Complete Proximal Hamstring Avulsions

A Series of 41 Patients With Operative Treatment

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Background: Complete proximal hamstring avulsions can cause considerable morbidity and are often associated with significant functional loss.

Hypothesis: Early surgical treatment leads to better results than does surgery in the chronic phase.

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

Methods: Forty-one patients (21 men and 20 women) with a complete proximal hamstring avulsion were included. The cases were retrospectively analyzed, and a 4-category rating system was used to evaluate the overall result of the surgical treatment.

Results: The mean follow-up was 37 months (range, 12-72 months). Nineteen patients were rated as having an excellent result and 10 patients a good result. In 5 patients, the result was classified as moderate and in 7 patients poor. In the patients with an excellent or good result, the delay from the injury to surgery averaged 2.4 months, whereas in patients with a moderate or poor result, the delay averaged 11.7 months. The difference was statistically significant ($P < .001$).

Conclusion: Excellent or good results can often be expected with surgery, and considerable improvement of symptoms may be achieved even in chronic cases. According to the results, early operative treatment in complete proximal avulsions of the hamstring muscles gives better results than does late surgery and is therefore recommended.

Keywords: hamstring; muscle injury; complete tear; avulsion; surgical treatment

The hamstring muscle group consists of 3 muscles: the biceps femoris, the semitendinosus, and the semimembranosus muscles. The last 2 and the long head of the biceps femoris all have their origins in the ischial tuberosity, and they all cross 2 joints, which makes them susceptible to injury.[5,27]

Hamstring strains are the most common muscle injuries of any of the muscle groups.[9,24] The vast majority of these injuries are treated nonoperatively, and full recovery can usually be expected. The most commonly injured muscle in the hamstring group is the biceps femoris, and the injuries are usually found at the muscle-tendon junction.[6,8,22]

In adolescents, apophyseal avulsions in sites of muscle insertions are occasionally seen. The pelvis is a common location as many muscles of the lower extremity originate from it. In a study by Rossi and Dragoni,[19] the most common location of 203 acute pelvic apophyseal avulsions was the ischial tuberosity (109 cases). Most apophyseal avulsions can be treated nonoperatively. Operative treatment has been recommended if the displacement of the avulsed fragment is 2 cm or more.[5,14,21]

Complete avulsions of the hamstring muscle group from the ischial tuberosity are unusual in adults. We present a retrospective series of 41 cases with operative treatment and follow-up. Our aim was to evaluate the results of surgical treatment of complete proximal hamstring avulsions and to compare the outcome of surgery in cases operated in the acute or in the chronic phase.

MATERIALS AND METHODS

During the years 1995 to 2004, a total of 43 patients with a complete proximal hamstring avulsion were treated operatively at our center. In all cases, there was a complete avulsion of the biceps femoris, the semitendinosus, and the

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semimembranosus muscles. The cases were retrospectively reviewed. The number of patients included in this study was 41, as 2 cases were excluded: 1 because of a concomitant posterior cruciate ligament injury in the ipsilateral knee and 1 because of a short follow-up period (6 months). No apophyseal avulsions were included in the series.

There were 21 men and 20 women. The mean age of the patients was 46 years (range, 18-71 years). The right side was affected in 25 patients and the left side in 16 patients. Twenty-nine of the patients were actively involved in sports, and 2 of these were competitive athletes.

In 22 cases, the injury was sports related. The 3 most common athletic activities in which the injuries occurred were cross-country skiing (9 cases), waterskiing (3 cases), and downhill skiing (3 cases). In all of the sports-related injuries and in 15 of 19 non–sports-related injuries, the injury mechanism was falling or slipping resulting in a forceful forward flexion of the hip with the ipsilateral knee in extension, thereby violently overstretching the hamstring muscles. In no cases was a direct blow to the ischial tuberosity reported.

The patients all had weakness of the hamstring muscles, and they were all unable to run. Especially in the early phase, they had trouble even in walking. The patients reported pain and discomfort in the posterior thigh and symptoms of instability or poor leg control. In the acute phase, a massive hematoma was seen in the posterior thigh, however, often only after a few days from the injury. A palpable defect just distal to the ischial tuberosity was noted, and a distal bulge was seen caused by the retracted muscles, especially when the patient was asked to flex the knee against resistance. Marked weakness in knee flexion was noted in all cases. In chronic cases, the patients often reported neuralgia and sciatica-type symptoms.

Many of the patients were referred from other centers after an incorrect primary diagnosis and unsuccessful nonoperative treatment. Often the diagnosis had been a muscle strain or a partial tear. The diagnosis of a complete proximal hamstring avulsion was preoperatively confirmed using an MRI in all cases (Figure 1).

Figure 1. Magnetic resonance images of a 39-year-old female patient after falling while roller skating with a resulting complete proximal hamstring tear on the right side. Axial fat-suppressed proton density (fast spin echo, 4360/14 [repetition time/echo time]) image (A) at the level of common hamstring origin. Normal low-intensity tendons at the side of the left ischial tuberosity (arrowheads) can be seen. The sciatic nerve is indicated with small black arrows. Hematoma but no tendons can be seen on the right side (white arrows). Sagittal proton density (fast spin echo, 2850/14) images (B, C) visualizing torn and retracted right hamstring tendons (B, arrow) and muscle belly (star). Intact left side with straight and tight tendons (C, arrowheads).

All of the patients were treated operatively, and a complete avulsion of the proximal hamstring muscle group was found. The delay from the injury to the operation averaged 5 months (range, 1 week to 6 years). A total of 14 cases were operated within 4 weeks from the injury.

In surgery, the patient was positioned prone, and a pillow was placed under the feet to hold the knees in slight flexion to relax the hamstring muscles. A vertical skin incision of approximately 15 cm was used. The incision was done over the ischial tuberosity starting at the gluteal crease and continuing distally. A fasciotomy was done in the line of the skin incision. The lower edge of the gluteus maximus muscle was freed and retracted proximally, and the posterior cutaneous femoral nerve was identified and spared. The ischial tuberosity was debrided, and 2 to 4 anchors (DePuy Mitek, Raynham, Mass) preloaded with size 2 Panacryl or Ethibond sutures were inserted (Figure 2). In chronic cases, the incision was extended longer distally to be able to release the retracted muscles, and the laterally running ischial nerve was freed from adhesions. In the cases in which the operation was performed soon after the injury, there were no problems in anatomical reattachment of the torn tendons (Figure 3). However, in the chronic cases, this was much more difficult, and often the knee had to be flexed more to achieve apposition of the tendons to the ischial tuberosity.

In 1 chronic avulsion case, apposition was not possible; in this patient, an autologous free graft from the ipsilateral distal iliotibial tract was used to bridge the torn end of the hamstrings to the ischial tuberosity using a technique described earlier.[17]

An elastic bandage was used for 2 weeks postoperatively. No casts or orthoses were used. Sutures were removed 10 to 14 days after surgery. The patients used crutches for 2 to 3 weeks during which only light-touch weightbearing was allowed. After that, the patients moved gradually to full weightbearing. The patients were instructed to avoid sitting for the first 2 weeks. After 3 to 4 weeks, light pool

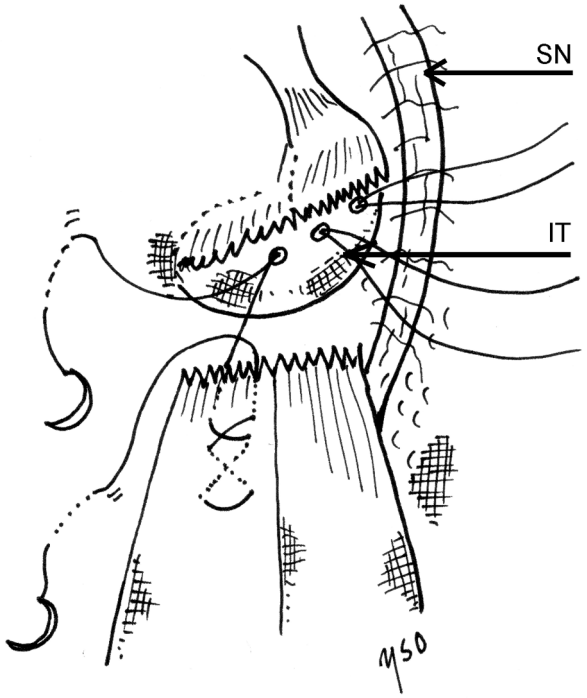

Figure 2. Complete avulsion of the proximal right hamstring muscles. Three suture anchors are inserted to the ischial tuberosity (IT). The sciatic nerve (SN) is exposed lateral to the ischial tuberosity.

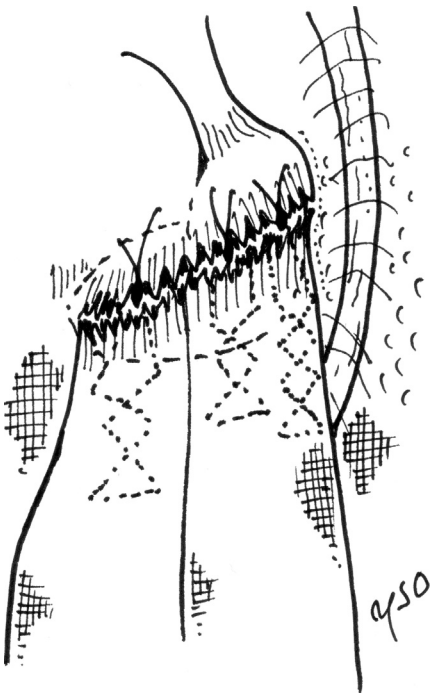

Figure 3. The avulsed hamstring muscles have been attached to the ischial tuberosity by suture anchors, and the sciatic nerve is freed from adhesions.

training including swimming was allowed, and after 4 to 6 weeks cycling was allowed. At this point, isometric muscle exercises were begun as well. Range of motion exercises were started 5 weeks after surgery. All kinds of stretching of the hamstrings were avoided for the first 4 weeks. Running and more active muscle training were allowed 2 to 4 months from the operation according to the patient's progress.

Follow-up was arranged at our outpatient clinic with monthly visits up to 3 to 4 months and then at 6 and 12 months postoperatively. Additional visits were scheduled as necessary as well as for study purposes. Improvement of preoperative symptoms was evaluated, and the patients were asked about subjective feelings of pain, cramping, walking, running, and so forth. Hip range of motion and hamstring strength were compared with that of the unaffected extremity. Also, the patients' return to preinjury levels of physical activity was evaluated.

A 4-category rating system was used to evaluate the overall result. The result of the surgical treatment was rated excellent when the patient was free of symptoms and was able to return to preinjury level of activity. In the cases rated good, the patient had minor symptoms of pain, stiffness, and/or weakness that, however, did not restrict activity level. The result was graded moderate when the patient's activity level was significantly lowered because of the residual symptoms of pain, stiffness, and/or weakness; however, there were only minor symptoms in activities of daily living. Finally, a poor result was assigned to cases in which there were difficulties in activities of daily living because of pain, weakness, and muscle cramps and/or reoperations without reinjury.

The correlation between the delay from the injury to surgery and the result of the operative treatment was calculated. The Mann-Whitney U test was used to compare differences between the excellent or good groups and the moderate or poor groups. The Kruskal-Wallis test was used to compare differences between all 4 groups: excellent, good, moderate, and poor. Nonparametric methods were used because the variable delay was not normally distributed. The Student t test was used to compare differences in age between the same groups in the case of delays. Response variable was used as binary variable and in 4 classes. In this case, variable age was normally distributed. A chi-square test was calculated to compare differences between groups in number of used suture anchors. For the binary variable, the Fisher test with exact P values was also calculated. To further evaluate the effect of the delay to surgery, additional logistic regression was used to compare differences between groups of delay. Variable delay was divided into 3 groups: 0 to 3 months, 3 to 6 months, and those with delay greater than 6 months. There were 22 cases in the first group, 12 cases in the second group, and 7 cases in the third group. Odds ratios were calculated as well. $P < .05$ was considered statistically significant. All statistical analyses were performed with SAS System for Windows, release 9.1/2004 (SAS Institute, Cary, NC).

The local hospital ethics committee approved the study protocol.

RESULTS

The mean follow-up in our study was 37 months (range, 12-72 months). Nineteen patients were rated as having an excellent result and 10 patients a good result. In 5 patients, the result was classified as moderate and in 7 patients poor.

TABLE 1
Results of the Surgical Treatment in the 29 Patients Actively Involved in Sports in the Series of 41 Patients With a Complete Proximal Hamstring Avulsion

Group	Excellent	Good	Moderate	Poor
Competitive-level athletes	1	1		
Recreational athletes	13	7	3	4
Total	14	8	3	4

Twenty of the 27 recreational athletes in our series were rated as having an excellent or good result, and they all were able to return to their preinjury levels of sports activities 4 to 10 months after surgery. A national-level handball goalkeeper was able to return to competitive play 10 months postoperatively. The other competitive athlete, who was a senior sprinter, was able to return to competition with some residual symptoms. She ended her career later during the follow-up period. The results of the athletes in this series are presented in Table 1.

In the patients with an excellent or good result, the delay from the injury to surgery averaged 2.4 months (range, 1 week to 9 months; median, 1.5 months), whereas in patients with a moderate or poor result, the delay averaged 11.7 months (range, 2 months to 6 years; median, 4.5 months). The difference was statistically significant ($P < .001$). There was also a statistical difference in the delay to surgery between the group with an excellent result and the groups with a moderate result ($P = .0025$) or a poor result ($P = .0014$). In the 7 cases with a poor result, the shortest delay from injury to surgery was 2 months and the longest delay 12 months.

In patients with an excellent or good result, the mean age was 45.9 years (range, 24-62 years; median, 48 years), whereas in patients with a moderate or poor result, the mean age was 46.6 years (range, 18-71 years; median, 46 years). Statistically significant differences were not found in age between these groups ($P = .8757$). There were no statistically significant differences between the groups in the number of suture anchors used ($P = .8470$). Also, no statistically significant differences were reached when the response variable was in 4 classes.

When the patients were divided into 3 groups (0-3 months, 3-6 months, and >6 months) depending on the delay from injury to surgery, there were statistically significant differences in the result of surgery between groups 0 to 3 months and 3 to 6 months ($P = .0041$) and between groups 0 to 3 months and greater than 6 months ($P = .0091$). Between the groups 3 to 6 months and greater than 6 months, there was no statistically significant difference ($P = .9596$).

When calculating the odds ratios, the risk of a moderate/poor result was 29.4-fold (95% confidence interval, 2.92-296.53) in the group with delay from 3 to 6 months compared with the group with delay from 0 to 3 months. In the group with delay greater than 6 months, the risk of a moderate/poor result was 28.0-fold (95% confidence interval, 2.29-342.15) when compared with the group 0 to 3 months (Table 2).

TABLE 2
The Delay From Injury to Surgery in 41 Patients With a Complete Proximal Hamstring Avulsion Treated Surgically

	Months		
Group	0-3	3-6	>6
Patients with moderate/poor result	0/1	3/4	2/2
Total patients	22	12	7

Five patients had to undergo a reoperation during the follow-up period. In 1 case, 3 weeks after the primary operation, the patient lost her balance, which resulted in heavy weightbearing and a muscle contraction of the operated hamstrings. In the reoperation performed 2 weeks later, the torn tendons were reattached using the same technique as in the first operation. The final result in this case was good.

In another case, overly aggressive postoperative rehabilitation was thought to have caused the partial rerupture. A reinsertion was done 6 months later. The result was rated poor because of the need for reoperation. The patient continued to suffer from neuralgia-type symptoms despite 2 operations, and in nerve conduction studies, severe denervation of the hamstring muscles was found.

In the remaining 3 cases with a reoperation, no specific reinjury was reported by patients. Retraction of the previously reattached muscles was noted in clinical examination. The reoperations were done 11 to 24 months after the primary operations. In all of these 3 reoperations, anatomical reattachment of the tendons to the ischial tuberosity was impossible owing to scar tissue and adhesions, and therefore an autologous graft was used as described earlier.[17] After the reoperation, the patients were followed for 12 to 60 months, and they all improved both objectively and subjectively. However, because of the reoperation, the results in all of these cases were rated poor in this study.

One patient had a postoperative deep venous thrombosis that was treated with anticoagulants. Four patients complained of neuralgia-type pain and decreased sensation in the proximal posterior thigh. This was thought to be owing to intraoperative traction of the posterior cutaneous femoral nerve. In all cases, the symptoms subsided during the follow-up. There was 1 superficial wound infection that was successfully treated with oral antimicrobial drugs. One postoperative seroma was drained percutaneously. In 1 case, there was a partial dehiscence of the wound that did not require surgical intervention.

DISCUSSION

The typical injury mechanism causing a complete proximal hamstring avulsion is a violent eccentric muscle contraction with the knee extending and the hip flexing.[7,20] This injury has been most commonly described in waterskiing, in which the skier either falls forward or is forcefully pulled out of the water at the takeoff.[1,4,7,12,20] Some other

sports in which these injuries have been reported are rugby, sprinting, volleyball, tennis, soccer, judo, and badminton.[2,7,11,12,15,26] In our series, the injury was sports related in 22 of the 41 cases, and cross-country skiing, waterskiing, and downhill skiing were the most common sports. In all cases, the injury mechanism was similar to that described earlier.

After the injury, there is often gross swelling and ecchymosis in the posterior thigh. The patient may have trouble even in walking. A palpable proximal defect is a common finding; however, in the early acute phase, this can be masked by the hematoma.[12] A distal bulge is often palpated when the patient is asked to flex the knee against resistance. There is typically marked decrease in strength in knee flexion and in hip extension. These signs and symptoms combined with the typical injury mechanism should alert the physician to suspect a complete proximal hamstring tear.

In the chronic cases, the patients may complain of weakness and poor leg control as well as cramping of the posterior thigh, and they usually have difficulty in running or are unable to run. Sitting may aggravate the pain in the posterior thigh, and there may be loss of range of motion in the hip joint. There may also be sciatica-type symptoms owing to adhesions around the sciatic nerve.

There are a couple of unusual cases reported in which a complete foot drop with numbness of the lateral calf and dorsal foot has occurred some months after a complete proximal hamstring tear.[10,23] In both cases, neurolysis of the sciatic nerve resolved the symptoms. Similar cases have been described in incomplete proximal hamstring tears.[3,25] Proximal hamstring tear has also been reported to cause posterior thigh compartment syndrome.[16,18]

In complete proximal hamstring avulsions, plain radiographs are typically negative, as in adults the tear usually occurs with no or only minor bony avulsion. In adolescents, the injury is usually an apophyseal avulsion. However, in children, the avulsion fragment may sometimes not be visible on plain radiographs.[14]

Magnetic resonance imaging should be used to confirm the diagnosis as it can confidently identify which muscle has been injured and the amount of tendon retraction. With sonography, only 58% of avulsions were diagnosed despite the examination being performed by experienced musculoskeletal sonologists.[13]

Nonoperative treatment seems to have a poor prognosis in cases of complete hamstring avulsions.[4,7,20] Even with a cast holding the knee in flexion, reattachment of the tendons to the ischial tuberosity did not occur in a case reported by Kurosawa et al.[15] The reason surgery is so often performed in the chronic phase in the prior series as well as in our study is probably owing to insufficient awareness of this particular injury and poor diagnostics in the early phase.[7,12]

When hamstring avulsions are operated on in the early phase, restoration of the anatomy is considerably easier than when operating in the chronic phase as the muscles can be mobilized because there are no or only minor adhesions. In chronic cases, it may be impossible to pull the torn tendons back to the ischial tuberosity. In these cases, an autograft from the iliotibial tract described previously can be used.[17] In chronic cases, the sciatic nerve is often surrounded by scar tissue, and to relieve the possible sciatica or neuralgia type of symptoms, a neurolysis needs to be done.

The results of surgical treatment in complete proximal hamstring avulsions have been mainly good, with most patients satisfied and able to return to preinjury levels of activity. In a series by Klingele and Sallay,[12] 10 of 11 patients were satisfied with their results, and 7 of 9 athletically active patients were able to return to their sports a mean of 6 months after surgery. Cross et al[7] published a series of 9 patients with chronic complete proximal hamstring avulsion. The patients were operated on 2 to 104 months after the injury. Two of the 9 patients were able to participate in sports before surgery. After surgery, all 9 patients believed that they had improved with surgery, and 7 had returned to their preinjury recreational sports. Seven of 8 patients were able to return to their preinjury levels of sports in the series of Brucker and Imhoff.[2] However, in 3 of the cases, there was not a complete avulsion of the hamstring muscles as the semimembranosus muscle was intact. In our series, 29 of 41 (71%) patients were rated as having an excellent or good result.

In complete proximal hamstring avulsions, it is possible to greatly improve the patients' symptoms with surgery even years after the injury. However, occasionally even after early surgery, considerable decrease of activity as well as other disturbing residual symptoms remain. The 7 cases in our series who had a poor result complained of weakness, pain, and discomfort in the posterior thigh as well as muscle cramps, neuralgia, and even difficulties in walking. In the series published by Klingele and Sallay,[12] 2 of the 11 patients reported moderate pain in strenuous sports or uphill climbing, and 1 patient described severe pain associated with climbing stairs and other strenuous activity. Other reported complaints in the same series were moderate limitations in walking uphill, stiffness in the morning, and numbness or tingling. The 1 dissatisfied patient continued to have pain, even after a reoperation in which a neurolysis of the sciatic nerve was done.

In previous studies, the strength of the operated hamstrings at the final follow-up has been around 60% to 90% of the uninjured side.[2,4,7,12] This can be the result of immobilization and to injury to the branches of the sciatic nerve occurring with the retraction of the muscles. Some degree of weakness and muscle atrophy was seen in all of our cases, even in those graded excellent or good. In the chronic cases, often parts of the torn muscles were macroscopically abnormal with a hardened fibrotic appearance and texture.

Previous series have found no differences in the final result between acute and chronic cases. In our series, however, there was a statistically significant correlation between the delay from injury to surgery and the end result. This does make sense as fatty degeneration has been shown to occur in hamstring muscles in chronic cases.[20] In chronic cases, reattachment of the torn tendons to the ischial tuberosity becomes more difficult because of adhesions. Also, the distal retraction of the hamstrings might cause irreversible damage to the branches of the sciatic nerve. Extensive neurolysis, which is often necessary in chronic cases, poses a risk to the nerve braches as well.

Despite the statistically significant correlation between the delay to surgery and the end result, there were patients in our series who had a moderate/poor result who were operated on in the early phase, and on the other hand, there were patients who had an excellent/good result although the operation was performed several months after the injury. Therefore, the delay from injury to surgery is not the only parameter affecting the end result. We believe that the degree of concomitant nerve damage might also play a key role in the end result.

In many prior series, immobilization of the knee in some degree of flexion with a postoperative cast or orthosis lasting from 2 to 8 weeks has been reported.[1,2,4,7,11,12,15,20,26] In our series, we used no immobilization. Whether this is the reason for the reruptures with no reinjury in our study is not known.

Our experience is that the sutures used to pull the muscle proximally toward the ischial tuberosity should engage healthy contractile tissue to achieve proper reattachment. In cases in which the proximal part of the torn muscles is denervated, the sutures should be continued distal to this denervated pathological part. Inability to recognize this could be a possible explanation of the late gradual attenuations or reruptures of the reattached muscles seen in our series. Overall, it seems that denervation of the torn muscles has an adverse effect on the outcome, and this theory was supported in some cases in EMG studies.

Complete proximal hamstring avulsion is a serious injury that may lead to significant pain and disability. A high level of suspicion combined with early, accurate imaging to confirm the diagnosis is needed. We recommend early operative treatment as the results are significantly better than are those of late surgery, although considerable improvement can be achieved in chronic cases even years after the injury. With surgical treatment, excellent or good results can often be expected.

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