Article published online: 2023-05-18

Proximal Hamstring Avulsions, from Diagnosis to Treatment: A Review Regarding a Clinical Case

Avulsión proximal de los isquiotibiales, del diagnóstico al tratamiento: una revisión del tema en relación con un caso clínico

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Rev Chil Ortop Traumatol 2023;64(1):e58–e68.

Abstract

Proximal hamstring avulsion is a rare injury that can produce permanent functional alterations, in addition to a high risk of retear (in up to 30% of the cases). It usually occurs in athletes who perform rapid accelerations or require ballistic movements during their training, although they also occur in a more sedentary population due to low-energy mechanisms. The most frequent mechanism of injury is an eccentric contraction of the proximal hamstrings when trying to resist a fall, with the hip in flexion and the knee in extension.

Numerous clinical signs are described at the physical examination. Regarding its study, although conventional radiography and ultrasound are very useful, magnetic resonance is recognized as the gold standard for its precise diagnosis.

Treatment will depend on the type of patient and their expectations, although in recent years the surgical option has been increasingly considered in cases of complete avulsion of the hamstrings associated with retraction.

We herein present a review of the topic in relation to a clinical case that was resolved surgically, and we discuss the basic concepts, clinical presentation, complementary images, and treatment options that are currently available.

Keywords
- avulsion lesions
- proximal hamstring
- surgical treatment of proximal hamstring avulsions
- hamstring rehabilitation

Resumen

La avulsión proximal de los isquiotibiales (ITs) es una lesión poco frecuente, que puede producir alteraciones funcionales permanentes, además de tener un riesgo de rerrotura elevado (en hasta un 30% de los casos). Ocurre habitualmente en deportistas que realizan aceleraciones rápidas o requieren "movimiento balístico" durante su entrenamiento, aunque también se presentan en la población más sedentaria con

received
June 8, 2022
accepted
March 7, 2023

DOI https://doi.org/10.1055/s-0043-1768241.
ISSN 0716-4548.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

caídas a nivel en mecanismos de baja energía. El mecanismo más frecuente de lesión es una contracción excéntrica de los ITs al intentar resistir una caída, con la cadera en flexión y la rodilla en extensión.

Existen numerosos signos descritos al examen físico y, dentro del estudio, si bien la radiografía convencional y la ecografía son de gran utilidad, se reconoce a la resonancia magnética como el estándar de oro para su correcto diagnóstico.

El tratamiento dependerá del tipo de paciente y sus expectativas, aunque en los últimos años se ha considerado cada vez con más relevancia la opción quirúrgica en los casos en los que se presenta una avulsión completa de los ITs asociada a una retracción de estos.

Se presenta una revisión del tema en relación con un caso clínico resuelto de forma quirúrgica, y se discuten las generalidades, la presentación clínica, el estudio, y las opciones de tratamiento con las que se cuenta en la actualidad.

Palabras clave
- lesiones avulsivas
- isquiotibiales proximales
- tratamiento quirúrgico de avulsión proximal de isquiotibiales
- rehabilitación de isquiotibiales

Introduction

Proximal hamstring avulsion (PHA) is a challenge for sports trauma specialists. In 1988, Ishikawa et al.[1] were the first authors to write about this lesion, reporting the surgical treatment of two cases. Known to be a rare lesion, PHA can cause permanent functional alterations (persistent pain, weakness, and sciatic nerve compromise).[2] In addition, PHA has a very high risk of retear (ranging from 12% to 31%),[3] and it is present in 9% to 12% of all injuries in this muscle group.[4] It is more frequent in athletes requiring rapid acceleration (running, hurdling) or rapid changes in hip and knee flexion-extension (skiing, skateboarding, weightlifting). There is controversy regarding the ideal treatment of PHA due to the different outcomes published in the literature comparing the conservative and surgical managements. However, the conservative treatment can leave unacceptable functional alterations in high-performance athletes, who sometimes do not manage to return to the preinjury level.

The present study discusses a clinical case, reviews the subject, and shows the resolution of the injury. We present the case of a 40-year-old male patient, a recreational athlete with no known morbid history, who fell off an electric longboard sustaining hyperflexion of the left hip and simultaneous hyperextension of the knee. This injury left the patient with pain in the gluteal region and functional impotence, and he presented to the emergency department with pain, claudication, extensive ecchymosis on the left gluteal region (►**Figure 1**), and inability to extend the hip in the prone position. An ultrasound study only revealed a lesion on the gracilis tendon with a 3-cm retraction. However, a magnetic resonance imaging (MRI) scan showed a complete tear, with avulsion of the hamstring attachment, a 2.5-cm retraction, and a hematoma with 17 cm in its major axis (►**Figure 2**).

Anatomy

The hamstrings attach at the ischial tuberosity. Approaching this muscle is a major challenge because of its close relationship with significant neurovascular structures. Although Stępień et al.[5] studied the anatomy of the hamstring, we must remember that the original anatomy is not observed when addressing this lesion because the avulsion creates an empty space. Therefore, it is critical to know the details of the normal aspect of the ischial tuberosity.

The attachment of the hamstring muscles typically has two major components, one for the semimembranosus (SM) and one for the conjoined tendon formed by the biceps femoris (BF) and the semitendinosus (ST) muscles. The SM has a lateral and anterior position, with a crescent aspect, measuring 3.1 cm from proximal to distal, and 1.1 cm from

Fig. 1 Ecchymosis at the gluteal region and posterior muscle.

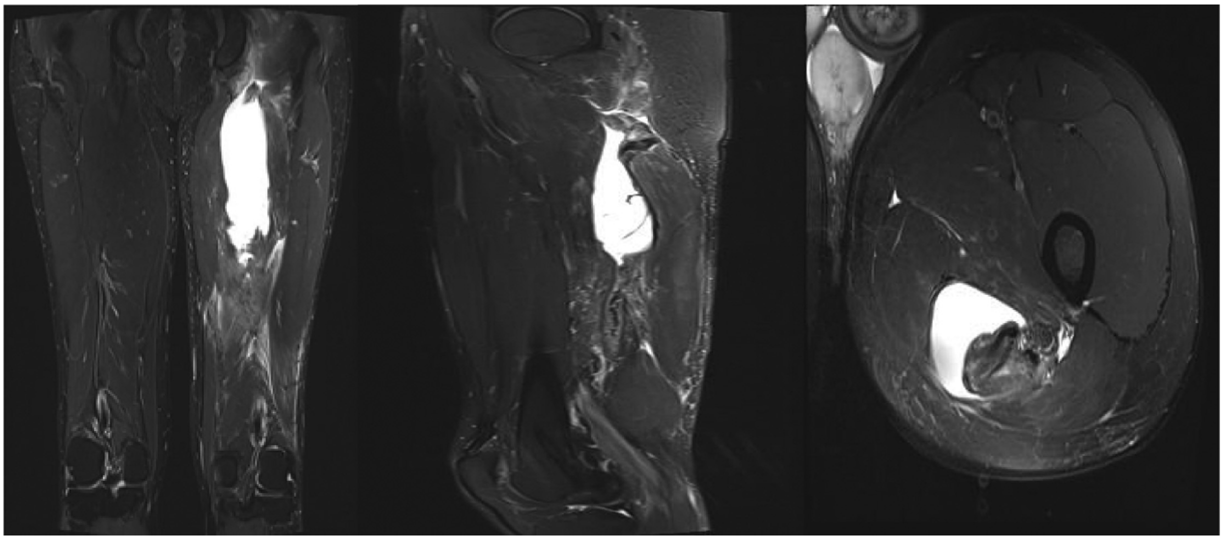

Fig. 2 Coronal, sagittal, and axial views of the complete lesion originating at the hamstrings.

medial to lateral. The conjoined tendon has a more medial and posterior position, an oval shape, and it measures 2.7 cm from proximal to distal and 1.8 cm from medial to lateral (►**Figure 3**). This conjoined joint separates into two units (ST and BF) 10 cm distal to the ischial tuberosity. The ST and SM muscles then descend posteriorly to the medial aspect of the thigh and insert themselves into the pes anserinus and the posteromedial aspect of the proximal tibia respectively. In contrast, the long head of the biceps attaches to the short head of the BF (the one originating from the linea aspera of the femur) and inserts itself into the head of the fibula. The sciatic nerve is very close during the surgical approach, so considering it is critical. This nerve is 1.2 cm lateral to the most lateral edge of the ischial tuberosity, and it must always be dissected for protection during surgery[6] (►**Figure 4**). Lastly, superficially to the description made previously, it is fundamental to consider the inferior gluteal nerve and artery, which are approximately 5 cm proximal to the lower edge of the gluteus maximus muscle. As such, one must be very careful when placing retractors through this structure.

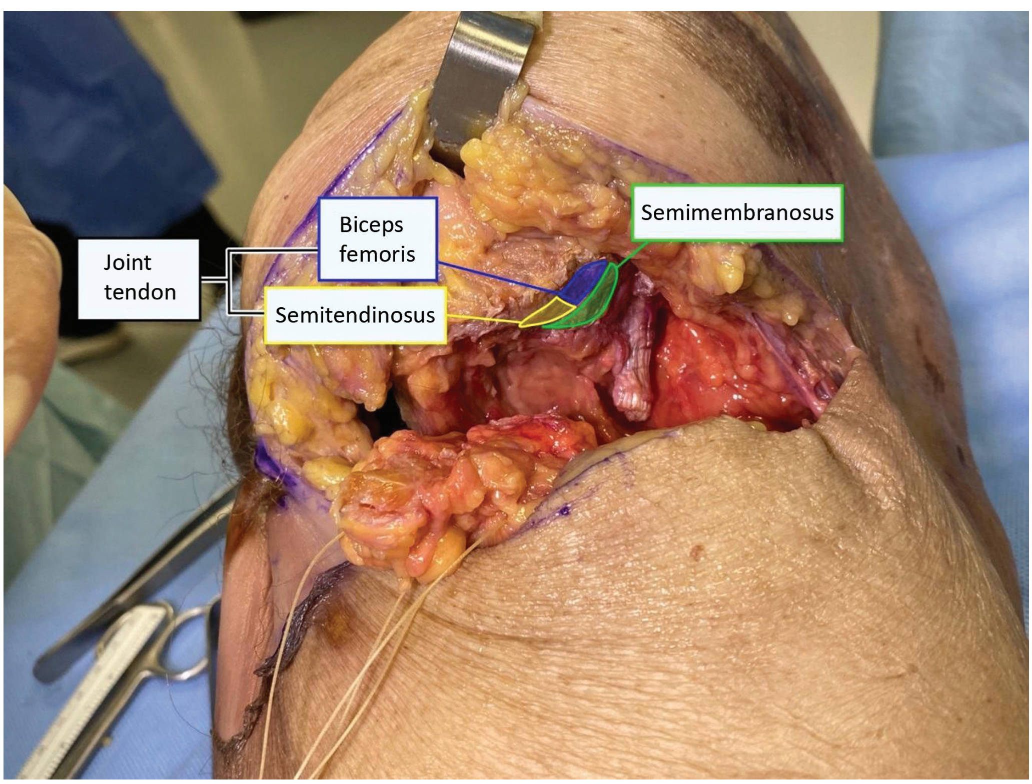

Fig. 3 Proximal hamstring attachment (cadaveric specimen).

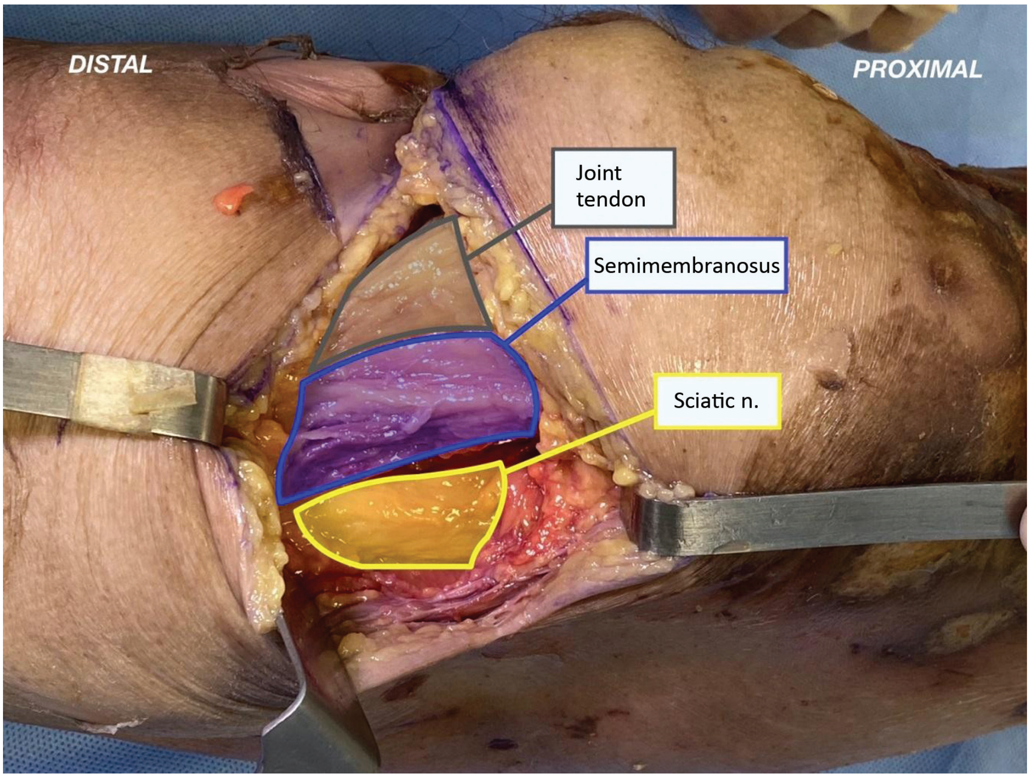

Fig. 4 Position of the sciatic nerve during the approach (cadaveric specimen).

Injury Mechanism

Due to its anatomical position, this muscle group performs a concentric contraction to flex the knee and extend the hip, and an eccentric contraction to do the opposite movement. The most common injury mechanism is a sudden eccentric contraction of the hamstrings trying to resist a fall, with the hip flexed and the knee extended.[7,8] This explains why the hamstring injury is more frequent in acceleration sports than in contact sports, even within the same modality in different positions. Most hamstring injuries in the United States' National Football League (NFL) occur in athletes with "speed position" roles (such as receivers, defensive backs, sprinters) rather than in those with a "strength position" (such as wide receivers and linebackers). In older patients, PHA may also occur when attempting to resist falls with the same hip and knee position but with lower energy mechanisms.

Clinical Picture and Physical Examination

The clinical picture often includes a sharp pain in the posterior aspect of the proximal thigh immediately after the injury, sometimes accompanied by an audible "pop" and difficulty and pain during walking.[9] The patient may also avoid simultaneous hip flexion with knee extension (hurdler position). In addition, there may be decreased hamstring mobility and discomfort when sitting, sometimes with paresthesia at the innervation territory of the sciatic nerve.[10]

At the physical examination, the patient may present an ecchymosis in the same area, often the day after the injury. Gait compromise may occur, sometimes requiring the use of canes.[11] Avulsion with significant retraction may cause a palpable depression at the proximal part of the affected thigh. A classic test is to ask the patient to bend the knee in the prone position; the patient will typically be able to do it, thanks to the use of the gastrocnemius and short head of the biceps, but will present weakness in comparison with the healthy side.[10] In addition, it is critical to assess the distal neurological status in the region of the sciatic nerve, since Wilson et al.[12] reported that up to 27% of their patients presented neurological symptoms, and 5% also had motor impairment.

Most common tests

- Bowstring sign: lack of palpable tension in the distal hamstring with the patient in the prone position and the knee flexed to 90° (►**Figure 5**).
- Popliteal angle: with the patient in supine position, with the hip and knee at 90° of flexion, gently extend the knee. Then, measure the angle of knee flexion and compare it with the contralateral knee angle; the affected side has a greater angle than the healthy side (►**Figure 6**).
- Active shoe removal sign: the patient presents difficulty to remove their shoe on the affected side (►**Figure 7**).
- Hip extension test: in the prone position, the patient will have difficulty to extend the hip on the affected side (►**Figure 8**).
- Puranen-Orava test: the patient, standing still, flexes the hip with the knee extended while placing the heel on some support; the maneuver causes pain on the affected side (►**Figure 9**).

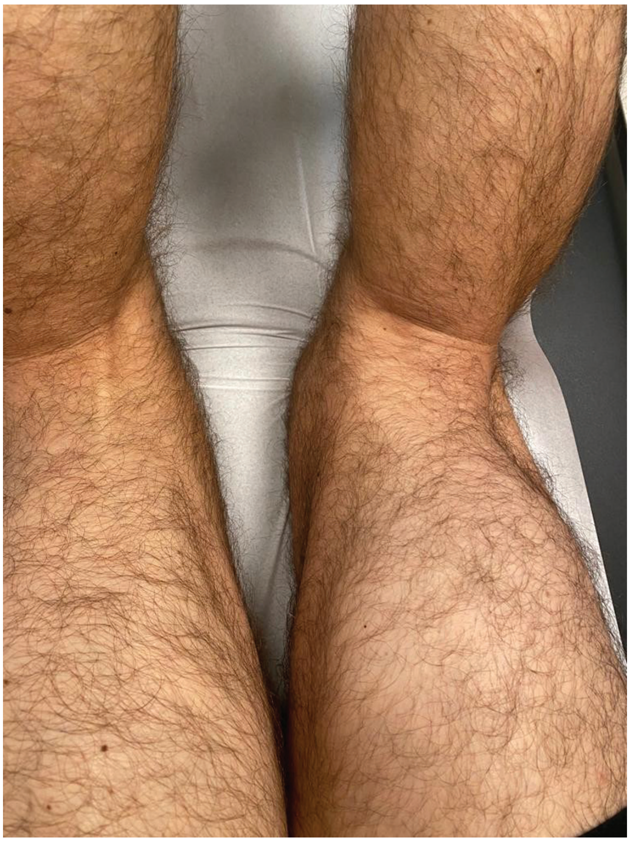

Fig. 5 Bowstring sign.

Fig. 7 Active shoe removal sign, with pain in the affected side.

– Bent-knee stretch test: place the patient in supine position with maximum hip flexion on the affected side; next, gently bring the knee into extension, which will cause discomfort in the proximal thigh.

Imaging Studies

The study begins with a plain radiograph of the pelvis, which usually does not reveal findings in hamstring injuries,[13] unless there is an avulsion fracture of the ischial tuberosity,

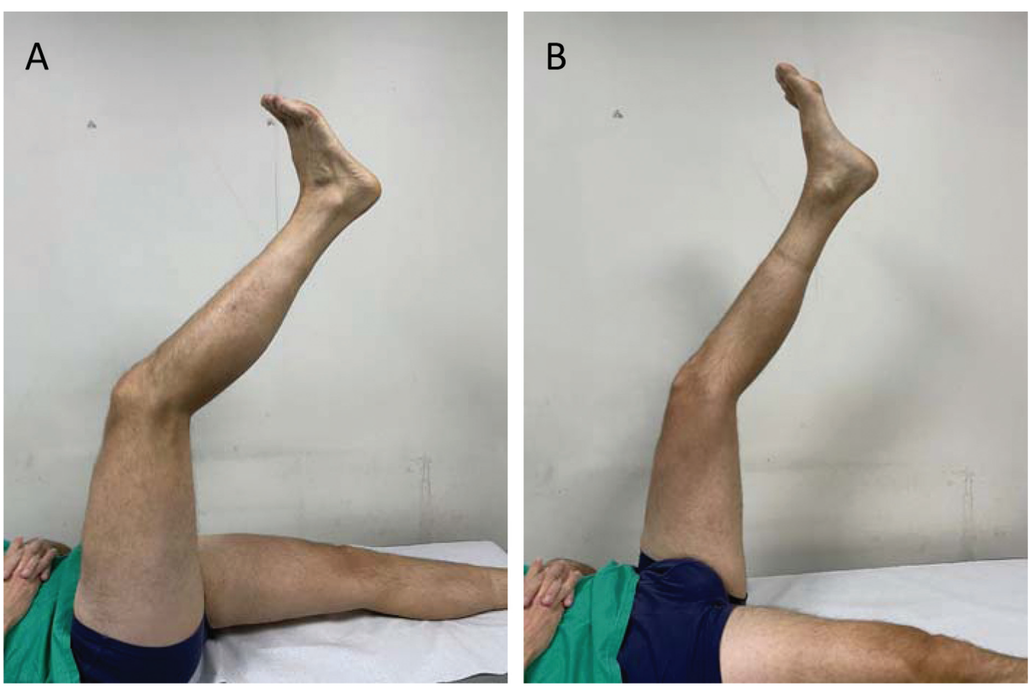

Fig. 6 Popliteal angle at the healthy side (A) and increased at the affected side (B).

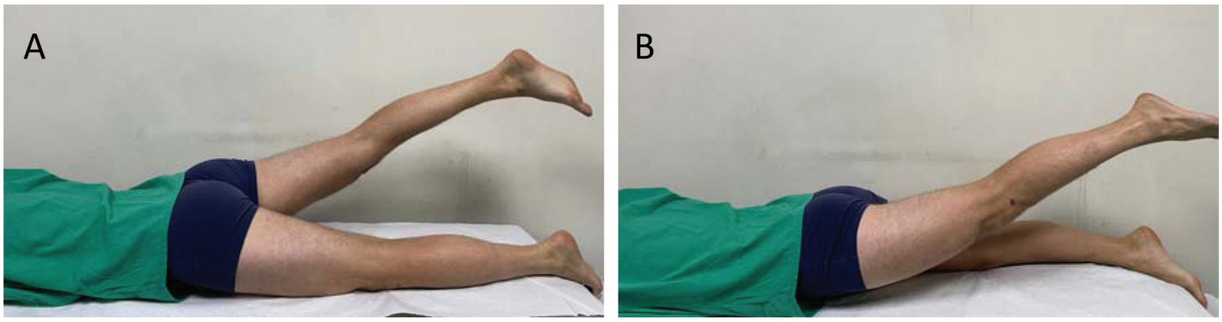

Fig. 8 Hip extension test, normal on the right side (**A**) and decreased on the left side (**B**).

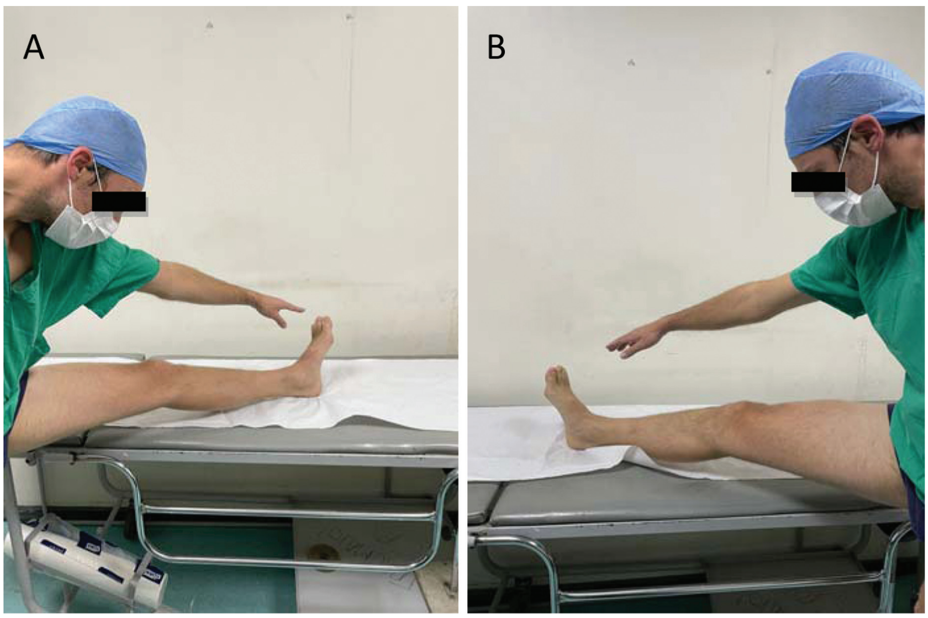

Fig. 9 Puranen-Orava test, normal on the left side (**A**) and altered on the right side (**B**).

especially in skeletally-immature children. Ultrasonography is an affordable, non-invasive test that provides high-resolution and dynamic images which may correlate with the physical examination to confirm the diagnosis.[14] Ultrasound can also show fluid collections around the lesion, representing edema, hemorrhage, or both.[15]

The MRI is the gold standard in hamstring avulsions, since it provides information on the tendons involved and reveals associated injuries (such as sciatic nerve compromise, a hematoma resulting in extrinsic compression of the neurovascular structures etc.). Regarding hamstring injuries, the MRI precisely identifies the location of the lesion (hamstring attachment site, either at the myotendinous junction or distal to it) and differentiates partial and complete lesions and acute and chronic injuries; moreover, it determines the number of tendons involved, any retraction, and tissue quality (fatty infiltration and atrophy).[14]

Classification

There are several ways to classify hamstring injuries to help guide their treatment and prognosis. These classifications include the following:

- Pathoanatomical classification:
  - Grade 1: mild (minimal) tear;
  - Grade 2: partial (incomplete) tear; and
  - Grade 3: severe (complete) tear.

- Temporal classification:
  - Acute: < 6 weeks;
  - Subacute: 6 to 12 weeks; and
  - Chronic: > 12 weeks.

- Radiological classification by Wood et al.[16] (MRI):
  - Type 1: bone avulsion (typically in patients with immature skeletons);
  - Type 2: avulsion at the myotendinous junction;
  - Type 3: incomplete bone avulsion;
  - Type 4: complete bone avulsion with minimal or no retraction; and
  - Type 5: complete bone avulsion with retraction:
    - Type 5a: with no sciatic nerve involvement; and
    - Type 5b: with sciatic nerve involvement.

Although the most used classification is pathoanatomical, it is less helpful regarding the characteristics of the avulsion.

The temporal classification is useful when choosing a surgical technique, since the treatment of acute injuries may employ a transverse approach in the gluteal fold of the affected side, or a distal longitudinal approach in the remaining cases, because of the retraction that occurs until the intervention. The MRI-based Wood et al.[16] classification is more complete, since it provides valuable information about the characteristics of the lesion. One must consider that type-2 and -3 injuries are further subdivided according to the involved tendons. However, they do not necessarily determine the preference of one surgical technique over another; instead, they provide information regarding the characteristics of the lesion that are significant for surgery if it is the chosen treatment.

Treatment

The treatment for PHA can be conservative or surgical, depending on the patient's age, level of activity, and the imaging characteristics of the lesion. Non-surgical treatment is always an option, because it avoids potential surgical complications and enables an earlier return to sports activities. However, it may result in suboptimal functional outcomes and a lower rate of return to sports practice. This was shown by Shambaugh et al.:[17] in a study with 25 patients (water skiing, hockey, and rugby athletes), 3 of the 11 subjects managed conservatively could not return to their previous levels, in contrast to the operated group (14 patients), in which all subjects resumed their previous activities.

In general, the studies currently published are of low quality, with case series including only patients treated surgically[18,19] and few comparative studies in which most included subjects underwent surgery.[20] In a 2011 systematic review by Harris et al.[21] on the differences between the conservative and surgical treatments, out of 298 patients who met the selection criteria, 286 underwent surgery, and only 14 underwent the conservative treatment.

The surgical indications are debatable due to the lack of group homogenization in different studies; however, the current recommendation based on the published literature is to reserve surgery for young, active patients with complete lesions in 2 tendons associated with a retraction greater than 2 cm (Wood type 5), complete avulsion of the 3 tendons,[21,22] or unsuccessful conservative treatment for 3 to 6 months, either due to significant functional alteration, pain, or sciatic nerve compromise.[10]

The timing of the surgery is also critical; some studies[13,23] report that an acute repair before four weeks has better outcomes than delayed surgeries. In a systematic review, Harris et al.[21] report that most studies comparing acute and chronic repairs present a higher rate of return to sport at the same level as previously (91% versus 75% respectively), greater patient satisfaction, fewer surgical complications, and lower risk of retear. As such, it is fundamental that patients with suspected PHA are referred early to a specialist.

Conservative treatment

The usual conservative treatment consists of temporary cessation of sports activities, local application of cold compress, analgesic agents, and rehabilitation with kinesiology. Therapies to manage non-avulsion muscle injuries, such as shock waves, corticosteroid infiltrations, or platelet-rich plasma administration, are not indicated.[10] Kinesiology often includes eccentric hamstring exercises, physiotherapy, massage therapy, and avoiding positions that stretch the hamstring (hip flexion with knee extension).[11] As local symptoms and edema decrease, core (abdominal) exercises, hip strengthening, and quadriceps must start.[24] The return to sports should be gradually allowed after four to six weeks,[22] once the patient shows significant symptom improvement and the strength deficit is slight in comparison with the contralateral side. Ideally, the strength is determined through isokinetic tests, which must show a difference lower than 10% in comparison with the unaffected side. Full return to sports can occur in two to four months, depending on the type of injury.

Surgical treatment

Surgical treatment is usually an open procedure, with the patient in prone position and using a transverse approach at the gluteal fold for acute cases and a longitudinal one for chronic cases. It is worth mentioning that there are successful reports using endoscopic and mini-open techniques, as demonstrated by Factor et al.,[25] Domb et al.,[26] and Laskovski et al.[27] However, the current recommendation is to perform an open procedure, especially when the surgeon does not have an extensive experience with this condition. Fixation also changed over time, from transosseous techniques (such as the one first described by Ishikawa et al.,[1] who used bone tunnels in the ischial tuberosity to reattach the three tendons in their report of two surgical cases) to anchor the fixation. The number of anchors is debatable; some groups[10] fixate the hamstrings with 3 anchors, while others[28,29] use 5 anchors with a smaller diameter (2.4 mm or 2.9 mm). Fixation must occur with the hip in extension and slight knee flexion (approximately 30°).[29]

The technique proposed and used by us is the following:

The patient must be in prone position under general anesthesia. Before surgery, it is advisable to mark the gluteal fold with the patient standing up. Protect bony prominences with padding. Make an 8-cm transverse incision in the gluteal fold centered on the ischium (►**Figure 10**). Identify the lower edge of the gluteus maximus and separate it proximally, with care not to injure the inferior gluteal artery and nerve with the retractors; these structures are 5 cm away from the lower edge of the gluteus maximus. Next, identify the sciatic nerve, which runs 1.2 cm lateral to the ischium; neurolysis is not required, except in chronic cases. Then, make a longitudinal incision in the fascia of the hamstrings. Serosanguineous content usually surrounds the avulsed tendons. Identify the tendons and place traction points to perform a distal blunt release. Place a Hohmann retractor in the ischium, separating the proximal and medial areas, and then pierce the ischium with a gouge (►**Figure 11**). Put three 5.5-mm titanium anchors loaded with high-

Fig. 10 Incision in the gluteal fold centered on the ischium.

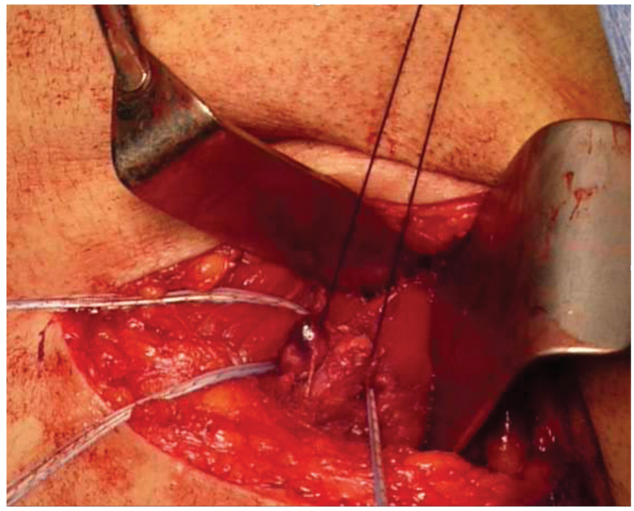

Fig. 12 Incision in the gluteal fold centered on the ischium.

strength double sutures in the hamstring indentation area (►**Figure 12**). Pass one of the anchor strands through the tendon with locked sutures, leaving the other strand to bring the tendon closer to the anchor when tying. Repeat the process with the remaining anchors. Tie the anchors with the knee flexed at 30° to facilitate this step (►**Figure 13**). Test the resistance of the construct by performing a progressive extension to determine the safe ranges of extension allowed in the postoperative period. Perform proper hemostasis to avoid bruising as a complication. Finally, suture the gluteal fascia and close the subcutaneous tissue and the skin.

Complications

Early surgical complications result from the approach and may include sciatic nerve injury. Sciatic compromise usually presents as neuropraxia due to nerve elongation during surgical manipulation, with leg paresthesia and paresis, which often disappear in a few weeks. Other nerves that may be affected include the posterior femoral cutaneous nerve and the gluteal nerve, potentially resulting in a temporary deficit in hip extension.

Other early complications are deep or superficial infections, usually managed with non-surgical treatment, thromboembolism, complex regional pain syndrome, and seromas. However, the complication rate is very low.

The main complication is hamstring retear, which occurs in less than 3% of the cases.[21]

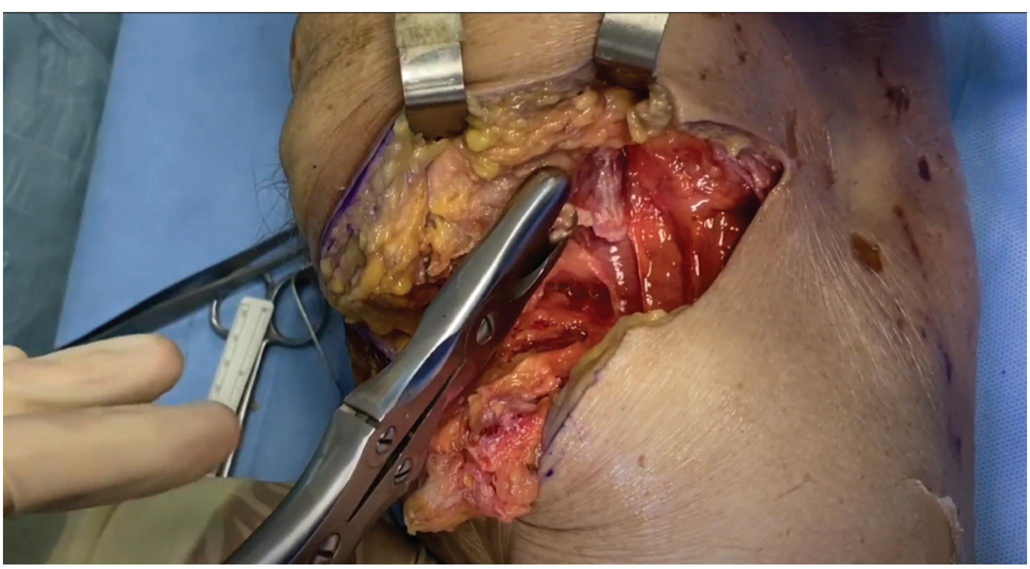

Fig. 11 Ischium piercing with a gouge (cadaveric specimen).

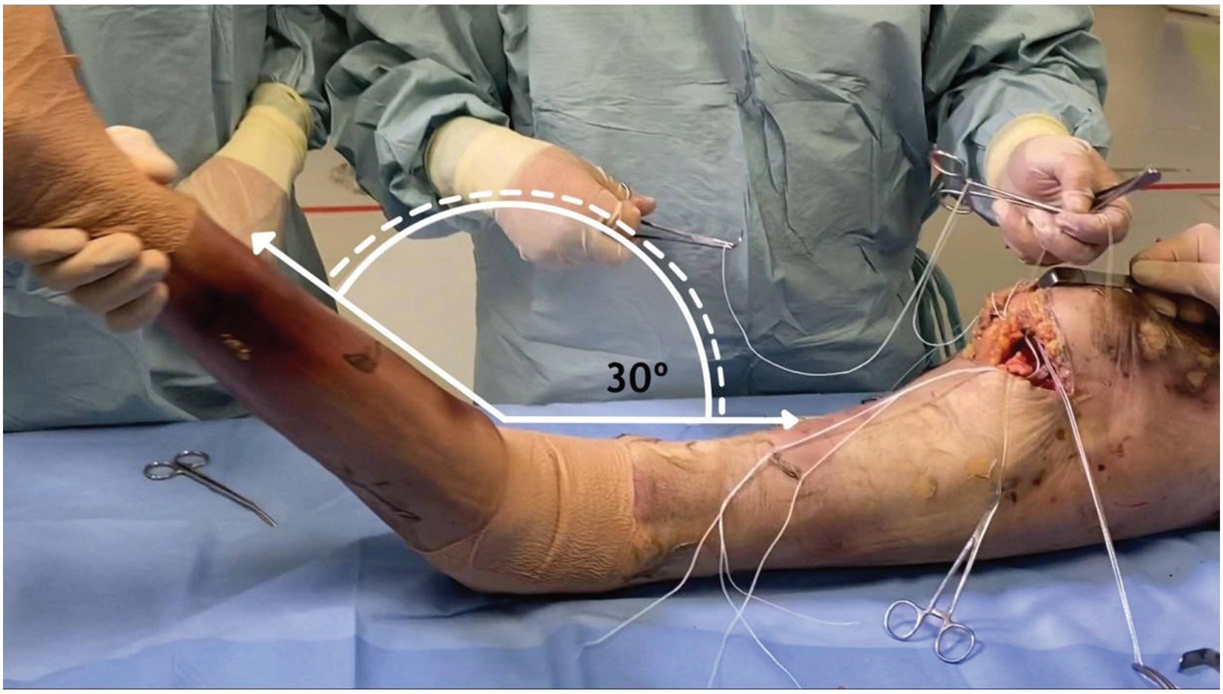

Fig. 13 Knee fixation at 30° of flexion (cadaveric specimen).

Rehabilitation

Rehabilitation protocols usually include an initial period with no load, avoiding knee extension above 30° to 40° by using an articulated knee splint for four to six weeks. Some groups recommend higher degrees of knee locking[30] and hip extension locking to protect the fixation.[29] Passive hamstring activation starts in the first two weeks, followed by movements against gravity. After the sixth week, it may be possible to remove the splint and allow a full load. In addition, if the patient tolerates sitting, it is possible to start with an exercise bike. Avoid hamstring stretching until week twelve; by this time, the patient should fully return to their daily living activities. Consider resuming sports in six to ten months.[31]

Rehabilitation of our patient

The initial treatment consisted of relative rest, local cold compresses, local measures, and oral analgesia. Surgery occurred four weeks after the injury, and it was performed with the patient in prone position, through a longitudinal approach, using the technique described earlier. Immediate postoperative immobilization employed an articulated knee splint blocked at 30° for 1 month. We allowed loading with two canes as tolerated. Kinetic therapy began in the sixth week with assisted hamstring activation, then, against gravity, and progressively increasing resistance until the sixth month. The patient returned to his sports activities seven months after surgery.

Discussion

Proximal hamstring avulsion is a rare injury. This rarity makes it more difficult to suspect and diagnose the condition. Therefore, there is considerably less experience with it in comparison with other sports injuries (such as meniscal and anterior cruciate ligament injuries). One must always suspect PHA in active patients presenting pain and inflammatory changes in the gluteal region, especially if they practice sports that require "ballistic positions".[4] The traumatologist must never forget to perform the physical examination in a patient with these characteristics in the prone position since it enables the observation of the main findings (hip extension test, bowstring sign).

The classic treatment is conservative. However, in recent decades, the therapeutic approach has changed due to the low rate of return to sports at the preinjury level, as shown by Sallay et al.[32] In 1996, in a population of water skiers, these authors[32] reported that orthopedic treatment resulted in a rate of return to sports of only 60%, and that most patients had a lower activity level than before the injury. This conclusion is consistent with that of Bodenhofer et al.,[18] who published a meta-analysis showing that operated patients presented greater satisfaction than non-operated patients (90% versus 52% respectively), higher hamstring strength compared with the healthy side (85% versus 63% respectively), and improved results in functional tests.[18] Even though the surgical indications remain controversial, we often consider that avulsion of two tendons with retraction greater than 2 cm, complete avulsion of 3 tendons, and failure of the conservative treatment harm the future performance of the patient.[17] Therefore, surgical treatment for these cases has gained popularity in sports medicine. Unfortunately, the studies published usually include only operated subjects,[18,19] and few studies have comparative groups, such as the one by Harris et al.[21] However, generally speaking, since the return to high-performance sports is greater and more predictable after the surgical treatment, the current recommendation is to perform an early surgical reattachment.

Moreover, different publications discuss a wide range of surgical techniques. Undoubtedly, the current recommendation is an open procedure, which shows very encouraging outcomes.[10,16,28,29] However, remember that there are reports of the use of mini-open and even endoscopic techniques with good results, but with smaller sample sizes (six patients) or simply descriptions of surgical techniques.[25–27] There are several forms of tendon fixation; as far as we know, Ishikawa et al.[1] made the first description using transosseous sutures in the ischial tuberosity. Today, we consider anchors the gold standard for fixation.[33] The number, size, and way of placing the anchors vary in the literature, with reports using 2 to 5 anchors with smaller (2.4 mm)[29] or larger diameters (5.5 mm),[34] and placement in an anatomical footprint area or an "X" configuration.[28,29] The published papers often do not specify the reason for selecting a particular type of fixation, except for Moatshe et al.,[28] who used 5 small-diameter (2.9 mm) anchors in the shape of an "X" because, in a previous biomechanical study,[35] they compared three configurations with a control group with no hamstring lesion and concluded that this configuration and anchor size was the most resistant. It is worth mentioning that this study of Moatsche did not have a group with 3 larger (5.0 mm or 5.5 mm) anchors. Since most published studies use this configuration, we selected it for our case. We highlight that, however, from a clinical perspective, there is no apparent relevant difference concerning the distinct configurations. As such, we believe that each surgical team must decide based on their expertise, considering the techniques described in the current literature.

Our case report proposes an open surgical technique with an 8-cm incision enabling the observation and protection of all structures at risk during the approach. Until now, we obtained very good outcomes, with no recorded complications impairing the proper performance of patients. Therefore, it seems reasonable to recommend it as a good option even though each surgical team should always decide their approach according to their preference and expertise, the way to fixate the hamstrings in the correct position, and the rehabilitation protocol resulting in the best outcomes for their patients.

Conclusion

A rare injury with difficult management, PHA may result in severe functional sequelae. Always keep a high index of suspicion; ideally, request an MRI for diagnosis and refer some cases for eventual surgical fixation. An active return to sports is achievable, often in six to nine months.

Funding

The present research did not receive any specific grants from the public, private or not-for-profit sectors.

Conflict of Interests

The authors have no conflict of interests to declare.

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