature is obtained. A small (3-cm) longitudinal incision is made in the sheath over the hamstring and adductor muscles, allowing identification of the avulsed stump of adductor magnus tendon (Fig 4). In this case, the avulsion involved the entirety of the adductor magnus and did extend slightly laterally into the insertion of the conjoined long head of biceps femoris and semitendinosus tendon. Serous fluid and hematoma are evacuated with irrigation and suction. Blunt finger dissection is used to palpate the anterior and posterior surfaces of and expose the adductor magnus tendon stump (Fig 5). The bare spot vacated by the adductor magnus tendon can be palpated at the medial aspect of the ischial tuberosity. The conjoined tendon insertion is palpable more lateral on the ischial tuberosity. A Richardson retractor is placed deep and medial to the intact conjoined tendon and gentle lateral retraction is applied. This ensures protection of and avoidance of iatrogenic injury to the more lateral sciatic

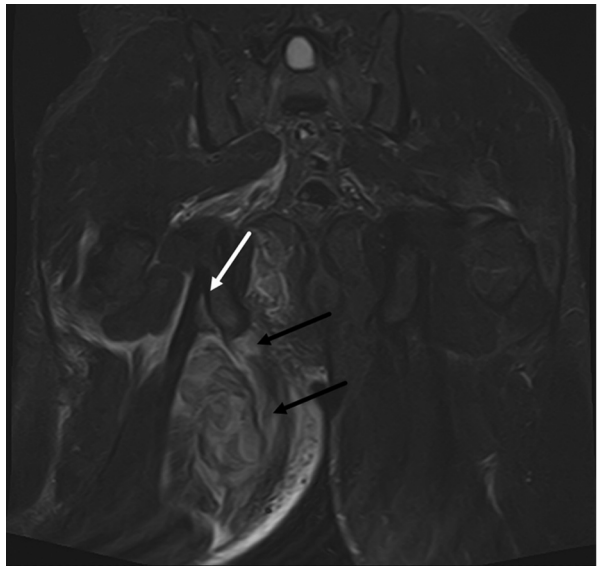

Fig 2. Magnetic resonance imaging of the hip will aid diagnostic evaluation and confirm diagnosis of proximal avulsion of adductor magnus. Coronal T2 imaging shows intact hamstring tendon insertion laterally (white arrow) with avulsion of the adductor magnus tendon and associated edema at the medial ischial tuberosity (black arrows).

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Sterilely prep as medial as possible	Aggressive lateral retraction of remaining hamstring tendon can cause iatrogenic sciatic nerve
Spend time to ensure drill direction allows anchor placement intra-osseous	Anterior perforation of ischial tuberosity at its medial aspect places pudendal nerves and its branches at risk
If the all-suture anchor pulls out, use the titanium anchor as salvage	
If limited by body habitus, use arthroscopic knot pusher to aid knot tying	

nerve (Fig 6). Richardson retractors are also used at the medial and distal aspects of the surgical incision to retract the skin and subcutaneous tissues.

Tuberosity Preparation/Anchor Placement

With retractors in place, the exposed ischial tuberosity is visualized. The footprint of the adductor magnus insertion is debrided of all residual soft tissue and the bone surface is roughened with a rongeur and a Cobb elevator. When satisfied with clearance of soft tissues, focus is then turned to placement of anchors in the medial ischial tuberosity. Mark the planned anchor site on the ischial tuberosity with Bovie electrocautery. The medial-lateral dimension of the adductor magnus footprint on the ischial tuberosity is a mean 17.3 mm (range, 6.5-27.5 mm) and is a mean 8.5 mm (range, 1.1-15.8 mm) from the conjoined tendon insertion on the ischial tuberosity.[1] On the basis of this anatomic study, we recommend marking the lateralmost anchor placement 5 to 8 mm medial to the residual intact insertion of the conjoined tendon and the medialmost anchor at least 10 mm medial to the lateral anchor near the transition site of the ischial insertion to pubic insertion of the adductor magnus tendon (Fig 7). This will allow passage of sutures to restore both the ischiocondylar and pubofemoral components of the tendon. A 2.3-mm all-suture anchor (ICONIX; Stryker, Kalamazoo, MI) 12° curved drill guide is placed at the site marked for the lateral anchor. The drill guide is held firmly against the exposed ischial tuberosity, with the curve oriented to allow the course of the drill to pierce the outer cortical bone and travel within the cancellous portion of the ischial tuberosity. Care should be taken to avoid anterior perforation through the ischial tuberosity as the pudendal nerve and its branch lie on the anterior and adjacent to the anterior ischium as it transitions to the pubis. The surgeon then drills through the guide to the hub of the drill guide. The drill guide remains held firmly against the ischial tuberosity and a 2.3-mm all-suture anchor double loaded with No. 2 nonabsorbable suture (ICONIX; Stryker) is malleted into the drill hole. The drill guide is then removed and gentle traction is pulled on the sutures to set the all-suture anchor against the inner cortical wall of the ischial tuberosity. Pull more moderate traction on the sutures to ensure avoidance of future pullout. The above steps are then repeated to place the more medial anchor, another 2.3-mm all-suture anchor double loaded with No. 2 nonabsorbable suture (ICONIX; Stryker). If the anchor pulls out with moderate traction, a titanium anchor (Titanium Intraline Anchor; Stryker) double loaded with No. 2 nonabsorbable suture may be inserted into the drilled hole as a salvage.

Tendon Repair

The suture limbs are then passed from lateral to medial through the tendon of the adductor magnus. The lateralmost limb is passed in a modified Mason-

Fig 3. The patient is positioned in a prone position with the operative (right) leg exposed, paying particular attention to ensuring adequate medial exposure when placing drapes. Surgical approach options are depicted. Selection of approach type remains per surgeon preference.

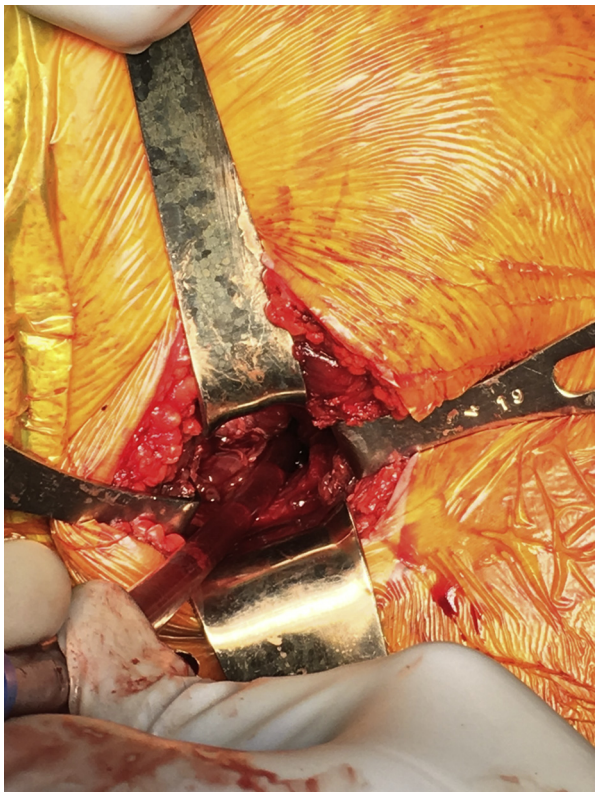

Fig 4. Patient in prone position, right leg. With the patient in a prone position, the adductor magnus tendon avulsion is exposed through a transverse gluteal crease incision with additional medial dissection. The inferior border of the gluteus maximus is identified, freed, and retracted superiorly with a Richardson retractor. Visualization of the medial hamstring and adductor magnus musculature is obtained. A small incision is made in the sheath over the hamstring and adductor muscles, allowing identification of the avulsed stump of adductor magnus tendon.

Allen fashion and the medial limb is passed just medial to function as the post. A small knot can be placed in the medial limb to aid in later identification as the post.

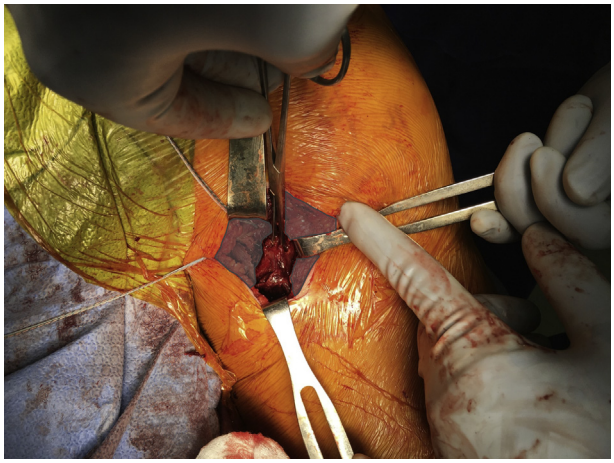

Fig 5. Patient in prone position, right leg. Blunt finger dissection is used to palpate the anterior and posterior surfaces of and expose the adductor magnus tendon stump. The stump is grasped with an Allis clamp.

This process is repeated to pass all suture limbs from lateral to medial. After passing all sutures, traction can be applied to assess footprint coverage. When pleased with footprint coverage, the knee is flexed and hip is adducted. Sutures are then tied sequentially from lateral to medial while the assistant maintains traction pulling the tendon to the ischial tuberosity with the remaining sutures. An arthroscopic knot pusher may be used to aid in suture tying, especially in a larger individual or if exposure remains difficult. After all sutures are tied, the sutures are cut above the knot and the ischial tuberosity is palpated to ensure adequate coverage and anatomic re-creation of the footprint (Fig 8). The wound is thoroughly irrigated and closed in layers.

Rehabilitation

Rehabilitation progresses through 4 phases. Phase I consists of maximum protection with no weight bearing for 4 weeks, then progression to weight bearing as tolerated. A brace is worn for the first 6 weeks limiting range of motion from 45° of hip flexion to 45° of hip extension. Active hip adduction and passive hip abduction are prohibited for the first 6 weeks. Phase II

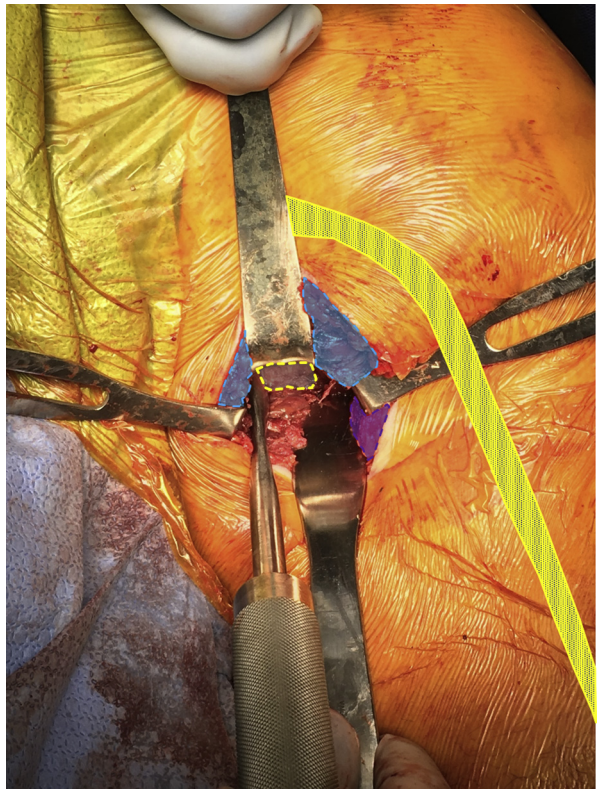

Fig 6. Patient in prone position, right leg. After isolating the torn tendon, the ischial tuberosity is exposed by retracting the gluteus maximus (blue) proximally and the conjoined tendon (purple) laterally with gentle traction using a Richardson retractor. The gentle lateral traction ensures protection of and avoidance of iatrogenic injury to the more lateral sciatic nerve (yellow).

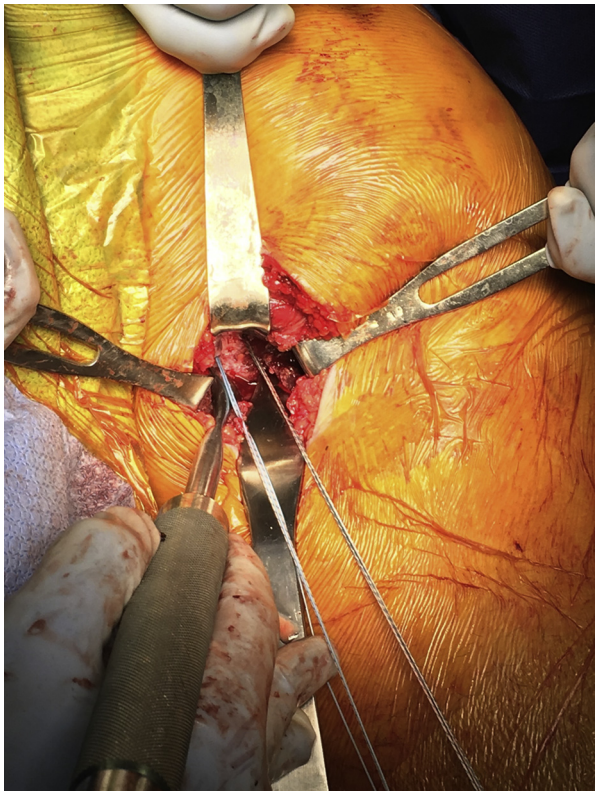

Fig 7. Patient in prone position, right leg. With the assistant continuing to hold the ischial tuberosity exposed, focus is then turned to placement of anchors in the medial ischial tuberosity. The planned anchor site for the lateralmost anchor on the ischial tuberosity is marked with Bovie electrocautery 5-8 mm medial to the residual intact insertion of the conjoined tendon. The medialmost anchor is marked at least 10 mm medial to the lateral anchor near the transition site of the ischial insertion to pubic insertion of the adductor magnus tendon. A double-loaded all-suture anchor is placed at both of the previously marked sites on the medial ischial tuberosity to re-establish the ischiocondylar and pubofemoral portions of the adductor magnus tendon insertion.

includes weeks 6 to 12 and consisted of progressive range of motion and closed-chain strengthening. During phase III (weeks 12-16), the focus is on increasing strength and endurance. Phase IV (weeks 16-24) involves a running progression with plan for return to sport between 5 and 6 months postoperatively.

Discussion

This study describes our approach to management of a rare proximal avulsion of the adductor magnus tendon. Case series and reports of management of avulsions of the proximal adductor longus insertion are present in the literature. Rizio et al.[10] reported successful management and return to professional football after adductor longus proximal avulsion repair through a medial approach with 2 3.5 bioabsorbable anchors. In another case series, 2 patients returned to prior level of sport following surgical management of acute avulsion of the fibrocartilaginous enthesis of the adductor longus origin with six to seven 2.4-mm nonabsorbable anchors. Despite these surgical successes, the need for operative repair of adductor longus proximal ruptures remains controversial, as one study found that nonoperative treatment of proximal adductor tendon rupture resulted in a statistically significantly faster return to play than does operative treatment in athletes competing in the National Football League.[12]

Although the adductor magnus is a primary hip adductor and it does not cross the knee, thereby excluding a functional connection to the remaining hamstring muscles, some consider its ischial insertion to be part of the hamstring group.[2] Others have characterized the ischial insertion of the adductor magnus as a

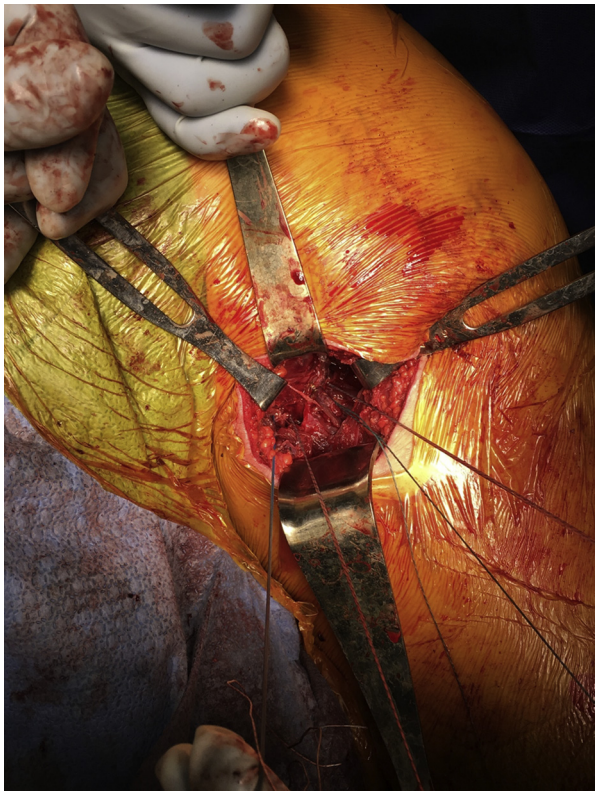

Fig 8. Patient in prone position, right leg. The suture limbs are then passed from lateral to medial through the tendon of the adductor magnus. The lateralmost limb is passed in a modified Mason-Allen fashion, and the medial limb is passed just medial to function as the post. After passing all sutures, traction can be applied to assess footprint coverage. When pleased with footprint coverage, the knee is flexed and the hip is adducted. Sutures are then tied sequentially from lateral to medial while the assistant maintains traction pulling the tendon to the ischial tuberosity with the remaining sutures. An arthroscopic knot pusher may be used to aid in suture tying, especially in a larger individual or if exposure remains difficult. After all sutures are tied, the sutures are cut above the knot and the ischial tuberosity is palpated to ensure adequate coverage and anatomic re-creation of the footprint.

"mini-hamstring."[16] Traditional management of hamstring injuries has largely been nonoperative, particularly in noninsertional injuries. Nonoperative management of proximal ruptures has resulted in poor outcomes, including higher pain rates and decreased ability to resume sport, prompting most surgeons to recommend operative repair of acute proximal avulsions to maximize outcomes and activity levels.[17-24]

A superiority or inferiority of operative versus nonoperative management strategy for adductor magnus avulsions has not been elucidated. As with all surgeries, the patient's activity levels and demands must be evaluated as part of the surgical decision-making process.

Special considerations include avoidance of iatrogenic injury, particularly to the sciatic and pudendal nerves. Preoperative consent should include careful discussion of these risks and their implication in lower extremity function and sexual health. Careful attention to gentle lateral traction and avoidance of overpenetration during drilling for anchor placement can help the surgeon mitigate these risks.

In this technique guide, we describe the surgical repair of an acute proximal avulsion of the adductor magnus using suture anchors. Surgical goals include re-creation of the native anatomic footprint while avoiding iatrogenic injury to the sciatic or pudendal nerve. Despite the success of the described technique, no objective data currently exist to guide a decision of operative versus nonoperative management for adductor magnus avulsion injuries. Decisions for surgical intervention should continue to be made on a case by case basis after careful discussion and consideration of patient activity and goals.

References

1. Obey MR, Broski SM, Spinner RJ, Collins MS, Krych AJ. Anatomy of the adductor magnus origin: Implications for proximal hamstring injuries. *Orthop J Sports Med* 2016;4. 2325967115625055.
2. Martini F, Timmons MJ, Tallitsch RB. *Human anatomy*. Boston, MA: Pearson Benjamin Cummings, 2012.
3. Emery CA, Meeuwisse WH, Powell JW. Groin and abdominal strain injuries in the National Hockey League. *Clin J Sport Med* 1999;9:151-156.
4. Lorentzon R, Wedren H, Pietila T. Incidence, nature, and causes of ice hockey injuries. A three-year prospective study of a Swedish elite ice hockey team. *Am J Sports Med* 1988;16:392-396.
5. Lynch SA, Renstrom PA. Groin injuries in sport: Treatment strategies. *Sports Med* 1999;28:137-144.
6. Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med* 1989;17:803-807.
7. Renstrom P, Peterson L. Groin injuries in athletes. *Br J Sports Med* 1980;14:30-36.
8. Dimitrakopoulou A, Schilders EM, Talbot JC, Bismil Q. Acute avulsion of the fibrocartilage origin of the adductor longus in professional soccer players: A report of two cases. *Clin J Sport Med* 2008;18:167-169.
9. Lohrer H, Nauck T. [Proximal adductor longus tendon tear in high level athletes. A report of three cases]. *Sportverletz Sportschaden* 2007;21:190-194 [in German].
10. Rizio L III, Salvo JP, Schürhoff MR, Uribe JW. Adductor longus rupture in professional football players: Acute repair with suture anchors: A report of two cases. *Am J Sports Med* 2004;32:243-245.
11. Sangwan SS, Aditya A, Siwach RC. Isolated traumatic rupture of the adductor longus muscle. *Indian J Med Sci* 1994;48:186-187.
12. Schlegel TF, Bushnell BD, Godfrey J, Boublik M. Success of nonoperative management of adductor longus tendon ruptures in National Football League athletes. *Am J Sports Med* 2009;37:1394-1399.
13. Symeonides PP. Isolated traumatic rupture of the adductor longus muscle of the thigh. *Clin Orthop Relat Res* 1972;88:64-66.
14. Serner A, Weir A, Tol JL, et al. Characteristics of acute groin injuries in the adductor muscles: A detailed MRI study in athletes. *Scand J Med Sci Sports* 2018;28:667-676.
15. Kuhlmann JN, Kirsch JM, Mimoun M, Baux S. [Traumatic rupture of the great adductor (adductor magnus). Apropos of a case]. *Rev Chir Orthop Reparatrice Appar Mot* 1986;72:317-319 [in French].
16. Broski SM, Murthy NS, Krych AJ, Obey MR, Collins MS. The adductor magnus "mini-hamstring": MRI appearance and potential pitfalls. *Skeletal Radiol* 2016;45:213-219.
17. Ahmad CS, Redler LH, Ciccotti MG, Maffulli N, Longo UG, Bradley J. Evaluation and management of hamstring injuries. *Am J Sports Med* 2013;41:2933-2947.
18. Birmingham P, Muller M, Wickiewicz T, Cavanaugh J, Rodeo S, Warren R. Functional outcome after repair of proximal hamstring avulsions. *J Bone Joint Surg Am* 2011;93:1819-1826.
19. Brucker PU, Imhoff AB. Functional assessment after acute and chronic complete ruptures of the proximal hamstring tendons. *Knee Surg Sports Traumatol Arthrosc* 2005;13:411-418.
20. Cohen S, Bradley J. Acute proximal hamstring rupture. *J Am Acad Orthop Surg* 2007;15:350-355.
21. Cohen SB, Rangavajjula A, Vyas D, Bradley JP. Functional results and outcomes after repair of proximal hamstring avulsions. *Am J Sports Med* 2012;40:2092-2098.
22. Cross MJ, Vandersluis R, Wood D, Banff M. Surgical repair of chronic complete hamstring tendon rupture in the adult patient. *Am J Sports Med* 1998;26:785-788.
23. Harris JD, Griesser MJ, Best TM, Ellis TJ. Treatment of proximal hamstring ruptures—A systematic review. *Int J Sports Med* 2011;32:490-495.
24. Sallay PI, Friedman RL, Coogan PG, Garrett WE. Hamstring muscle injuries among water skiers. Functional outcome and prevention. *Am J Sports Med* 1996;24:130-136.