Damage to or Injury of the Distal Semitendinosus Tendon During Sporting Activities: A Systematic Review

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Abstract *Background:* Isolated distal semitendinosus tears and avulsions sustained during sporting activities are uncommon. *Question/Purposes:* We sought to systematically review the literature to identify athletes sustaining distal semitendinosus tears and avulsions during sporting activities and to better understand injury mechanisms, management, and return-to-sport timing. *Methods:* PubMed, Biosis Previews, SPORTDiscus, PEDro, and EMBASE databases were searched from January 1970 to January 2018 using the search terms *distal hamstring*, *semitendinosus*, *sport*, *athlete*, *tear*, *rupture*, and *avulsion*. Inclusion criteria were studies documenting (1) isolated, complete distal semitendinosus tears and avulsions during sporting activity, (2) injury management, and (3) athlete outcome. Exclusion criteria were studies reporting (1) partial tears, (2) injuries from non-sporting activities, or (3) athlete sustaining injury with concomitant injuries about the knee. Sporting activities, tear location, management strategy, time from injury to surgery, and return-to-sport timing were analyzed. Statistical analysis was used to evaluate return-to-sport timing based on treatment type and tear location. *Results:* Four studies met the inclusion criteria, comprising a total of 23 cases of complete, isolated distal semitendinosus avulsions or tears. Injuries were sustained predominantly while running or

sprinting and most commonly were avulsions off the tibia. Injuries were treated surgically in 70% of cases. Overall time to return to sport was 2.5 ± 1.4 months with athletes treated conservatively returning significantly more quickly (1.5 ± 0.8 months) than athletes undergoing surgery (3.0 ± 1.3 months). Return-to-sport time was significantly shorter in athletes with complete avulsions (2.2 ± 1.3 months) than in those sustaining tears at the musculotendinous junction (3.8 ± 0.8 months). No significant correlation between time to surgery and return-to-sport time was appreciated. *Conclusion:* Isolated, complete distal semitendinosus tears and avulsions remain infrequently reported during sporting activities and, in this review, occurred predominantly during non-contact activity. Athletes treated conservatively were found to return to sport more quickly, although additional studies are needed to determine the clinical relevance of treatment option, tear location, and concurrent injuries.

Keywords distal semitendinosus · distal hamstring · athlete · tear · avulsion

Introduction

Hamstring injuries are one of the most common athletic injuries, usually caused by the demand placed on the hamstrings and tendons during rapid acceleration, deceleration, and pivoting [6]. Hamstring injuries often require significant time lost from competition to allow for adequate rehabilitation [4, 10, 11, 14, 28]. While most hamstring injuries involve strains to the muscle or myotendinous junction [3, 9], reports of sport-related injuries to the distal hamstring tendon and its insertion (biceps femoris, semitendinosus, semimembranosus) are limited primarily to case reports and small case series [1–3, 13, 17, 24]. Moreover, while less common than injuries to the distal biceps femoris [23], complete distal semitendinosus tears have been reported [2, 16, 27, 29].

Spanning both the hip and knee, which move in opposite directions during movement, the distal semitendinosus is at

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risk for eccentric load and injury during strenuous activity [24]. Specifically, sports requiring sprinting and knee hyperextension increase the distal tendon's susceptibility to injury [7]. Injuries to the distal semitendinosus generally occur alongside injuries to ligaments adjacent to the knee [1, 29]. However, no study has reviewed the literature to determine the prevalence of complete, isolated tears to the distal semitendinosus and their impact on time lost from sport in athletes.

The purpose of this study was to systematically review the literature to better understand the impact of complete, isolated tears to the distal semitendinosus tendon. Specifically, we sought to evaluate (1) the prevalence of complete, isolated tears to the distal semitendinosus sustained during sporting activities, (2) the mechanisms and sporting activities responsible for injury, and (3) outcomes and return-to-sport timing based on management (operative vs. non-operative), tear location (musculotendinous junction vs. avulsion), and time from injury to surgery. We hypothesized a low prevalence of complete, isolated tears sustained primarily during running, successfully treated with non-operative and operative management, enabling return to pre-injury levels of activity.

Methods

A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and checklist [18]. All articles related to individuals who sustained complete, isolated tears of the distal semitendinosus during sporting activities between January 1970 and January 2018 were identified. We defined "sporting activity" as any activity in which an athlete is competing against other athletes. Two reviewers independently conducted the literature search in January 2018 using the following databases: PubMed, Biosis Previews, SPORTDiscus, PEDro, and EMBASE. Combinations of the following search terms were used: *distal hamstring AND semitendinosus AND sport AND athlete AND tear AND rupture AND avulsion*.

Inclusion criteria were articles in English or English translation; human subjects sustaining complete, isolated tears or avulsions to the semitendinosus diagnosed by magnetic resonance imaging (MRI) or ultrasound presenting for initial evaluation; documented sporting activity causing injury; treatment method (operative vs. non-operative); and return-to-sport timing. Cases were excluded if injuries resulted from activities other than sports (trauma, falls), if athletes sustained partial tears of the semitendinosus or complete semitendinosus injuries with concomitant pathology about the knee (meniscal tearing, semimembranosus tears, biceps femoris tears), or if athletes presented for a second opinion or after failed initial management.

A total of 13 citations were identified. The search process is shown in the flow diagram (Fig. 1). Titles and abstracts were assessed, and a total of eight full-text articles were selected for further evaluation. Of these, three were excluded based on reports of distal semitendinosus tears

occurring with concomitant injuries within and around the knee. One additional case series was excluded because it reported only on partial distal semitendinosus tears. Individual cases within included case series were excluded due to partial tearing ($n = 3$), injuries resulting from activities other than sport ($n = 2$), or patients presenting with injury for second opinion due to failed conservative management ($n = 1$). References within included and excluded articles were cross-referenced for inclusion as well.

Statistical analysis was used to evaluate mean time to return to sport in athletes based on treatment type (operative vs. non-operative) and tear location (musculotendinous junction vs. avulsion). Due to the small sample size of included studies, Fisher's exact test was performed, with a p value of < 0.05 to determine statistical significance. A correlation coefficient was calculated to evaluate whether time from injury to surgery affected return-to-sport time. All statistical analyses were performed using SPSS, version 23 (IBM, Armonk, NY, USA).

Results

Four studies met the inclusion criteria, comprising a total of 23 cases of complete, isolated distal semitendinosus avulsions or tears (Table 1). All (100%) of the 23 athletes were male, and the mean age at time of injury was 28.3 ± 5.3 years. Running or sprinting during competition was the most common mechanism of injury, responsible for 57% ($n = 13$) of tears, while no clear mechanism was reported in 26% ($n = 6$) of cases [17, 24]. Hyperextension of the knee [17], planting the foot while changing direction [23], and diving to catch a ball or stepping into a pass [7] were responsible for the remainder. Knee hyperextension occurred in a non-contact incident, a quick change-of-direction movement, during competition [17]. Of sporting activities, baseball accounted for the highest prevalence of injuries (39%; $n = 9$), followed by football (35%; $n = 8$) and soccer (17%; $n = 4$). Injuries also occurred during rugby [24] and Finnish baseball [17].

MRI or ultrasound was used to diagnose the presence and location of complete tears in 100% of athletes. A total of 78% ($n = 18$) of injuries involved complete avulsions from the medial tibia; 22% ($n = 5$) of tears were localized to the musculotendinous junction.

Seventy percent ($n = 16$) of tears were treated operatively and 30% ($n = 7$) conservatively. Conservative management consisted of rest, followed by range-of-motion and strengthening exercises, with gradual progression to running, sprinting, and sport-specific drills [7, 23]. One athlete was treated with bupivacaine and lidocaine injection to the distal thigh at the area of maximal tenderness [23]. The mean time from injury to surgery in operatively treated athletes was 3 months (range, 2 weeks to 9 months). Operative management in athletes with tendon avulsions from the bone consisted of resection of the torn tendon, followed by re-insertion with suture repair to the tendinous portion of the sartorius muscle [17] or without suture repair and isolated resection [7]. All athletes with tears at the musculotendinous junction underwent operative treatment

Fig. 1. Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) flowchart of study.

through an incision parallel to the course of the distal semitendinosus, where scar tissue and adhesions were released. The tendon was then resected, mobilized, and repaired using suture [17] or left resected without suture repair [7, 24]. No peri-operative or post-operative complications were reported. Post-operative management primarily consisted of early mobilization, with weight bearing beginning 3 to 5 days after surgery [24] or by 2 to 4 weeks [17]. Gradual range of motion and progressive stretching was implemented, and by 6 weeks, strengthening and running was initiated, followed by sport-specific training.

Mean overall return-to-sport time was 2.5 ± 1.4 months. Athletes treated conservatively reported earlier return to sport (1.5 ± 0.8 months) than athletes treated with surgical repair (3.0 ± 1.3 months) ($p = 0.002$). Overall, return-to-play timing was significantly shorter in athletes with complete avulsions from the bone (2.2 ± 1.3 months) than in those with complete tears at the musculotendinous junction (3.8 ± 0.8 months) ($p = 0.008$). In athletes who had surgery, no significant difference was seen between those with avulsions (2.7 ± 1.4 months) and those with tears at the musculotendinous junction (3.8 ± 0.84 months) ($p = 0.06$). No significant correlation between time from injury to surgery and time to return to sport was seen ($r = 0.15$).

Discussion

This systematic review investigated the prevalence, mechanism, outcome, and return-to-play timing in athletes who sustained complete, isolated tears in the distal semitendinosus during sporting activities. Twenty-three cases were identified; most injuries occurred by non-contact mechanisms, primarily during running and sprinting in baseball, American football, and soccer [7, 17, 23, 24]. Mean return-to-play time was significantly increased in athletes undergoing operative repairs and those with tears at the musculotendinous junction. No significant delay in return-to-sport timing was seen in athletes undergoing operative management based on either tear location or time from injury to surgery.

This study has several limitations. Due to strict inclusion and exclusion criteria, the sample size analyzed was small. The definition of a sporting activity and the focus on complete, isolated injury to the distal semitendinosus resulted in our excluding multiple cases, as a means of reducing the heterogeneity of articles. The level and quality of performance to which athletes were able to return and remain in competition was not reported; only the ability to return to sport was analyzed. Plus, the lack of studies reporting return-to-sport timing excluded

Table 1 Overview of studies included in review

Study	Journal (year)	Level of evidence	Sex (age)	Sporting activity	Injury mechanism	Tear location	Treatment	Time to surgery (month)	Return to sport (months)	Complication
Lempainen et al. [17]	<i>Br J Sports Med</i> (2006)	4	M (24)	Soccer	Kicking	Avulsion	Surgery	0.5	5	None
Sonnery-Cottet et al. [24]	<i>Orthop J Sports Med</i> (2015)	4	M (25) M (26) M (25) M (28) M (19) M (31) M (24)	Finnish baseball Soccer Soccer Soccer Rugby Football Baseball	NR NR NR NR NR Planting	MTJ MTJ MTJ MTJ MTJ Avulsion	Surgery Surgery Surgery Surgery Surgery Conservative	1 9 3 4 8 0.5	5 5 3 4 3 1	None None None None None None
Sekhon et al. [23]	<i>J Knee Surg</i> (2007)	4	M (37)	Baseball	Running	Avulsion	Surgery	2	3	None
Cooper and Conway [7]	<i>Am J Sports Med</i> (2010)	4	M (25) M (22) M (34) M (39) M (28) M (32) M (39) M (28) M (25) M (33) M (29) M (25) M (28) M (26)	Baseball Baseball Baseball Baseball Baseball Baseball Baseball Football Football Football Football Football Football Football	Running Running Running Running Running Running Running Diving for ball Running Stepping to pass Sprinting Running Running Sprinting	Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion Avulsion	Surgery Surgery Surgery Surgery Surgery Conservative Surgery Surgery Surgery Surgery Conservative Conservative Conservative	4 1 1 1 1 1 1 4 1 1 6 3 3 1	5 2.5 2.5 1.75 1.75 0.75 2.5 2.5 0.75 3 1.5 3 1 1.5	None None None None None None None None None None None None None None

M, male athlete; F, female athlete; MTJ, tears to the musculotendinous junction; NR, not reported

further cases during analysis. The operative technique, while described in some articles, was not presented in detail in others, nor were rehabilitation protocols consistently recorded for each study or each case. This was true of both the use and length of pre- and post-operative rehabilitation, where the authors anticipate that conservative management was utilized in a number of athletes prior to operative treatment. Therefore, return-to-sport timing cannot be fully evaluated based on data from this review.

Athletes undergoing operative treatment reported significantly longer return-to-sport times than did athletes treated conservatively, perhaps because of delays in surgical management and the time required for post-operative rehabilitation. Potentially, after resection of the distal semitendinosus, greater time is required to achieve the strength and mobility needed to return to sport [12]. As no uniform method of rehabilitation was reported in included studies with either conservative or operative treatment, the significance of rehabilitation and timing cannot be adequately assessed. Therefore, the clinical relevance of management method on return-to-sport timing requires further investigation. However, studies have suggested that as the semitendinosus is regularly harvested for anterior cruciate ligament reconstruction without notable adverse effects, operative repair for semitendinosus tearing is not critical to restoring function or ensuring optimal outcomes [5, 12, 15, 17, 19, 20, 25].

The anatomical appearance and biomechanics of the distal hamstring muscle complex has been studied in attempting to determine injury patterns, but the anatomy of the distal semitendinosus insertion, along with the biomechanical forces applied to the tendon, must be considered as well. It has been suggested that the overlapping of distal hamstring tendons leads to an incongruent force not aligned with the tendon itself, predisposing the tendons to injury [26]. Further, an abundance of type 2 muscle fibers in the hamstrings lends more explosive power there than in the quadriceps, further predisposing the tendons to injury during running and sprinting [21].

Imaging studies have noted that tears of the distal semitendinosus tend to be significantly larger than tears within the muscle or at the proximal origin [8]. Operative resection and repair of large tears could lead to increased pain, longer periods of rehabilitation, and longer return-to-sport times [22]. However, tear size was not consistently reported in these studies, and its impact cannot be extrapolated.

The most commonly reported mechanism of injury was sprinting or running during competition [7, 17]. Simultaneous contraction of the hamstrings and the knee extensors has been shown to increase tension across the distal hamstrings, creating a high-power/high-strain relationship across the tendon, increasing risk of tearing and rupture [17]. The hamstrings span both the hip and the knee, and these joints move in opposite directions during activity, increasing the risk for eccentric injury [24]. Also, the biomechanical force required to injure the distal semitendinosus often results in concomitant injury to surrounding knee structures, most notably the distal biceps femoris [1, 17].

Diagnosis of tears and avulsions to the distal semitendinosus is dependent on thorough clinical evaluation and imaging.

Athletes commonly report acute pain and a sharp popping sensation, accompanied by tenderness to the distal posterior thigh. Examination may demonstrate ecchymosis at the posterior and medial aspects of the knee, with weakness in knee flexion [1, 2, 7, 17]. Most athletes typically report no antecedent pain or injury. MRI and ultrasound are generally used to diagnose injuries to the distal semitendinosus, but they may not fully visualize injuries to the muscle belly [7]. Therefore, such injuries are likely underdiagnosed, emphasizing the need for thorough clinical examination along with imaging.

In conclusion, complete, isolated sporting injuries to the distal semitendinosus remain infrequently reported in athletes. The injury occurs predominantly through non-contact mechanisms, including sprinting and running. While we found that athletes treated conservatively returned to sport more quickly, further study is necessary to determine the clinical relevance of treatment option and tear location, as well as the impact of concurrent injury, on return-to-sport timing.

Compliance with Ethical Standards

Conflict of Interest: Kathryn B. Metcalf, MD, and Derrick M. Knapik, MD, declare that they have no conflicts of interest. James E. Voos, MD, reports being a paid consultant to Arthrex, outside the submitted work.

Human/Animal Rights: N/A

Informed Consent: N/A

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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