Proximal Hamstring Avulsion – Anatomy, Cause of Injury, Surgical treatment and Post-operative Treatment Protocol

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Avulsion injury to the proximal origin of hamstring muscles is rare and often requires surgical treatment. There is a lack of high-quality research into the methods of treatment and rehabilitation. As a result, an evidence-based approach to injury management does not exist. Management is based on clinical experience, anecdotal evidence and the knowledge of the biological basis of tissue repair.

Hamstring anatomy, mechanism of injury, cause of injury, diagnosis and treatment are discussed.

A previously unpublished surgical method of transgluteal approach and an active treatment protocol that has been used in Töölö Hospital in Helsinki are described in this article.

The reference articles include the two recently published reviews (1,2), the four case series reports with the greatest number of patients (3–6), an article describing the anatomy of the hamstring-muscles (7) and four studies with description of different surgical methods (5,6,8,9). Also a thesis by Lasse Lempainen is worth reading if more information about hamstring injuries and disorders is needed (10).

Hamstring related injuries are common among athletes and people with high physical activity, the most typical injury being muscle sprain. Those injuries are typically treated with non-operative rehabilitation. Avulsion injury is much more rare than muscle sprain and often more serious. Usually surgical treatment must be considered to get the best possible results. Unfortunately a great deal of avulsion injuries are either completely missed or misdiagnosed by general practitioners, or the injured person does not seek medical aid until several weeks or months after the injury. The delay of diagnosing the injury can make the treatment much more difficult. However, even in a case of late diagnosis, it is still often possible to get good results after proper treatment.

Anatomy of hamstrings and the injury

The hamstring muscle group includes semitendinosus and semimembranosus medially and biceps femoris, short and long heads, laterally. All muscles attach proximally to the ischial tuberosity, except for the short head of biceps femoris, which originates at the linea aspera and lateral supracondylar line of the femur. At the proximal origin the long head of biceps femoris and semitendinosus form a conjoint tendon and it is

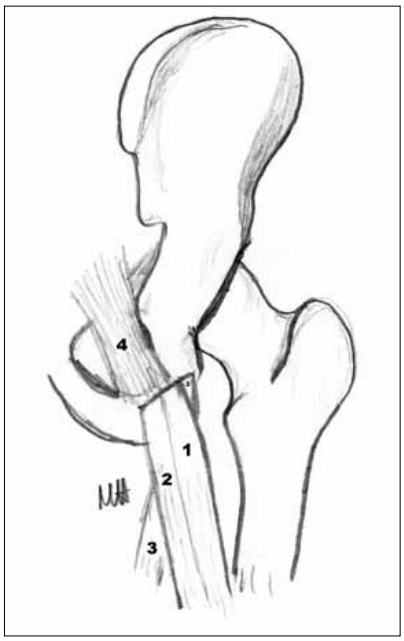


Figure 1. Posterior view of the ischial tuberosity. 1-biceps femoris, 2-semitendinosus, 3-semimembranosus, 4-sacrotuberal ligament

Figure 2. Complete rupture of the hamstrings. Retracted tendons (black arrow), area of detachment (white arrow).

attached to lateral (and slightly dorsal) part of ischial tuberosity and semimembranosus is attached slightly ventrally and laterally to the attachment of the conjoint tendon (Figure 1). Beltran et al (7) describe well the anatomy and biomechanics of hamstring muscles and also pathophysiologic mechanism of injury.

The avulsion injury can be partial or complete (3,5). In complete avulsion the tendons usually retract from the bone. However there can be some surrounding tissues to prevent major retraction and tendons may remain fairly close to the bone. In a partial avulsion only part of the tendon or tendons are avulsed and there is usually no retraction of the tendons from the bone.

Most often the affected part of the hamstring origin is the conjoint tendon. It can be completely avulsed and retracted even if the semimembranosus is left intact. A common injury pattern is also a complete avulsion of all three tendons (Figure 2). The tendons can retract either minimally or several centimeters depending on the severity of the trauma.

A rare juvenile avulsion injury is the apophyseal (Salter Harris 1) avulsion fracture of the ischial tuberosity (Figure 3a).

The injury can also be either acute or chronic at the time of the diagnosis and operation. Usually the end result of the treatment is better in acute injuries. There are very different opinions in the literature on when the injury is considered acute. Often the injury is considered acute if the treatment can be started within 4 weeks from the original injury (3–6). If the

Figure 3a. Bony avulsion (arrow) of the left ischial tuberosity on a 15-year-old boy after stepping on a football in a game and slipping.

Figure 3b. Fixation of the avulsion fragment with 3,5mm cannulated screws (and PDS cord which is not seen on the x-ray).

injury is a complete avulsion and there is retraction of the tendons more than 3-4 cm, the operation becomes more demanding after 4-6 weeks because of scar tissue and muscle contraction. If there is a partial or complete rupture with less that 2 cm of retraction the time aspect might not be that important. Sarimo et al reported nearly 30-fold risk of poor/moderate results if operated after 6 months compared to early (0–3 months) operation (5).

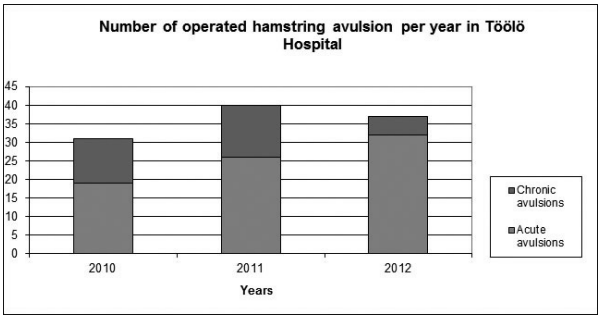
It is possible that there is also muscle fiber injury and/or damage to the nervous supply of the muscles together with the tendon avulsion but this is not much discussed in the literature. That kind of damage can be one of the reasons why sometimes even after a successful operation and rehabilitation the end results are fair or poor.

Injury mechanism, cause of injury and "typical patient"

A typical mechanism causing a proximal hamstring avulsion is indirect force to the muscle: a forceful hip flexion with knee extended and therefore great eccentric load to the muscle-tendon unit. Because the typical age of the avulsion injury patient is between 40–60 years (later in this article) it is very possible that there are pre-existing degenerative tissue changes in the tendon-bone attachment.

The author searched all hamstring injuries from Töölö hospital records of three consecutive years, 2010–2012, to find out the cause of injury. Most of the patients treated at Töölö hospital in general are non-athletes or only active recreation sportsmen/-women and the cause of injury is somewhat different than in publications reporting the injury of professional or semiprofessional athletes (1).

There were 108 hamstring avulsions operated during the three years (Table 1). 77 were recorded as acute (operated within 4 weeks of the injury) and 31 were chronic. There were 44 (32 acute) men and 64 (45 acute) women. The average age of the patients was 51,0 years, which is clearly higher than in review by Harris et al (1) with total of 298 patients with mean age of 39,7. In the study conducted by Birmingham et al (6) the average age was 46 years. In Töölö hospital records women were slightly older than men: 52 (range, 15–80) years compared to 49,5 (range, 15–72) years respectively. The age groups with most injuries were 41–50 years of age and 51–60 years of age (Tables 2 and 3).



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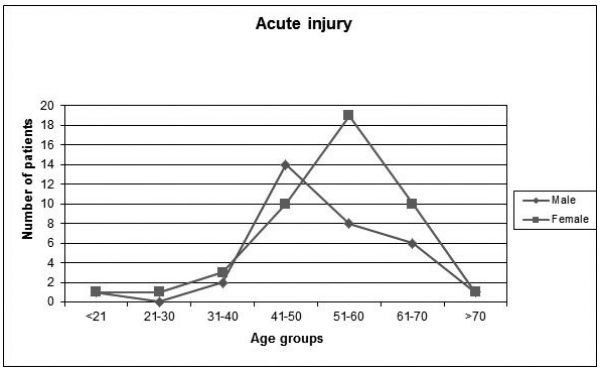

Table 2. Number of patients with acute proximal hamstring avulsion injury in different age groups (years 2010-2012 together).

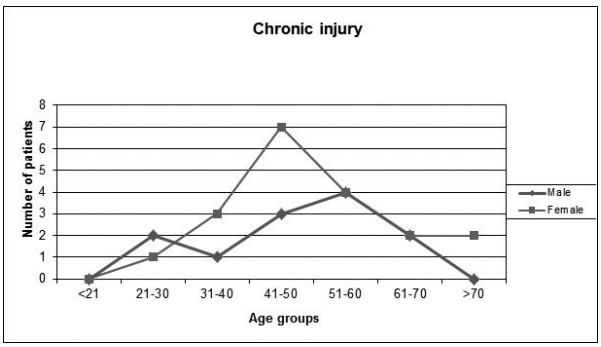

Table 3. . Number of patients with chronic proximal hamstring avulsion injury in different age groups (years 2010-2012 together).

The cause of injury with Töölö patients was most often slipping on slick surface (33% of all patients, but with women 48,4%). Other non-sports related causes were tumbling while walking the dog (3,7%), falling while dancing (1,8%), and quite often the cause of injury was not known (8,3%). That was true especially for women with chronic partial avulsions. The recreational sports caused about 33% of all injuries. Those

Table 4. Different recreations or sports played while sustaining proximal hamstring avulsion injury.

Cause of injury			
	Male	Female	All
Slipping on slick surface	5	31	36
While walking the dog	1	3	4
Dancing		2	2
Playing soccer	8	1	9
Cross country skiing	1	4	5
Icehockey	4		4
Playing tennis	3		3
Martial arts/combat sport	2		2
Playing beach volleyball	1	1	2
Other sports	9	4	13
Other mechanims	8	11	19
Not known or no injury	2	7	9
All together	**44**	**64**	**108**

sports included soccer (8,3%), cross-country skiing (4,6%), ice hockey (3,7%) and tennis, martial arts and beach volleyball (1,8% each) (Table 4).

Diagnosis

In order to be able to reach the correct diagnosis early after the injury, a doctor has to do a proper clinical examination. Patients often have difficulties in walking and sitting and they feel pain around the injured site. Examination includes inspection and palpation of the injured thigh and the area of ischial tuberosity. Also muscle strength should be checked and compared to the uninjured site. There is usually tenderness around the tuberosity. One might also feel the gap under the tuberosity when patient tries to flex the knee and sometimes the muscle forms an abnormal bulge on the lower part of the thigh. Weakness of the knee flexion is usually present in the beginning. There can be a hematoma on the backside of the thigh (usually appears within 48 hours after the trauma and dissolves around 2-4 weeks afterwards) and when present should alert the physician about the possibility of avulsion not just a muscle sprain. Sometimes ischial irritation can be present, especially in chronic cases.

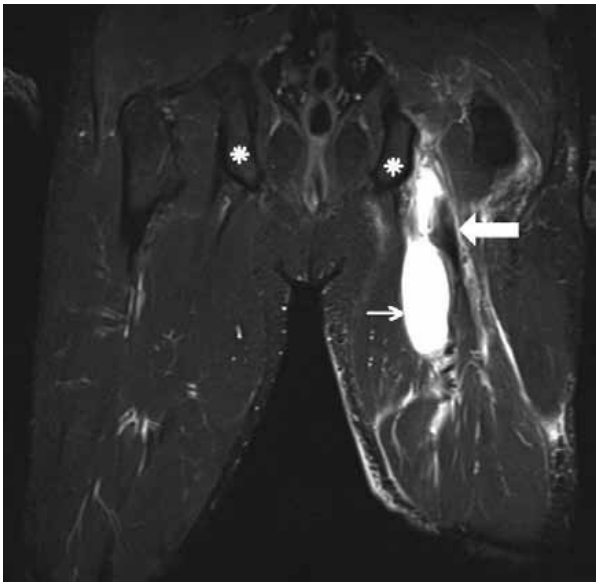

Figure 4. Coronal plane MRI image of typical acute avulsion of left hamstrings. Hematoma (small arrow) and the retracted tendon-head (big arrow) are seen. Asterisk marks the ischial tuberosities on both sides.

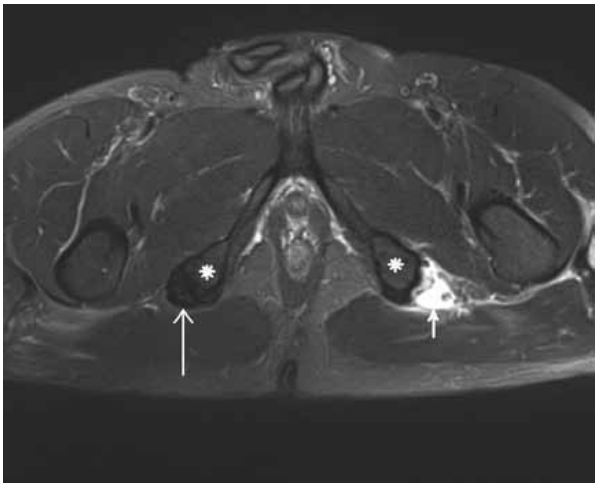

Figure 5. Axial MRI image of the avulsion of left hamstrings. Asterisk marks the ischial tuberosities. Hematoma (small arrow) can be seen on the left side whereas on the right side the tendons (long arrow) attach normally to the tuberosity.

Ultrasound can be used as an aid to evaluate the attachment of the tendons but even with experienced radiologists the specificity is only around 60%. X-ray of the pelvis is usually normal except in juvenile bony avulsions (Figures 3a, 3b).

Figure 6. Positioning on the operating table. The knee slightly flexed to relax the hamstrings.

Figure 7. Transgluteal transverse incision and longitudinal incision.

MRI is still the best imaging method to get the correct diagnosis and to plan the operation. The injury can be classified as complete or partial and the affected tendons can be identified and their retraction measured (Figures 4, 5). MRI should always be performed if an avulsion injury is suspected.

Operative technique

The operation can be performed through different approaches. The most common approach in the literature is a vertical incision starting from the gluteal crease downwards (5,6,8). Also a transverse incision along the gluteal crease can be used (4,9).

In Töölö hospital most of the surgeons treating hamstring avulsions have used a slightly different approach. This approach allows us to use the same type of suture anchor-attachment as used by others but it also allows us to "hang" the tendons to the very strong sacrotuberal ligament to get most of the tension off from the anchor sutures. The role of the anchors is merely to press the tendon heads firmly against the bone.

The patient is placed in prone position on the operating table. A pillow is placed under the ankles. The leg is draped so that free movement is possible (Figure 6). If augment is needed, only the ankle and foot are covered. The thick combined fascia of soleus and gastrocnemius -muscles can then be harvested for grafting in the chronic case if it's not possible to attach the

tendon to the tuberosity because of extensive muscle contraction.

The transverse incision of 7–8cm is made horizontally on the buttock perpendicular to the location of the ischial tuberosity. Sharp dissection through the subcutaneous tissue is continued until the gluteus maximus muscle is reached. The posterior fascia is incised and detached from the muscle fibers cranially and caudally. Then blunt dissection is used to go through the muscle. Anterior fascia of the muscle covering the ischial is opened carefully with scissors. In an acute case there is usually a large hematoma which is removed with suction. One must be careful with the branch of the inferior gluteal nerve that can sometimes be seen. Also ischial nerve runs close to the injury site and must be protected. Often the detached tendon head can be seen or felt through this approach and it is then grasped with suitable forceps and a thick slowly absorbable 1.5mm PDS-Cord suture is attached to the tendon with Kessler suture.

If the tendons cannot be reached or the scarring prevents the mobilization of the tendons through the first approach then a longitudinal incision is made 4-5 cm below the gluteal crease (Figure 7). The length of the incision depends on the amount of fatty tissue over the thigh muscles. The fascia is incised also vertically and the PFC-nerve is identified and protected. Then it is possible to feel and identify the muscle bellies of the hamstrings and to identify the avulsed tendon head/heads.

The tendon head is freed from all scar tissue with a round curette and the PDS-Cord is attached. The bone is cleaned from scar tissue and the surface is roughened with periosteal elevator, rongeur, curette and chisel. Then there should be slight bleeding from the bone to produce new cells to reimburse the growth of the tendon back to the bone.

3-5 2.8mm suture anchors are screwed to the bone in a shape of triangular, rectangular or X. The number of anchors depends on the area of detachment. The tendon is then pulled back to its anatomical position and the sutures are tied to the tendon head so that anatomical attachment is achieved.

The PDS-Cord suture is then put through the sacrotuberal ligament just next to the bone and tightened and tied to keep the tension away from the suture anchors and to maximize the strength of attachment (Figure 8).

If exposure of the ischial nerve is required, the longitudinal incision is continued as much as needed.

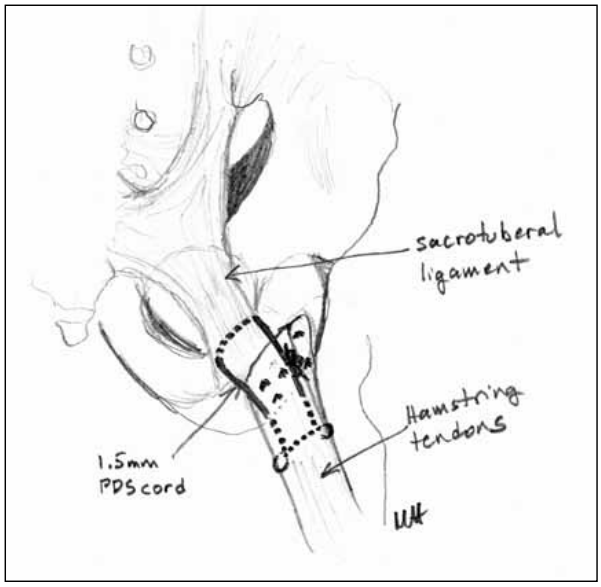

Figure 8. Schematic drawing of the fixation and the position of the 1,5mm PDS cord on the tendons and sacrotuberal ligament.

From the first described transgluteal incision the view of the injury site is excellent compared to the view when lifting up the edge of the gluteus maximus muscle. This incision also heels well and is unnoticeable because it is usually covered with clothing even when swimming.

Another advantage of this described approach is that quite often it is possible to perform the operation only through the transgluteal approach (without the second incision). There have been some problems with the longitudinal incision below the gluteal crease: the posterior femoral cutaneus nerve is in danger and sometimes excessive scar tissue formation has been seen after this incision.

Postoperative rehabilitation protocol

Our postoperative rehabilitation protocol is not based on evidence-based research but on clinical experience and the knowledge of the biological basis of tissue repair. It is most important that the patient is motivated and understands that it will take time to get back to normal. Physiotherapist should be part of the team that instructs the postoperative exercises to the patient and appointments with physiotherapist should be in the protocol. Postoperative examinations by the surgeon and physiotherapist are done at 6, 12 and 26 weeks.

First six weeks:
The patient is allowed full weight bearing from the beginning with short steps. Crutches should be used for 4-6 weeks. The patient should avoid hip flexion more than 45 degrees or until tension is felt. Also sitting on the injured buttock is not allowed before 4-6 weeks. The main goal during first 6 weeks is to normalize walking: first with the aid of crutches then without them.

6-12 weeks:
Progressive stretching exercises are started and within few weeks the normal flexibility should be achieved. Exercise bicycle and running in water are used to train the muscles to work better and gradually retain part of the power lost during the time after injury.

12 weeks:
Gym exercises are started with weights around ankles, exercise rubber band and treadmill. Stretching is continued.

4-5 months:
Sports specific drills and exercises are started. Nordic hamstring exercises are started.

6-8 months:
Return to most sports is possible if rehabilitation has advanced as planned.

Conclusions

Hamstring avulsion is a rare injury that can happen to almost anyone. Patients can be professional athletes, recreational sportsmen/women or just persons who injure themselves by slipping on slick surface. It seems that people at their fifties are in greater risk of getting hamstring avulsion injury if slipped during sports or otherwise. Unfortunately some of the injuries are misdiagnosed as muscle sprains and the correct diagnose is delayed. Therefore some patients are operated weeks or months after the original injury and surgery can then be technically more difficult. Fortunately the knowledge of this injury has lately increased among physicians and more often the correct diagnose is made and the proper treatment can be started early enough.

The treatment of avulsion injuries of the hamstrings is almost always surgical repair of the injured tendons. Usually the results are good or excellent after surgery and rehabilitation. Most often it is possible to return to the previous level of physical activity (1,3–6). The results are better if the surgery can be performed within 4 weeks after the injury but even if the surgery is done after several months it is possible to return to normal activities.

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Disclosures
None.

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