Efficacy of Surgical Tenodesis for Treatment of Distal Semitendinosus Hamstring Tendon Injuries

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Background: Understanding the optimal management of distal semitendinosus hamstring injuries is critical for reducing pain, restoring preinjury function, maintaining knee stability, improving hamstring muscle strength, and minimizing the risk of complications and recurrence. To our knowledge, the outcomes of surgical tenodesis for distal semitendinosus hamstring injuries have not been previously reported.

Hypothesis: Surgical tenodesis for injuries of the semitendinosus would enable return to preinjury level of sport with low risk of recurrence.

Study Design: Case series; Level of evidence, 4.

Methods: This prospective single-surgeon study included 13 professional athletes (12 men, 1 woman; mean age, 32 ± 8.2 years; mean body mass index, 26.7 ± 3.9 kg/m^2) undergoing treatment for distal semitendinosus hamstring injuries with primary tenodesis to the distal semimembranosus. Indications for surgical tenodesis included distal semitendinosus tendon avulsion injury (n = 8) or residual tendon instability and hamstring weakness after semitendinosus graft harvest for anterior cruciate ligament reconstruction (n = 5). All study patients underwent a standardized postoperative rehabilitation program. The primary outcome was defined as time for return to sporting activity. Secondary outcomes were patient satisfaction, injury recurrence, and complications. The mean follow-up time was 17 months (range, 12-24 months) from date of surgery.

Results: All study patients returned to their preinjury level of sporting activity. The mean time from the surgical intervention to return to full sporting activity was 15 ± 4.6 weeks. At 1-year follow-up, all study patients were still participating at their preinjury level of sporting activity, and 12 patients (92%) were very satisfied and 1 patient (8%) was satisfied about the outcomes of their surgery. No study patients had recurrence of the primary injury. No surgical complications, injury recurrence, or reoperations were observed within the follow-up period.

Conclusion: Early return to sporting activity was seen after surgical tenodesis for distal semitendinosus hamstring injuries after acute trauma or residual symptoms following previous hamstring graft harvest, with high levels of patient satisfaction and low risk of recurrence at short-term follow-up.

Keywords: semitendinosus; hamstrings; avulsion; tenodesis; recurrence; surgical treatment

Hamstring injuries are among the most frequent sports injuries in high-level athletes and are associated with long periods of rehabilitation and high risk of recurrence.[3,10,11,27] These injuries most commonly involve tears through the proximal musculotendinous junction or proximal avulsion of the hamstring origin from the ischial tuberosity.[10,11,20,38,40] Less commonly, hamstring injuries involve the distal hamstring muscle complex, and more rarely they include the distal semitendinosus.[26,37]

Elite athletes place an especially high demand on the hamstring muscle complex, with rapid acceleration, deceleration, and pivoting maneuvers inherent in multiple sporting disciplines.[35] Muscle strains typically affect superficial muscles working across 2 joints.[19] Specifically, rapid explosive movements produced by eccentric contraction of the hamstring muscles with the ipsilateral hip in flexion and the knee in extension may predispose the hamstring musculotendinous junction or the tendon to injury.[6,7,9,29] Furthermore, in comparison with the quadriceps, the hamstring muscles contain a higher density of type 2 muscle fibers that enable more explosive forces to be generated but also predispose these muscles to higher risk of injury.[29]

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Complete hamstring tendon ruptures and injuries of the musculotendinous junction hold prognostic uncertainty, delay return to preinjury muscle strength and level of function, and lead to high risk of recurrent injury in up to 63% of patients.[13,14,21,34] In athletes with high-functional demands, high-grade hamstring injuries are potentially career-threatening injuries, with the risk of premature retirement from the elite sporting level.[21,34]

Semitendinosus muscle injuries account for approximately 32% to 37% of hamstring injuries.[11,38] However, because of the paucity of reports within the literature, treatment protocols for the management of distal hamstring complete ruptures remain contentious.[26] Semitendinosus and gracilis tendon autografts are a commonly used graft in anterior cruciate ligament (ACL) reconstruction, with varying reports of regenerative rates within the literature.[4,16,18,23,24,33,39] Ongoing pain, strength deficits in knee flexion and internal rotation, and impaired dynamic stability have been reported as complications after semitendinosus harvest for ACL reconstruction.[23,24] The semitendinosus muscle is important to knee flexion strength at increased flexion angles and has a key role in internal rotation of the tibia.[31,36] The optimal surgical management of these acute injuries has yet to be defined,[17] but understanding the optimal management of distal semitendinosus hamstring injuries is critical for restoring preinjury function, improving hamstring muscle strength, increasing range of motion, and minimizing the risk of complications and recurrence.

Distal semitendinosus hamstring insufficiency due to traumatic rupture or autologous graft harvest may lead to chronic pain, impaired hamstring function, and knee instability, with subsequent poor return to preinjury function in the elite athlete.[23,24,26,35] This impairment may be refractory to nonoperative management and pose a threat to elite-level performance.[35] Surgical techniques, including direct surgical repair, anchor repair, or tenotomy techniques, have been suggested in the limited literature on this injury.[2,12,26,30,35] Considering our soft tissue surgical experience in our center, we hypothesized that these would carry risk of rerupture and ongoing pain at the repair site because of tension and scar tissue strictures. We therefore employed the surgical technique of tenodesis in elite athletes to reduce the tension and the risk of injury recurrence. To our knowledge, the outcomes of surgical tenodesis for distal semitendinosus hamstring injuries have not been previously reported. The findings of this study will provide an improved understanding of the efficacy of surgical tenodesis for these injuries on return to preinjury level of sporting activity, injury recurrence, and functional performance at short-term follow-up.

The primary objective of this study was to assess the efficacy of surgical tenodesis for distal semitendinosus hamstring injuries following trauma or due to residual symptoms after previous hamstring graft harvest. We assessed return to preinjury-level sporting activity and injury recurrence. The secondary objectives were to assess the effect of surgical tenodesis on time to return to preinjury level of sporting function, patient satisfaction, and complications. The study hypothesis was that surgical tenodesis of these types of injuries would facilitate return to preinjury level of professional sporting function with low risk of recurrence.

METHODS

Patient Selection

This prospective study included 13 professional athletes undergoing surgical tenodesis for distal semitendinosus hamstring injuries. Indications for surgery were as follows: distal semitendinosus acute avulsion injuries (n = 4); chronic symptomatic avulsion injuries refractory to nonoperative management; pain and medial knee instability from loss of the semitendinosus muscle as a dynamic stabilizer in knee flexion[23,24] (n = 4); rerupture of the reconstitute semitendinosus distal tendon with associated hamstring weakness; and pain and semitendinosus tendon instability after autologous semitendinosus hamstring harvest (n = 5). All operative procedures were performed by the senior author (F.S.H.) between 2012 and 2018. The baseline and characteristics data for all study patients are shown in Table 1. It was not possible to include a control group undergoing nonoperative management, because all study patients were high-performance athletes, who were either refractory to nonoperative management (n = 9) or not interested in undergoing randomization and potential allocation to nonoperative management (n = 4) because of risk of chronic strength deficit, knee or tendon instability, or functional disability.

Preoperative magnetic resonance imaging (MRI) was undertaken in all study patients to confirm the diagnosis and identify any concurrent injuries. All operative procedures were performed by the senior author. Inclusion criteria for study participation included the following: chronic rupture of the semitendinosus refractory to nonoperative management; acute complete rupture of the semitendinosus with an associated Stener-like lesion (soft tissue interposition between the distal semitendinosus tendon and its tibial insertional footprint); or previous semitendinosus hamstring graft for ACL reconstruction with clinical loss

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Ethical approval for this study was obtained from The Princess Grace Hospital, London, UK.

TABLE 1
Characteristic and Baseline Data Summary for Study Patients Undergoing Surgical Tenodesis Repair of the Semitendinosus Hamstring (N = 13)[a]

Characteristic	Value
Age, y, mean ± SD	32 ± 8.2
Sex, n (%)	
Female	1 (8)
Male	12 (92)
BMI, mean ± SD, kg/m^2	26.7 ± 3.9
ASA score (1-4), n (%)	
1	13 (100)
2-4	0
Laterality, n (%)	
Right	8 (62)
Left	5 (38)
Sporting activity, n (%)	
Rugby	6 (46)
Soccer	4 (31)
Track athlete	2 (15)
Gymnastics	1 (8)
Time from injury to surgery, mean (range)[b]	
Acute, d (n = 4)	20 (14-40)
Chronic, d (n = 4)	138 (110-198)
Autograft harvest, mo (n = 5)	40.2 (14-78)

[a]ASA, American Society of Anesthesiologists; BMI, body mass index.

[b]Acute, acute avulsion; chronic, chronic symptomatic avulsion injuries refractory to nonoperative management; autograft harvest, pain and tendon instability with hamstring weakness after autologous semitendinosus hamstring harvest (time from anterior cruciate ligament reconstruction to surgery).

of strength, flexibility, and/or stability of the hamstring complex and knee in conjunction with operative intervention undertaken by the senior author. Exclusion criteria included the following: multiligamentous injury involving the posteromedial corner or cruciate ligaments; unsuccessful semitendinosus reconstitution requiring concomitant revision ACL reconstruction; and revision surgery after previously failed semitendinosus reconstruction at another treatment center.

For athletes undergoing tenodesis after graft harvest, harvest-related issues were seen at 14 to 78 months (mean 40.2 months) after ACL reconstruction. All patients reported some rehabilitation-related hamstring problems and not the typical uneventful recovery, but they did recover and return to sport after reconstruction. These patients later re-presented with acute rerupture of the reconstitute semitendinosus distal tendon and failed nonoperative management for a minimum of 3 months.

The study was prospectively reviewed by the hospital review board who advised that further research ethics committee approval was not required. Written informed consent for participation was obtained from all study patients.

Surgical Technique

All operations were performed under general anesthesia, with the patient in the prone position (Figure 1). Before positioning the patient, the operating surgeon (F.S.H.) performed an examination with anesthesia to assess the competency of the ACL, the posterior cruciate ligament, and the collateral ligament. Using measurements extracted from the diagnostic MRI, ultrasonography, or direct palpation, the site of proximal retraction or distal reconstitution of the semitendinosus tendon was marked on the skin. An 8- to 12-cm posteromedial curvilinear longitudinal incision centered over the site of proximal retraction or distal reconstitution of the semitendinosus was performed. Electrocautery was used to incise the underlying subcutaneous tissue in line with the skin incision. The overlying fascia of the hamstring compartment was incised longitudinally. The saphenous nerve and medial compartment tendons (sartorius, semimembranosus, with or without gracilis) were identified and protected. Any underlying hematoma or seroma was evacuated and the medial collateral ligament was identified and assessed to ensure its integrity.

The retracted and defunctioned semitendinosus was traced to its site of injury or distal reconstitution, and any scar tissue was excised using finger dissection and electrocautery to mobilize the distal tendinous portion. For athletes undergoing tenodesis after graft harvest for ACL reconstruction, a significant scar tissue was typically seen at the distal semitendinosus musculotendinous junction with variable distal regeneration or reconstitution. Two stay sutures were passed through the distal semitendinosus tendon to help retract and improve visualization of the tendon stump. Any residual devitalized, calcified, and degenerated tissue from this distal tendon stump was removed using electrocautery. The stay sutures were used to distally mobilize the semitendinosus tendon using low to moderate tension, and multiple interrupted No. 5 Ethibond (Ethicon; Somerville) braided nonabsorbable sutures were used to suture the distal semitendinosus tendon to the adjacent semimembranosus tendon at 30° of knee flexion (Figure 2). This technique provided a surgical construct with low to moderate tension and multiple repair sutures across a large surface area, which may enable more uniform distribution of stress forces and reduce the risk of injury recurrence. The knee was flexed from 0° to 120° on the table to ensure satisfactory tension in the surgical tenodesis within these ranges of movement. The overlying sartorial fascia was closed with absorbable sutures. The wound was copiously irrigated with normal saline, and absorbable sutures were used to perform a layered closure of the overlying subcutaneous fat and skin. All patients were placed in a hinged knee brace for 4 weeks and were limited to 60° to 120° of knee flexion for 0 to 2 weeks; they were instructed to avoid hip flexion greater than 70° followed by an incremental increase in range of motion 2 to 4 weeks postoperatively.

Postoperative Rehabilitation

All patients received a standardized milestone-based rehabilitation program supervised by an experienced sports physical therapist. The rehabilitation program was divided into 4 distinct phases:

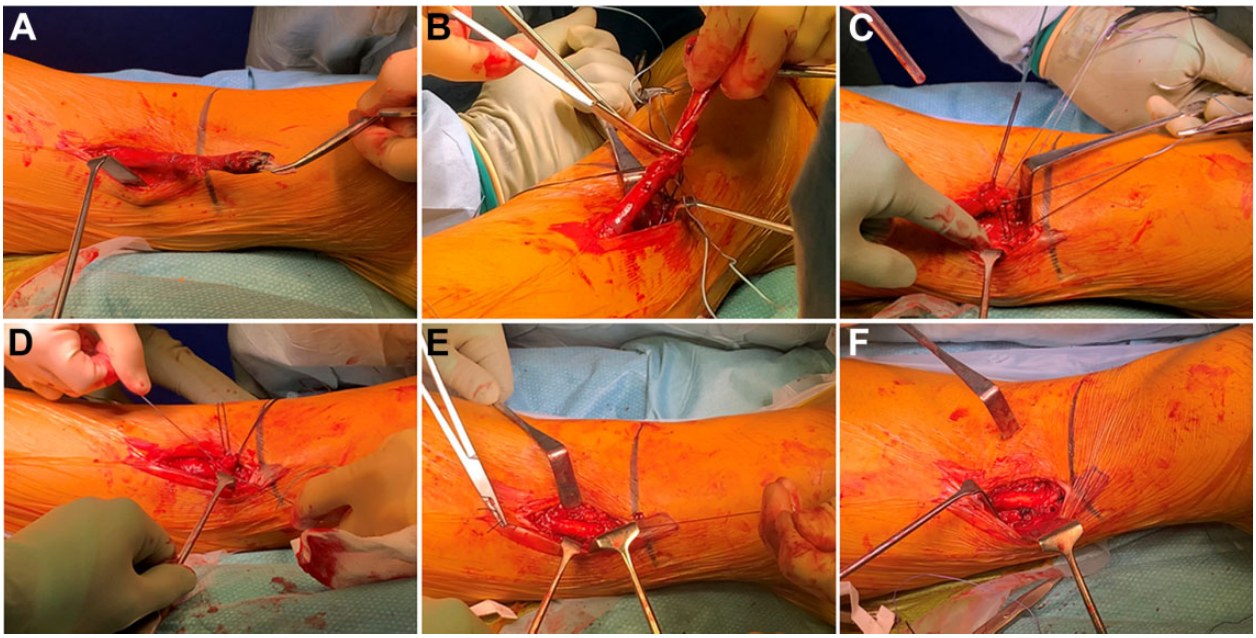

Figure 1. Intraoperative photographs of a surgical ST tenodesis for a chronic ST injury of the right leg refractory to nonoperative management; the transverse black line shows the location of the joint line. (A) Posteromedial approach via a longitudinal incision at the site of the proximal retraction of the ST tendon with the patient in the prone position. (B) An evident distal ST tendon scar and a degenerated tissue. (C-F) The distal ST tendon scar and the degenerated tissue were excised. By suturing the ST to the underlying semimembranosus the tenodesis was performed using No. 5 Ethibond braided nonabsorbable sutures under optimal tension. ST, semitendinosus.

Phase 1: Rest, ice, compression, and elevation; mobilize partial weightbearing with crutches; aspirin, 150 mg once daily; limit excessive combined hip flexion and knee extension; toe-touch weightbearing with progression to normalization of gait.

Phase 2: Regain pain-free range of motion; full weightbearing; concentric and eccentric training; core strengthening.

Phase 3: Aerobic conditioning with light jogging, cycling, and swimming; muscle strengthening with resistance exercises, double- and single-leg squats, quadriceps extension, and hamstring curls; sport-specific training.

Phase 4: Return to full sporting activity when full pain-free range of motion; isokinetic muscle strength 90% of uninjured limb (at 0°, 45°, and 90° of knee flexion); no concerns with sport-specific training.

Outcome Measures

All study patients were reviewed by the operating surgeon in the outpatient clinic at regular intervals until return to play. Study outcomes were recorded by a specialist nurse practitioner preoperatively at predefined intervals after surgery. All outcomes at 3 months, 1 year, and 2 years postoperatively were collected during clinical consultation or collated by telephone conversation or email because of the wide geographical location of study patients. Outcome measures included return to sporting activity, patient satisfaction, postoperative complications, and injury recurrence. Time from surgical intervention to full return to professional sporting activity was collected in all study patients. All complications with their respective treatments and outcomes within 2 years of the primary surgery were recorded. The recurrence of injury or reoperation were duly recorded. Outcomes of the surgical treatment were evaluated using the validated Subjective Patient Outcome for Return to Sports (SPORTS) criteria (Table 2).[8,25] Patient satisfaction was recorded using the Musculoskeletal Outcomes Data Evaluation and Management System and the Surgical Satisfaction Questionnaire, which scores satisfaction on a 5-point scale (1 = very unsatisfied, 2 = unsatisfied, 3 = neutral, 4 = satisfied, and 5 = very satisfied).[15]

RESULTS

Return to Function and Recurrence

All study patients completed a minimum of 12 months' follow-up. The mean follow-up time was 17 months (range, 12-24 months) from date of surgery. All study patients returned to their preinjury level of sporting activity. The mean time from the surgical intervention to return to full sporting activity was 15 ± 4.6 weeks. At the final follow-up, all study patients were still participating at their preinjury level of sporting activity. Also, 12 (92%) patients achieved a 10-point SPORTS score and 1 (8%) patient achieved a 9-point SPORTS score (Table 2). No study patients had recurrence of the primary injury.

Patient Satisfaction

The surgical repair of semitendinosus hamstring injuries was associated with high levels of patient satisfaction at

short-term follow-up after surgery. At minimum of 1-year follow-up, 12 patients (92%) were very satisfied and 1 (8%) was satisfied about the outcomes of their surgery.

Figure 2. Surgical illustration demonstrating a semitendinosus (ST) tendon-to-tendon tenodesis to the underlying semimembranosus after excision of the distal ST tendon as described within the text. (Illustration drawn by Deborah A. Gyamfuwah.)

Complications

No surgical complications were observed within the follow-up period. Specifically, there were no episodes of venous thromboembolisms or neurological complications. There was no incidence of injury recurrence, and no patient needed reoperation.

DISCUSSION

The findings of this study support the hypothesis that surgical tenodesis for distal semitendinosus hamstring injuries enables return to preinjury level of sporting function, with low risk of recurrence at short-term follow-up. To our knowledge, this is the first study to report on the efficacy of surgical tenodesis, and it provides valuable prognostic information on patient satisfaction, time for return to preinjury sporting activity, and complications after the surgical tenodesis of these injuries. In our study cohort of elite athletes who compete at the highest level of their respective professional sports, the rate of return to sport was 100%, with zero recurrence of injury at the final follow-up. These 2 outcomes are the most important factors that elite athletes consider when considering surgical repair or nonoperative treatment of semitendinosus hamstring injuries.

In elite athletes, the optimal management for distal hamstring injuries remains unknown because of the paucity of evidence reporting on these injuries within the literature. Low-grade or partial distal semitendinosus hamstring injuries are commonly treated nonoperatively; and complete injuries or recurrent injuries when managed surgically are most frequently treated using a tenotomy technique.[12,28,30,35] High-grade distal hamstring injuries are associated with enhanced scar formation, tendon hypertrophy, and soft tissue adhesions, resulting in refractory pain.[28] This adhesive scarring process, paralleled by tendon hypertrophy, results in fascial strictures within the popliteal region and typically impairs athlete acceleration during full sprinting speed.[28] Hypothetically, this may explain the

TABLE 2
SPORTS Score[8,25a]

Evaluation of Athletic Performance	SPORTS Score	Category	Definition
Good	10	Unlimited effort Unlimited performance No pain	Perform same sport at same level of effort; performance as before the onset of impairment with no pain
Moderate	9	Unlimited effort Unlimited performance Some pain	Perform same sport at same level of effort; performance as before the onset of impairment with pain
Poor	6	Unlimited effort Limited performance	Perform same sport at same level of effort; reduced performance level versus before the onset of impairment
Poor	3	Limited effort Limited performance	Perform same sport but at reduced levels of effort and performance vs before onset of impairment
Poor	0	Disabled	Unable to return to same sport

[a]SPORTS, Subjective Patient Outcome for Return to Sports.

unsuccessful nonoperative cases and high recurrence rates. Within the literature, 15 of 29 (52%) reported cases of distal semitendinosus hamstring injuries that were surgically managed were refractory to at least 3 months of nonoperative management.[2,5,12,22,26,30,35] Within our cohort, 4 patients failed nonoperative management therefore requiring surgical intervention.

Until the present study, the surgical management of distal semitendinosus tendon ruptures within the literature was dominated by tenotomy techniques with varying efficacy.[12,30,35] To date, Cooper and Conway[12] have provided the largest study on distal semitendinosus tendon rupture management, comprising 17 elite athletes, including 10 athletes managed surgically using a tenotomy technique. The surgical group included 5 athletes, of an initial 12 athletes (42%) treated nonoperatively (~16.8 weeks), who failed to return to sport because of chronic pain or hamstring weakness during functional activities and subsequently had surgery. Return to sport of the acute surgical group (n = 5) was 6.8 weeks (±3.2) and that of the surgical group of patients with injuries refractory to nonoperative management (n = 5) was 29.6 weeks (~12.8 weeks from operative date). They reported excellent results with the follow-up ranging from 4 to 55 months (~13 months) in all management subgroups, classified as return to sport, full knee range of motion, no loss of hamstring flexibility, and little or no injury-site tenderness.

Sonnery-Cottet et al[35] and Schilders et al[30] both described 4 professional soccer and rugby players treated surgically using tenotomy for recurrent distal semitendinosus hamstring injuries refractory to at least 3 months of nonoperative management. After surgery and postoperative rehabilitation, all patients returned to preinjury professional sporting levels without complication or recurrence of injury. The Schilders et al study included 1 patient who had undergone surgical repair of the distal semitendinosus tendon, but his symptoms continued unabated. Only Sonnery-Cottet et al specified the mean time from surgery to return to play (3.5 ± 0.5 months), similar to that of our study patients (15 ± 4.6 weeks). This study also reported excellent early functional scores at 3 months' follow-up; all athletes had Marx Activity Rating Scale scores of 16 of 16 and had Lower Extremity Functional Scale score of 80 of 80.[35]

The nonoperative management of isolated distal semitendinosus injuries within elite athletes is limited to a few studies with variable time to return to play.[1,12,32] Cooper and Conway[12] reported a mean return to play of 10.4 weeks in 7 successfully treated nonsurgical athletes.[12] However, it is important to note that 42% (5 of 12) of patients initially treated nonoperatively required a surgical intervention because of failure to return to sport. Two further studies reporting 2 case reports— each reporting on distal semitendinosus complete tears or avulsions in professional athletes—showed a different mean return-to-play time ranging from 3 weeks[32] to 11 months.[1] The latter study included elite track and field sprinters, where these athletes' high demand of the hamstring complex likely affected the time to return to sport.

The semitendinosus muscle is a dynamic stabilizer of the knee and provides knee flexion strength.[23,24] Certain athletes that demand high performance of the hamstring complex may notice weakness and dynamic instability. However, in our experience, not all athletes will notice this, as it will be dependent on specific sport demands. Specific sports, such as sprinting, rugby, and other pivoting sports, may need consideration for repair. Without repair, this muscle strength and dynamic stabilization may be lost. In our centre, we would advocate for a surgical intervention in the athlete with chronic injury or residual symptoms following previous hamstring graft harvest impeding return to sport and after acute injuries with Stener-like lesions of the distal semitendinosus tendon necessitating surgical repair to expedite return to sport.

Specific to the cohort of patients with hamstring harvest included, we hypothesized that some patients have their rehabilitation team (physiotherapists, strength and conditions coaches, sport specific coaches, etc) or push recovery too early after an ACL reconstruction, and therefore the semitendinosus tendon reconstitution never scars down properly. This process potentially increases the susceptibility of athletes to a retear or a rerupture at a later stage and the semitendinosus muscle to become unstable. This can result in recurrent tearing of the hamstring and persistent swelling, bruising, and discomfort in the associated area. In athletes, this can therefore impede function and increase time away from sport.

In accordance with previous studies, we hypothesized that anatomical reinsertion of the ruptured semitendinosus tendon using suture anchors would place the refashioned tendon under considerable tension,[26] and this may increase the risk of rerupture and pain at the insertion site. Specifically, from previous experience with suture anchors, we hypothesized that discomfort or pain at the tibial anchor site would be of longer duration than pain after soft tissue repair. Ahearn and Wood,[2] however, contradicted this idea when reporting on 7 semitendinosus avulsion repairs using suture anchors with excellent or good results (asymptomatic or occasional minimal symptoms during strenuous sporting activity and ability to return to the preinjury level of sporting activity) in 6 of 7 athletes. One athlete was unable to carry out strenuous exertion and therefore did not return to preinjury sporting level. Interestingly, there was an unreported pathology before the study of Ahearn and Wood. They reported upon 2 athletes with semitendinosus avulsions of reconstituted tendons after ACL reconstruction with the use of ipsilateral hamstring autografts. The reconstituted tendons ruptured at 3 and 1.5 years following the ACL reconstruction and full return to sport, and the 2 athletes sustained the semitendinosus avulsion during noncontact mechanisms. The authors reported a similar mean return-to-sport timing in our study of 4.5 months (range, 1-12 months) and 5.5 months (range 5-6 months) for primary and reconstituted tendons, respectively.[2] Because the case series presented in the current literature have such low numbers of patients, we feel that it is pertinent to present the alternative technique of tenodesis for distal semitendinosus hamstring injury.

The semitendinosus tendon is the most frequently used graft in ACL reconstruction, although donor-site morbidity has been reported for ongoing hamstring deficit and pain. Konrath et al[23] studied musculotendinous morphology and peak isokinetic concentric strength at 2-year follow-up after ACL reconstruction using semitendinosus tendon autografts, demonstrating significant altered musculotendinous anatomy and strength deficits.[23] In similarity to previous reports, semitendinosus regeneration was present in only 40% of patients at 2 years' after harvest, and the regenerated tendon demonstrated substantial hypertrophic morphological changes (longer, increased cross-sectional area and alternate proximal tibial reinsertion sites).[23,24,33,39] Strength deficits in knee flexion and internal rotation, as well as impaired dynamic stability, have been reported after hamstring allograft for ACL reconstruction surgery.[23,24] In our center, we have not witnessed such high rates of donor-site morbidity after ACL reconstruction, although we present here a surgical technique to facilitate return to sport in a very small cohort of patients with hamstring instability. Particularly, in the cohort of elite athletes, tendon functional restoration is critical for return to preinjury level of sporting activity.

Soft tissue tenodesis of the ruptured or reconstituted semitendinosus allows minimal change in length and tension of the muscle while maintaining the vector of contraction not achieved with nonoperative or tenotomy techniques. The longitudinal suturing technique of the semitendinosus tenodesis to the semimembranosus provides a large surface area to allow uniform stress distribution across the tenodesis. The poor-quality scar tissue formed at the zone of injury is placed under considerable tension with direct suture anchor repair and may lead to the risk of rerupture and ongoing pain. Suture anchor techniques have been reported in distal hamstring ruptures, although this can place the tendon under significant tension, with high biomechanical stress at a small insertion area.[2,26] Tendon-to-tendon tenodesis to the proximally inserting semimembranosus facilitates a tension-free repair. The soft tissue tenodesis robust repair construct potentially permits accelerated postoperative rehabilitation, with increased semitendinosus tendon stability and reduced risk of recurrence compared with nonoperative management of these injuries. Sonnery-Cottet et al[35] similarly described a tenodesis repair for proximal semitendinosus hamstring avulsions; however, we would caution against performing muscle-to-muscle tenodesis because of risk of suture cutout.

There are few reports of tendon-to-tendon tenodesis in the surgical management of distal hamstring avulsion injuries within the literature. Two studies report excellent results of single cases after surgical management of distal semitendinosus avulsion injuries by performing tenodesis of the injured semitendinosus to the gracilis and sartorius, respectively.[5,26] Ahmed et al[5]provided a case report of a 34-year-old male recreational athlete who sustained a semitendinosus complete distal avulsion with proximal retraction. Having failed initial nonoperative management because of persistent knee posterior medial pain at 6 months after the original injury, the patient was surgically treated with a formal tenodesis of the semitendinosus to the gracilis, followed by a directed physical therapy rehabilitation program. The study reported high patient satisfaction and return to preinjury function at 5 months postoperatively. Lempainen et al,[26] in their 13-year case series of surgically managed distal hamstring tears (n =18), reported a single case of semitendinosus-to-sartorius tenodesis with excellent results in a 24-year-old soccer player after an acute injury. At the time of surgery, anatomical reinsertion without considerable tension was not possible; thus, the avulsed tendon was reinserted into the tendinous segment of the sartorius muscle. They reported excellent results, with return to preinjury level of sport at 5 months and with the patient remaining asymptomatic during athletic performance at short-term follow-up. While the sartorial distal tendon inserts at the pes anserinus with the semitendinosus, we prefer the aforementioned semimembranosus tenodesis, as this maintains the native vector of muscle contraction, allows greater excision of the remnant scar tissue, and reduces potential tension across the repair by performing the tenodesis proximally to the knee joint.

This study provides a valuable addition to the limited case series literature. We present herein an alternative to direct surgical repair, anchor repair, or tenotomy techniques presented in the literature discussed. In our experience, return to previous sporting level and patient satisfaction in this cohort of elite athlete, competing at the highest level of their respective professional sports, are the most important outcomes. Limitations of our study include that there were no detailed functional outcome scores or postoperative strength testing. Such data were difficult to prospectively collect because of the geographical variation in professional athletes based across multiple countries. We argue that our elite group of athletes all returning to previous sporting level confirms the greatest functional outcome and adequate strength restoration. Other study limitations include reporting on a small number of athletes because of the rarity of the injury. It was not possible to include a control group undergoing nonoperative management, and therefore the optimal treatment option for these injuries remains unknown. All study patients were high-performance athletes, and they were either refractory to nonoperative management or were not willing to be randomized to nonoperative management because of risk of chronic strength deficits, semitendinosus tendon instability, and functional disability. Finally, the results are specific to elite athletes and predominately male patients, and thus study findings may not be replicable in the general population.

CONCLUSION

Surgical tenodesis for distal semitendinosus hamstring injuries after acute trauma or residual symptoms after previous hamstring graft harvest enables early return to sporting activity, with high levels of patient satisfaction and low

risk of recurrence at short-term follow-up. This study demonstrates primary tenodesis of the distal semitendinosus as a reliable surgical technique for the treatment of these injuries.

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