Nonoperative Treatment of Single-Tendon Proximal Hamstring Avulsions in Recreational Athletes

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ABSTRACT

The purpose of this study was to evaluate the patient-reported and objective functional outcomes of those patients who underwent nonoperative management of a single-tendon retracted proximal hamstring avulsion. A retrospective case series of consecutive patients with an MRI-confirmed diagnosis of single-tendon proximal hamstring avulsion treated nonoperatively with at least one year of follow-up was performed. Patient-reported outcome measures (PROMs) including SF-12v2, Lower Extremity Functional Score (LEFS), Hip Outcome Score-activities of daily living and sport subscale (HOS-ADL, HOS-SS) were prospectively collected. Objective measurements included strength testing of the affected and unaffected limbs with a handheld dynamometer and single-leg hop test. Student's t-tests were used to determine differences between limbs. Eleven of fourteen patients were available for PROMs (79%); five completed functional testing. Subjective scores revealed a mean SF-12v2 mental component score of 56.53 ± 8.2, and a physical component score of 50.1 ± 12.7. LEFS was 84% ± 19.8, HOS-ADL 87.9% ± 17.2, and HOS-SS 80.9% ± 24. The differences between limbs were not statistically significant for strength at 45 or 90 degrees of knee flexion, nor for single-leg hop distance. Patients in a non-professional athlete population who undergo nonoperative management of single-tendon retracted proximal hamstring avulsions can expect good subjective and objective outcomes.

Introduction

Trauma to the hamstrings is common, representing up to 29% of sporting injuries [1]. Athletes sprinting or participating in sports requiring explosive hip flexion with knee extension such as waterskiing are prone to hamstring tears [2]. Despite the frequency of hamstring injury, severity is highly variable. Hamstring injuries are separated based on proximal, muscle belly, and distal location, with muscular injury being the most common [1, 3, 4]. A rare subset of hamstring injury is the proximal avulsion tear, with an incidence of 12%. Even more uncommon is proximal avulsion of a single tendon, defined as either the semimembranosus or conjoint (biceps and semitendinosus) tendon [5]. Avulsion of the conjoint tendon is the most common pattern of a one-tendon avulsion [6].

While muscular strains are often treated successfully nonoperatively with symptom-driven return to play [1], previous literature has demonstrated significant strength deficits in patients treated nonoperatively for complete proximal avulsions [7]. Furthermore, pain, weakness, decreased function, and even delayed sciatic nerve palsy have been cited as reasons for repairing complete avulsions acutely [4, 8, 9]. A meta-analysis by Bodendorfer et al. found that surgical

repair for proximal hamstring avulsion resulted in superior outcomes, including satisfaction, strength testing, single-leg hop test, and Lower Extremity Functional Score (LEFS), compared to nonoperative treatment. Interestingly, the percentage that returned to sport or their preinjury activity level did not differ between groups [10].

While the literature points to operative treatment for complete proximal hamstring avulsions, some argue there is still an indication for non-surgical treatment for single-tendon retracted tears or 2-tendon tears with less than 2 cm of retraction [6, 11]. Typical nonoperative treatment includes activity modification, anti-inflammatories, and physical therapy. In a retrospective review of 25 patients with high-grade partial hamstring avulsion or complete tear with retraction less than 2 cm, Piposar et al. found that there were improvements in the subjective outcomes, such as LEFS and SF-12 physical component summary, in the operative treatment group compared to nonoperative group; however, there was no significant difference in objective outcomes such as isokinetic torque and single-leg hop test [12]. Another study investigating surgical versus non-surgical treatment of proximal hamstring avulsions found no difference in LEFS between groups even after adjusting for confounders at a mean follow-up of 3.9 years [13]. In a prospective study of 59 patients with proximal hamstring tendon avulsions comparing clinical outcomes of operative and nonoperative treatment using shared decision-making, van der Made et al. found no difference in mean Perth Hamstring Assessment Tool (PHAT) score between groups at 1-year follow-up [14]. They also found no difference in return to sport, hamstring flexibility, and the majority of their isometric hamstring strength tests.

There is a paucity of literature regarding retracted single-tendon avulsion ruptures. There was, however, a recent study [15] suggesting better outcomes in professional athletes treated operatively for complete, non-avulsion single-tendon ruptures; that being said, little is known about short and mid-term outcomes in the non-professional athlete population who sustain a single-tendon rupture, in part because of the rarity of the condition.

The purpose of this study was to evaluate the patient-reported and objective functional outcomes of those patients who underwent nonoperative management of a single-tendon retracted proximal hamstring avulsion. To our knowledge, this is one of few studies assessing single-tendon hamstring ruptures in a non-professional athlete population. Our hypothesis was that patients who undergo nonoperative management of single-tendon retracted proximal hamstring avulsions will have favorable subjective and objective outcomes.

Methods

Retrospective Review

After local institutional review board (IRB) approval, a retrospective review was undertaken on patients treated by a single surgeon at a single institution with a diagnosis of a single-tendon retracted (> 2 cm) hamstring rupture confirmed by MRI. The senior author's clinical records were accessed from 2016 to 2019 to identify patients who suffered a retracted single-tendon hamstring avulsion. A representative MRI is demonstrated in ▶ **Fig. 1**. Inclusion criteria were single-tendon avulsion retracted greater than 2 cm, nonoperative management, and minimum clinical follow-up of 12 months. A physical exam was completed in the office and objective diagnostic signs of hamstring tear were noted. Diagnosis was confirmed with an MRI in all cases to confirm single-tendon rather than complete proximal hamstring avulsion. The MRI-based Miller Proximal Hamstring Tear Classification was used to classify the patients' tears [5]. At the time of diagnosis, both surgical and non-surgical management, including risks, benefits, and alternatives, were discussed with the patient, and each individual decided to undergo nonoperative management of their injury as a shared treatment decision with the senior author (SLM).

Nonoperative Treatment Protocol

All patients underwent standardized physical therapy treatment in addition to activity modification. This entailed focus on pain and inflammation control during the first three weeks following diagnosis. At three to six weeks, they began to work on restoring range of motion and gait in addition to recruiting intact muscles such as the gluteal muscles, adductors, and abductors. At 10 + weeks, patients could return to sporting activity as allowed safely based on mechanics and physical therapy evaluation.

▶ **Fig. 1** Axial (left) and coronal (right) STIR MRI image of a left-sided single conjoint tendon- only tear. The arrowhead demonstrates the bare footprint of the conjoint tendon on the ischial tuberosity with associated edema. The semimembranosus tendon can be seen inserting more laterally and anteriorly (arrow).

▶ **Table 1** Patient demographics.

Patient	Age at Injury (years)	Gender	Laterality	BMI	Mechanism	Time to Diagnosis	Degree of Retraction (cm)	Miller Classification *
1	62	F	Left	30.4	Walking	10 days	2.3	Type 2c
2	83	M	Right	28.1	Tennis	2 months	3.0	Type 2c
3	55	M	Right	27.3	Basketball	1 months	2.2	Type 2c
4	40	M	Right	28.6	Softball	3 weeks	6.3	Type 2c
5	56	F	Left	22.9	Walking	3 weeks	3.5	Type 2c
6	51	F	Right	20.0	Wakeboarding	9 days	1.0	Type 2c
7	73	M	Right	31.5	Softball	2 weeks	7.0	Type 2c
8	50	F	Right	25.6	Tennis	1 week	4.0	Type 2c
9	53	M	Right	22.9	Soccer	2.5 months	2.3	Type 2c
10	52	M	Left	26.5	Soccer	6 weeks	4.0	Type 2c
11	15	M	Right	19.6	Gymnastics	11 years	4.5	Type 2c

* Miller Proximal Hamstring Tear Classification

Patient Cohort

Fourteen patients met the inclusion criteria of single-tendon avulsion retracted greater than 2 cm, nonoperative management, and minimum clinical follow-up of 12 months. All were contacted via phone to complete questionnaires and were invited to return to the office for functional testing. Three separate attempts were made by telephone and email, and if no response, the patient was then excluded. Eleven patients (79 %) completed subjective questionnaires, 5 (45 %) of whom underwent functional testing. The telephone interview served to assess the patient's satisfaction with the treatment decision as well as subjective recovery regarding activities of daily living and return to the same level of pre-injury sporting activity.

Subjective Functional Testing

Functional outcome scores were collected prospectively at a minimum of 12 months follow-up including the lower extremity functional scale (LEFS), which is a reliable and validated outcome scale to evaluate patient's functional level [16], and Hip Outcome Score-activity of daily living and sport-specific subscales (HOS-ADL, HOS-SS) [5]. The SF-12 v2 [17] was collected with its mental and physical component subscales as well as a binary "are you satisfied with your treatment?" recorded as a "yes" or "no" answer.

Objective Strength Testing

Isometric muscle testing was conducted with the assistance of an independent, licensed athletic trainer with over 10 years of experience using a handheld dynamometer (Lafayette Instrument, Lafayette, IN, USA), and included the following: prone hamstring strength at 45 and 90 degrees of knee flexion, quadriceps strength, and single-leg hop test. All testing methods were performed bilaterally with the unaffected limb used as a control.

Data Analysis

Isometric and functional testing results were assessed using a two-tailed t-test comparing affected to unaffected limb. Any missing data was omitted from analysis.

Results

All patients sustained unilateral injuries. Average age at time of injury was 53.6 years ± 15.6 (range 15–83). The median time to diagnosis was 21 days (range 7–4015), with an outlier who was diagnosed 11 years after injury. Mean follow-up was 29 months (range 12–138). The average BMI of this cohort was 25.7 ± 3.6. There was only one patient considered underweight (BMI 19.6) and two obese (30.4 and 31.5). Eleven of 14 patients completed patient-reported outcome questionnaires. This group comprised four females and seven males. There were three left and eight right-sided injuries. The mechanism of injury for each patient varied and included basketball, tennis (2), softball (2), soccer (2), wakeboarding, and gymnastics. Two patients were walking while the injury occurred. All patients tore their conjoint tendon and had greater than 2 cm of retraction. Demographic data for each patient is presented in ▶ **Table 1**.

Subjective scores revealed a mean SF-12v2 mental component score of 56.53 ± 8.2, physical component score of 50.1 ± 12.7. Mean Lower Extremity Functional Scale (LEFS) was 84 % ± 19.8, HOS-ADL 87.9 % ± 17.2, and HOS-sport of the 8 individuals who completed this survey was 80.9 % ± 24. Complete data are shown in ▶ **Table 2**.

Satisfaction rate was measured on a binary scale of "are you satisfied with your treatment?": 9 of the 11 patients who completed questionnaires were satisfied (82 %). Two patients regretted their treatment decision and wished they had surgery on the affected limb. Both dissatisfied patients were male. Out of the eleven patients, only two did not return to their prior level of sport at the time of initial interview; however, one of these patients eventually returned to tennis after a separate procedure (arthroscopic rotator cuff repair of the dominant arm), leaving one patient who truly did not return to athletics. This patient was an elite gymnast in his teens at time of injury, and he had a delayed diagnosis (11 years) of hamstring injury. He was unable to return to his previous level of play. Of note, he still endorsed satisfaction with his treatment.

From the patients included in this study, five patients were successfully contacted to complete follow-up objective testing: two male and three female patients. From these five patients, four right hamstring injuries and one left hamstring injury were reported.

Four of the five individuals were satisfied with their treatment. Average follow-up for this cohort was 17.8 ± 6 months. All patients were able to complete functional testing without complications. The mean quadricep strength of the affected limb (used as an effort control) was within 10 percentage points of the control limb in all but one patient, who measured 87.2 % of normal. The differences were not statistically significant ($P = .85$). There was no difference in mean hamstring strength between limbs at either 45 or 90 degrees of flexion ($P = .55$ and $P = .62$, respectively). Similarly, there was no difference in mean single-leg hop test distance between limbs ($P = .59$). These data are shown in ▶ **Table 3** and graphically in ▶ **Fig. 2**.

▶ **Table 2** Subjective scores. HOS-ADL: hip outcome score, activities of daily living; HOS-SS: hip outcome score, sport subscale; LEFS: lower extremity functional scale; MCS: mental component score; PCS: physical component score

Patient	HOS-ADL	HOS-SS	LEFS	SF-12v2 MCS	SF-12v2 PCS	Satisfied
1	100	n/a	85	55.25	60.69	Yes
2	100	n/a	95	56.84	57.65	Yes
3	100	94.4	97.5	n/a	n/a	Yes
4	98.5	94.4	98.7	60.79	53.55	Yes
5	100	100	98.7	60.75	56.57	Yes
6	100	100	100	60.75	56.57	Yes
7	68	53	62.5	68.66	33.74	No
8	95	87.5	95	44.51	58.46	Yes
9	82.4	63.9	80	62.13	50.64	Yes
10	50	37.5	36.3	41.43	21.15	No
11	73.5	n/a	76.3	54.24	52.17	Yes

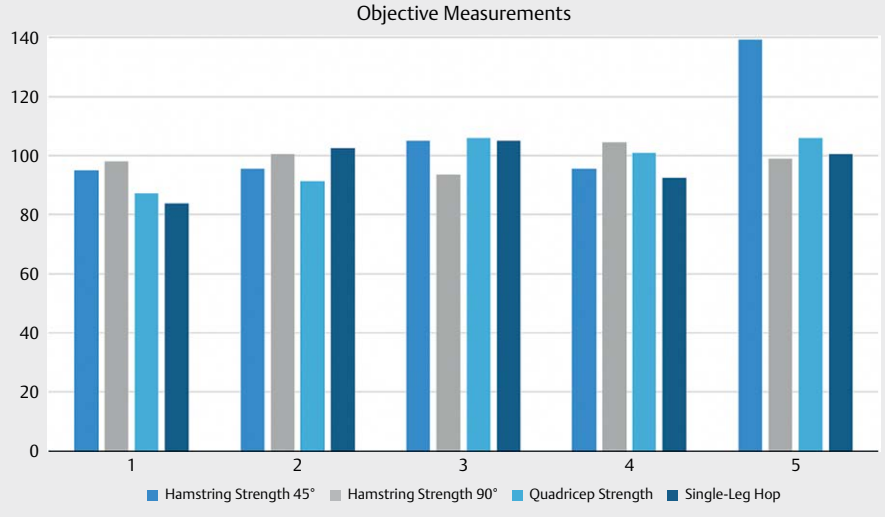
Discussion

The results of this study suggest good patient-reported outcome measures following nonoperative management of single-tendon retracted proximal hamstring avulsions. Eleven patients completed subjective testing. A majority of those patients (7/11) achieved very high scores in the HOS-ADL category, well above the previously defined patient acceptable symptom state for hip arthroscopy (89.7) [18]. There is no reported value for hamstring tendon injuries. Furthermore, 10 of 11 patients (91 %) were eventually able to return to sport at the same level following their rehabilitation, and 9 of 11 (82 %) patients were satisfied with their treatment. Five patients completed objective strength testing. This revealed no significant strength deficits as compared to the unaffected limb; four of five patients achieved results within 90 % of their unaffected limb.

An accurate diagnosis of severity of hamstring rupture is of paramount importance. A patient presenting with a single-tendon

▶ **Table 3** Mean values (in pounds) of patients who underwent strength testing. Differences between affected and unaffected limbs were insignificant for all tests.

	Mean Hamstring Strength 45 °	Mean Hamstring Strength 90 °	Mean Quadricep Strength	Mean Single-Leg Hop
Affected	23.74	21.24	28.17	102.0 cm
Unaffected	22.78	21.46	28.39	103.9 cm
Percentage (Affected/Unaffected)	106.1 %	99.1 %	98.6 %	96.9 %
***P*value**	.55	.62	.85	.59



▶ **Fig. 2** Graphic representation of objective scores for the five patients who completed strength testing. Data reported as percentage of contralateral (unaffected) limb.

avulsion, even in a subacute setting, may be able to consider nonoperative treatment based on the results of this study. Appropriate rehabilitation with a supervised physical therapy program can allow for the patient to achieve 90 % strength or greater of the affected limb. This data can be used in counseling patients regarding their injury. Differentiating a single-tendon from a complete rupture can help guide treatment as previous data has suggested a sharp decrease in outcomes scores as well as strength deficits in patients treated nonoperatively for complete avulsions [7]. Yet more recently, studies comparing operative versus nonoperative treatment of acute, complete ruptures have found no difference in subjective outcome scores between groups [14, 19]. Shambaugh et al. did, however, find that 27 % of nonoperatively treated patients we unable to return to sport [19]. Interestingly, Bodendorfer et al. found the opposite in that operative treatment of proximal hamstring avulsion led to superior outcomes including strength testing, single-leg hop test, LEFS, and SF-12, compared to nonoperative treatment. There was no difference, however, in return to sport or preinjury activity level between groups (79.75 % who returned to sport in operative group vs. 70.59 % in nonoperative group, $P = .363$) [10]. van der Made et al. also found no difference in return to sport at one-year follow-up between operative and nonoperative treatment (23 % unable to return to sport in operative group vs. 12 % unable to return to sport in nonoperative group, $P = .80$) [14]. In our cohort, 9 % (1/11) of patients were unable to return to the same level of sporting activity.

Limited data is available on sequelae following single-tendon hamstring avulsions, especially in the general recreational athletic population. Typically, patients with these injuries participate in recreational levels of physical activity and may have elevated operative risk due to age and/or comorbidities. These considerations were present in this study, as the average age was over 50, and the highest level of activity was in recreational sport leagues. Of those who reported on the HOS-sport subscale, their outcomes were adequate in all but two patients. Our data suggests that return to a more moderate level of athletics is possible after nonoperative management of a single-tendon hamstring rupture.

While single-tendon retracted hamstring avulsions are extremely rare, the senior author's facility represents a tertiary care referral center for hamstring injuries, and therefore this study is thought to represent one of the largest available cohorts for an uncommon injury pattern. Furthermore, we believe our study is generalizable to the middle age population, with mean age of 53.6 years very similar to the patient cohorts in the studies by Pihl et al. and Bodendorfer et al. [10, 13]. The authors believe the data reported is valuable for guidance in the shared decision-making process between clinician and patient for the treatment of this rare type of injury.

Limitations

Limitations of this study include its small sample size and retrospective nature. Each patient received nonoperative management after a discussion with their orthopedist; however, a prospective study would be better able to standardize physical therapy protocol for each patient to track recovery more accurately. Additionally, the lack of a control group may limit the results of this study. At the time of study enrollment only three patients in the senior author's cohort had undergone surgery for this type of injury; this was not thought to represent large enough numbers for statistical comparison. Further limitations exist because of the attrition rate for functional testing and the lack of patients with semimembranosus tears in the sample.

Conclusions

Patients in a non-professional athlete population who undergo nonoperative management of single-tendon retracted proximal hamstring avulsions can expect good subjective and objective outcomes.

Conflict of Interest

There are potential conflict of interests not directly related to this particular study, but related to orthopaedic surgery. Dr. Shah is a paid consultant for Exactech, Inc. Dr. Miller is a paid presenter or speaker for Arthrex, Inc. There are no other disclosures.

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