Clinical and Magnetic Resonance Imaging Outcomes After Surgical Repair of Complete Proximal Hamstring Ruptures

Does the Tendon Heal?

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Background: The use of validated outcome questionnaires and magnetic resonance imaging (MRI) when assessing outcomes after surgical treatment of proximal hamstring avulsions has been limited.

Purpose: To comprehensively evaluate clinical, functional, and radiological outcomes in patients treated with surgical repair for complete proximal hamstring avulsions.

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

Methods: A retrospective review of 15 consecutive patients was performed. Outcome measures included the Single Assessment Numeric Evaluation (SANE), visual analog scale (VAS) for pain, Proximal Hamstring Injury Questionnaire, Lower Extremity Functional Scale (LEFS), Harris Hip Score (HHS), and Tegner Activity Scale (TAS). Physical examination was performed by an independent sports medicine fellow. Magnetic resonance imaging of the lower extremity was used to assess tendon healing and muscle quality after repair.

Results: Thirteen of 15 (87%) eligible patients were available for follow-up at a mean 36.9 months (range, 27-63 months), including 8 men and 6 left-sided injuries. The average age was 44.6 years (range, 26-58 years). Twelve of 13 patients underwent surgical repair within 60 days of injury. Mean (± standard deviation) postoperative functional outcome scores were as follows: LEFS, 74.9 ± 7.8 (range, 59-80); HHS, 90.7 ± 13.9 (range, 67-100); SANE, 93.6 ± 7.5 (range, 75-100); VAS for pain, 1.3 ± 1.9 (range, 0-5); and TAS, 4.6 ± 2.3 (range, 1-7). All 11 patients who participated in sports before surgery were able to return to sport, but 45% reported a decrease in their current level of activity. Isokinetic muscle testing demonstrated that injured hamstring strength recovered up to 78% ± 6.1% (range, 74%-88%) of the contralateral side. The MRI examinations revealed that 100% of patients had a healed proximal hamstring repair, with signs of tendinopathy and mild atrophy in 3 of 12 patients.

Conclusion: The current findings indicate that surgical repair of complete hamstring ruptures provides reliable pain relief, good functional outcomes, high satisfaction rates, and excellent healing rates (MRI) but does not fully restore hamstring function and sports activity to preinjury levels.

Keywords: proximal hamstring rupture; MRI; outcome; strength

The hamstring muscles are the most commonly strained muscles in the body and account for 25% to 30% of all muscle strains.[7,9,23] While the majority of hamstring injuries occur at the myotendinous junction and respond well to nonoperative treatment modalities, as many as 12% of injuries may involve a tear or avulsion of the proximal hamstring's origin, and 9% may be complete avulsions.[2,17,26] The frequency of acute hamstring ruptures appears to be increasing as middle-aged patients continue to be physically active and as the recognition and potential for treatment have become better established.[7]

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Our understanding of the natural history of complete proximal hamstring ruptures has been informed by a limited number of case series with small numbers of patients undergoing nonoperative management.[10,18,22] Albeit limited, the available evidence suggests that a complete rupture of all 3 tendons has been associated with persistent pain, decreased function, prolonged time away from sports, and appreciable weakness.[22] Sallay et al[22] demonstrated that of 12 patients who underwent initial nonoperative treatment, 7 patients returned to most of their preinjury sports at a lower level. Of these 7 patients, 6 had a partial tear of the proximal hamstring complex. Of the 5 patients who had complete disruption of the hamstring tendons, all 5 patients were unable to run or participate in sports requiring agility.[22]

There is some evidence in the form of retrospective case series that suggests that surgical repair of proximal hamstring avulsions results in good pain relief, return to sports, and high patient satisfaction.[‡] A systematic review of 18 studies and 298 patients with proximal hamstring avulsions demonstrated that 82% of patients (236/298) were able to return to sports at preinjury levels after surgical treatment.[11] Data pertaining to the 14 patients who had undergone nonoperative treatment were abstracted from 3 of the 18 included studies.[10,18,22] Of these 14 patients, 2 patients (14%) were able to return to sports at preinjury levels at final follow-up.[11] With respect to surgical management, repair within 4 weeks of injury resulted in significantly better patient satisfaction and a higher rate of return to a preinjury level of sport compared with after 4 weeks of injury.[11]

The majority of studies that have looked at outcomes after operative and nonoperative treatments of proximal hamstring injuries have reported nonvalidated, subjective clinical variables such as pain relief, return to sport, patient satisfaction, responses to study-specific subjective questionnaires (excellent, good, fair, poor), as well as isokinetic strength testing.[11] Although no instruments have been tested for reliability, validity, or responsiveness in patients with proximal hamstring avulsions, the use of joint-specific or global lower extremity functional scales to assess outcomes has also been limited.[11,14,20] The use of magnetic resonance imaging (MRI) to assess healing, as well as hamstring muscle and attachment characteristics, has been reported in one previous series with 6 patients.[20]

The objective of this study was to comprehensively evaluate clinical, functional, and radiological outcomes in a cohort of consecutive patients treated with surgical repair for complete proximal hamstring avulsion injuries. We hypothesized that patients undergoing surgical repair of complete proximal hamstring avulsions would have excellent functional outcomes, high patient satisfaction, and a high proportion of healed repairs as per postoperative MRI.

MATERIALS AND METHODS

This is a retrospective case series. Ethics approval was obtained by the Institutional Review Board of the center at which this study was conducted.

‡References 2, 5, 6, 8, 9, 13, 15, 16, 19-23, 26.

Participants and Procedures

All consecutive patients between 2006 and 2009 who underwent surgical repair of an acute complete proximal hamstring rupture (2 or 3 full-thickness tendon tears) were identified from the administrative database of the senior authors. A minimum 24-month clinical and MRI follow-up was required for enrollment in the current study. Patients who had a previous hamstring injury, revision procedures, full-thickness injury to one hamstring tendon only, and/or the presence of concomitant injuries were excluded. All eligible patients were contacted by a study coordinator and asked to return to a follow-up clinic for clinical and radiological review. Informed consent was then obtained from eligible participants.

A chart review of pertinent information was conducted to confirm that patients had a diagnosis of a complete proximal hamstring avulsion and that all of the aforementioned eligibility criteria were met. Diagnosis was confirmed with details from history, clinical examination, and MRI findings. Patients had at least one of the following: acute posterior thigh pain, an audible "pop," or a tearing sensation of the posterior aspect of the thigh at the time of injury. In all cases, this was accompanied by posterior ecchymosis and swelling from the attachment site extending distally toward the knee. With regard to mechanism of injury, all of the patients had a forceful eccentric muscle contraction with hip flexion and ipsilateral knee extension. The activities associated with injury in this series included waterskiing (n = 8), falling (n = 2), baseball (running bases) (n = 1), martial arts (n = 1), and professional race walking (n = 1). Upon physical examination, patients were placed in a prone position. Palpation of the attachment site at the ischial tuberosity produced tenderness and pain in all cases. A positive bowstring sign, which is defined as an absence of palpable tension in the distal part of the hamstring with the patient prone and the knee flexed to 90°, was also observed in all patients.[2] Magnetic resonance imaging with a combination of proton density and fat-suppressed proton density fast spin echo sequences in multiple orthogonal planes was used to confirm the diagnosis of a complete 3-tendon proximal hamstring avulsion.[2,26]

Surgery for repair of all proximal hamstring avulsions was done with the patient lying in a prone position. A transverse incision was made along the gluteal crease of the affected side. The incision was made down into the subcutaneous tissue with care to avoid damage to the posterior femoral cutaneous nerve. The inferior border of the gluteus was identified and mobilized superiorly to expose the proximal hamstring fascia. The hamstring fascia was opened posteriorly with a longitudinal incision, revealing the hamstring muscle. Any existing hematoma was evacuated. The sciatic nerve was located and mobilized lateral to the attachment site at the ischial tuberosity to prevent inadvertent nerve damage. If necessary, a ronguer and a curette (to create a bony bleeding bed for healing) were then used to expose the anatomic attachment site at the ischial tuberosity, followed by the placement of one to three 5.5-mm full-thread corkscrew anchors (Smith & Nephew, Andover, Massachusetts). The average number of anchors used was

2.5 (range, 1-3). The sutures were passed through the hamstring tendon in a Mason-Allen–type fashion. Sutures were then placed and tied.

Postoperatively, all patients were fitted with a knee brace with the knee locked in 30° of flexion and followed a nonweightbearing regimen for 6 weeks. As the recovery progressed, patients were weaned from crutches and followed a postoperative physical therapy regimen of progressive weightbearing exercises for the repaired leg until 12 weeks, with progression to strengthening thereafter. Return to sports was generally allowed at 6 months after repair.

Outcome Measures

Primary outcome measures of interest included the Lower Extremity Functional Scale (LEFS),[1] Harris Hip Score (HHS),[12] healing at the repair site (MRI), and isokinetic hamstring strength. Secondary outcome measures included the Single Assessment Numeric Evaluation (SANE),[25] Tegner Activity Scale (TAS),[24] and physical examination findings including gait examination, leg contour, thigh circumference, sciatic neuralgia, and hip range of motion.

The LEFS has been validated for patients with various lower extremity functional disorders and consists of 20 items, each with a maximum score of 4.[1] The total possible score of 80 indicates a high functional level. The scale is one page, can be filled out by most patients in less than 2 minutes and is scored by tallying the responses for all of the items.[1] For the HHS, a score of less than 70 is poor, 70 to 79 is fair, 80 to 80 is good, and 90 to 100 is excellent.

Isokinetic hamstring strength testing was conducted using an Isobex dynamometer (Cursor AG, Bern, Switzerland), and tests were run with the patient lying prone as per a previously published protocol.[15] An average of 2 separate measurements from both legs were taken with the knees flexed at 0° (fully extended), 25°, 50°, 75°, and 125°.

All physical examinations and strength measurements were performed by an independent sports medicine fellow. Hip range of motion was measured using a goniometer. Thigh circumference measurements were taken at a point immediately inferior to the crest of the buttock and a second time at the midthigh level (one half the distance between the tip of the greater trochanter and lateral epicondyle of the femur). The MRI scans were reviewed by an independent fellowship-trained musculoskeletal radiologist for pertinent variables including tendon healing, fatty infiltration, and tendinopathy. Fatty atrophy was graded from 0 to 4 with definitions of grading as follows: 0 = no intramuscular fat; 1 = amount of fat stranding is greater than that demonstrated on the contralateral side; 2 = fat less extensive than muscle; 3 = fat equal to muscle; and 4 = fat more extensive than muscle.

Statistical Analysis

Statistical analysis was performed using SAS 8.1 (SAS Institute, Cary, North Carolina). Unpaired t tests and analysis of variance (ANOVA) were employed where applicable. Descriptive statistics included frequencies, means, standard deviations, and ranges. The level of significance was determined to be $P < .05$.

TABLE 1
Results of Hamstring Strength Testing With the Isobex Dynanometer[a]

	% Strength of Repaired Hamstring Compared With Contralateral Side
0°	74 (±12.7)
25°	74 (±13.0)
50°	74 (±10.4)
75°	81 (±16.0)
125°	87.5 (±35.3)
Total average of % strength recovery	78.04

[a]n = 12. Values are expressed as mean (±standard deviation).

RESULTS

Thirteen of 15 (87%) eligible patients were available for review at a mean (± standard deviation) postoperative follow-up of 36.9 ± 11.2 months (range, 25-63 months), including 8 men and 6 left-sided injuries. The average age was 44.6 years (range, 26-58 years). Before injury, 11 of 13 (85%) patients were engaged in sports at least once per week. Ten patients participated at a recreational level, and one female patient was a professional race walker.

Ninety-two percent of patients (12/13) sustained a proximal hamstring avulsion due to a traumatic injury during an athletic event. No concomitant procedures were performed at the time of hamstring repair. Three of the 13 patients underwent a trial of physical therapy before proceeding with surgical intervention. The rest of the patients were treated with no formal physical therapy preceding the repair. Overall, 12 of 13 patients (92%) were treated within 60 days from injury and were considered to have "acute" injuries. One patient was treated 4 years after the time of injury. Overall, the mean time to surgery (from injury) was 134.8 days (range, 9 days to 4 years).

Primary Outcomes

1. The mean postoperative LEFS score was 74.9 ± 7.8 of 80 (range, 59-80). Seven of 13 patients (53.8%) had a maximum score of 80, indicating high ceiling effects for this outcome instrument.
2. The mean postoperative HHS was 90.7 ± 13.9 (range, 67-100). Eight patients had an excellent result, 1 had a good result, and 4 had poor results. All 4 patients with a poor result were female. One of the 4 patients with a poor result underwent repair 4 years after the original injury. Eight of the 13 patients (61.5%) achieved a score of 91, which suggests that the HHS may also have high ceiling effects in patients with a proximal hamstring injury.

3. Isokinetic muscle testing for 12 patients demonstrated that injured hamstring muscle strength recovered to 78% ± 6.1% (range, 74%-88%) of the contralateral healthy hamstring. While there was a trend for increasing the strength deficit with the operative leg in extension, the results were not statistically significant (F = 1.14, P = .35). Complete results are shown in Table 1. It is interesting to note that patients estimated their repaired hamstring to have returned to 91.3% ± 8.3% (range, 75%-100%) of strength compared with the contralateral side, which is higher than the aforementioned objective findings. Furthermore, the patient who underwent operative repair 4 years after injury had equivalent strength to the contralateral extremity.

   The Isobex (Cursor AG) posed a challenge for most patients in that the isolated contraction of the reattached hamstring solicited cramping of the muscle belly. Eight of 12 patients experienced intense cramping of the repaired hamstring when contracting at 125°. Cramping withheld patients from pulling with maximum strength.
4. Twelve of 13 patients consented to come in for physical examination and MRI. Postoperative MRI examination was performed at a mean 36 ± 11.4 months of follow-up (range, 24-62 months) for a total of 12 patients. Findings are consistent with postsurgical proximal hamstring reattachment at the ischial tuberosity. In all cases (12/12), the hamstring muscle complex was noted to be reattached to the ischial tuberosity. Five patients demonstrated grade 0 atrophy, 5 patients had grade 1 atrophy, and 2 patients had grade 2 atrophy of the hamstring's musculature on the operative limb. Three patients also demonstrated mild tendinopathy, but in all cases, the insertion appeared grossly intact, and no discrete muscle tears were visualized. The remaining MRI scans (9/12) demonstrated symmetrical hamstring tendons in size as well as imaging characteristics. Some subtle asymmetry was present in all patients at the hamstring insertion at the ischial tuberosity, but this was unremarkable given the history of surgical fixation. Other nonspecific findings included minimal artifacts at the anchor sites (2/12) and thickened hamstring tendons (2/12).

   One patient's MRI revealed a mild, hazy fluid-like signal intensity at the inferior and medial insertion of the repaired hamstring (right), which is described as a nonspecific finding. This patient was our professional race walker with a chronic origin of a proximal hamstring tear. Her MRI also revealed tendinopathy of her contralateral (left) untreated proximal hamstring with a small partial tear.

Secondary Outcomes

1. There was no significant difference in preoperative (postinjury) (mean, 5.5 ± 2.3) and postoperative (mean, 4.6 ± 2.3) activity as measured by the TAS (P = .27). All 11 patients who participated in sports before surgery were able to return to sport, but 45% reported a decrease in their current level of activity because of the injured hamstring. After the injury, the professional race walker was no longer able to compete but is still an avid distance runner. For the 5 patients who had experienced a change in activity level after surgery, all were satisfied with their choice of surgical repair as a treatment option.
2. All patients (13/13) were "extremely satisfied" with the surgery. The SANE scores showed that patients estimated a recovery of 93.6% ± 7.5% (range, 75%-100%).
3. On average, results from the visual analog scale (VAS) showed that patients reported minimal to no pain: 1.3 ± 1.9 (range, 0-5). Three (23%) patients subjectively reported postoperative pain within the past week, and one (8%) patient reported an unresolved knot on the repaired hamstring with no pain. One patient (8%) reported discomfort with sitting beyond 45 minutes. One (8%) patient occasionally still took pain medication for the repaired hamstring (about 1-2 times a week). Another patient admitted to rarely taking medication in the past for the hamstring (a few days in a month).
4. Three (23%) patients reported stiffness with the injured hamstring at all times. Three other patients (23%) reported stiffness upon waking up in the morning. One patient reported numbness and tingling below the knee of the repaired leg, but this was not considered to be bothersome by the patient.

TABLE 2
Comparison of Hip Range of Motion[a]

	Injured Side	Contralateral Side
Leg flexion with knee extension	102.6 (92-112)	103.4 (90-111)
Leg flexion with knee flexion	129.4 (110-142)	128.5 (111-142)
Hip abduction	85.8 (75-97)	83.6 (73-99)
Hip adduction	54.5 (46-69)	54.6 (42-72)
External rotation with knees bent at 90°	95.6 (80-115)	101.2 (84-120)

[a]Average of 11 of 12 patients. Values are expressed in degrees as mean (range).

Physical Examination

All patients had symmetrical walking (12/12). At the upper thigh, the injured side had an average calf circumference of 57.5 cm compared with 57.2 cm on the contralateral side. Circumference measured at the midthigh level of the injured side was 58.5 cm compared with 59 cm on the contralateral side. Differences in circumference between repaired and uninjured extremities were not statistically significant.

While lying in the prone position and upon flexion of the repaired hamstring, 5 of 12 patients demonstrated a distinctive asymmetric prominence in the contour of the repaired hamstring compared with the contralateral leg. In all cases, the reattached muscle belly could be traced proximally to the attachment site at the ischial tuberosity. The patient with a chronic repair had a normal contour.

Range of motion was measured at various positions with a goniometer. There was no statistically significant difference in range of motion between the injured and uninjured leg (Table 2).

DISCUSSION

The results of this study indicate that surgical repair of acute complete hamstring ruptures provides reliable pain relief, good functional outcomes, high satisfaction rates, and excellent healing rates (MRI) but does not fully restore hamstring function and sporting activity to preinjury levels. This study is unique in that a comprehensive evaluation of outcomes was conducted by utilizing joint-specific and lower extremity–specific functional outcome scales, results of strength testing, as well as an assessment of healing rates utilizing MRI. To the best of our knowledge, this is the first study in the literature to incorporate all of the aforementioned indices when assessing outcome in patients undergoing surgery for hamstring avulsions.

Overall, we observed excellent functional outcomes as measured by the HHS and LEFS. All patients were also satisfied with their surgical treatment as measured by the SANE.

All 11 of 13 patients who participated in sports before surgery were able to return to sport, but 45% reported a decrease in the level of intensity or level of competition of sport they participated in because of the injured hamstring. This is in contrast to the results of the systematic review by Harris et al,[11] who reported 82% return to sports (at the preinjury level) after surgical repair. Nonetheless, for the 5 patients who had experienced a change in activity level after surgery, all were satisfied with their choice of surgical repair as a treatment option.

The average hamstring muscle strength among all patients in our series was 78% compared with the uninjured limb. While this is similar to values reported in 2 other studies,[16,26] several other authors have reported a return of hamstring strength at values greater than 85%.[2,5,9,15] Interestingly, patients estimated their repaired hamstring to have returned to 91.3% of strength compared with the contralateral side, which is higher than the objective findings in this study.

A post hoc analysis of content validity of the HHS and LEFS in our series revealed that there were unacceptably high ceiling effects. Acceptable floor and ceiling effects have been demonstrated to be less than 30%.[3,4] Seven of 13 patients (53.8%) had a maximum score of 80 for the LEFS, and 8 of the 13 patients (61.5%) achieved a score of 91 for the HHS. These findings suggest that these instruments may not contain the items and scoring scales that can differentiate among patients with varying levels of recovery or disability after proximal hamstring repair. The results reported by Mica et al[20] also demonstrate high ceiling effects for the HHS (66.7%).

An analysis of the HHS demonstrates that 4 patients had a score lower than 70, which is considered to be a poor outcome. All 4 of these patients were female; the significance of this remains uncertain and is not consistent with findings in the literature.[11] Only one of these 4 patients underwent a repair for a chronic tear (4 years from the time of injury). Furthermore, of the 4 patients with a poor result, one patient had a SANE score of 75, and the other 3 patients had scores over 90. This may suggest that the HHS does not correlate well with overall patient satisfaction in patients undergoing hamstring repair for proximal avulsions. Nonetheless, one previous study utilizing the HHS demonstrated excellent results in all 6 patients undergoing surgery for a proximal hamstring rupture.[20]

The MRI findings in postsurgical patients in our cohort demonstrated a 100% healing rate. At a mean follow-up of 36 months after surgery, the hamstring muscle complex was noted to be attached to the ischial tuberosity with anchors in all cases. Three patients showed mild fatty atrophy of the repaired hamstring with signs of mild tendinopathy, but in all cases, no discrete muscle or tendon tears were visualized. Despite the presence of tendinopathy and fatty atrophy of the hamstring muscle in 3 cases, these findings were nonspecific, and only one of these patients reported stiffness and pain, with a score of 4 on the VAS. Mica et al[20] reported a 100% healing rate for 6 cases of acute hamstring repair with no signs of muscle fatty infiltration or signal at the bone-tendon interface.

The strengths of this study include the analysis of a consecutive cohort of patients, a high follow-up rate, and a comprehensive evaluation of outcomes using clinical, functional, and MRI-based indices. Limitations include the retrospective nature of this case series, the absence of a comparative control group that has undergone nonoperative treatment, and the small sample size of the current patient cohort.

In summary, surgical repair of proximal hamstring ruptures results in excellent healing rates as measured by MRI and a high proportion of good and excellent results as measured by the HHS and LEFS. Our series of patients had a lower return to sport to the preinjury level and slightly lower strength gains compared with the literature. Overall, patients were satisfied with surgical repair. Future work will focus on generating a larger patient cohort with comprehensive follow-up, and we will also test the psychometric properties of various outcome instruments in this patient population to determine which symptoms, disabilities, and concerns are most pertinent.

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