Proximal hamstring tendinopathy: pathophysiology, diagnosis and treatment

ABSTRACT

Proximal hamstring tendinopathy is a chronic degenerative disease associated with progressive morbidity and functional decline. There is a growing incidence of the disease process but diagnosis is commonly delayed as patients present with vague and indolent symptoms, often without a specific precipitating injury. Treatment is also challenging as the existing literature varies in the nomenclature used for proximal hamstring tendinopathy and clinical trials use different management protocols with variable follow-up times. This review explores the existing literature on proximal hamstring tendinopathy and discusses the relevant anatomy, pathology, medical history, differential diagnosis, clinical assessment, diagnostic imaging and treatment of patients with proximal hamstring tendinopathy. This structured approach to proximal hamstring tendinopathy will enable clinicians to better understand the pathophysiology of the disease process, improve referrals to diagnostic imaging, and follow a stepwise approach to medical treatment and surgical referral.

Hamstring injuries are one of the most common injuries suffered by athletes (Lempainen et al, 2015). These injuries often occur in sprinters or middle- to long-distance runners, and range from acute hamstring sprains and tears to chronic degenerative injuries. Acute hamstring sprains usually occur during high-speed running as the hamstring muscles eccentrically contract to decelerate the swinging phase of the leg. Patients often report a sudden onset of sharp, stabbing pain in the posterior thigh and difficulty in continuing sporting activity (Lempainen et al, 2015). Hamstring injuries may also occur as a result of minor repetitive loading and trauma at the origin of the hamstring tendons from the ischial tuberosity. This is called proximal hamstring tendinopathy, which is also known as high hamstring tendinopathy, ischiatic intersection syndrome, hamstring enthesopathy or hamstring origin tendinopathy.

The diagnosis and treatment of proximal hamstring tendinopathy are challenging owing to variations in the nomenclature of this condition within the literature, vague and indolent symptoms produced by the disease process, and paucity of studies with long-term clinical and functional follow up. This article provides clinicians in secondary and tertiary care with an evidence-based approach for history taking, clinical examination, diagnostic investigation and treatment of proximal hamstring tendinopathy. Improvements in establishing the correct diagnosis and early implementation of suitable treatment in proximal hamstring tendinopathy will help to optimize short-term functional recovery and long-term clinical outcomes (Lempainen et al, 2009).

Methods

Electronic searches were performed using PubMed, Embase and the Cochrane database for studies relating to proximal hamstring tendinopathy. The following medical subject headings (MeSH) were used to carry out a systematic search of the literature: 'hamstring', 'tendinopathy', 'tendinitis', 'anatomy', 'diagnosis', 'histology', 'imaging', 'rehabilitation', 'treatment', and 'surgery'. Articles published in English between January 1990 and March 2018 were selected and reviewed for inclusion into the study. The reference lists from the retrieved articles were reviewed for additional articles.

Anatomy

The hamstring complex is composed of three muscles: semimembranosus, semitendinosus and biceps femoris (*Figure 1*). The long head of the biceps femoris and semitendinosus muscles form the conjoined tendon that inserts into the posteromedial aspect of the ischial tuberosity through an oval footprint measuring approximately 2.7 x 1.8±0.5 cm (Philippon et al, 2015). The semitendinosus muscle inserts onto the ischial tuberosity through a more anterolateral crescent-shaped attachment measuring 3.1 x 1.1±0.5 cm (Philippon et al, 2015). The corresponding tendon thickness at this level for the common semitendinosus and long head of biceps tendon is 1.0±0.3 cm, and for the semimembranosus tendon this is 0.8±0.2 cm (Phillipon et al, 2015).

The main functions of the hamstring muscles are hip extension and knee flexion with primary innervation from the sciatic (tibial) nerve. All three hamstring muscles receive their blood supply from branches of the profunda femoral and inferior gluteal arteries. Intraoperative biopsy samples from patients undergoing tenotomy for proximal hamstring tendinopathy have shown that the hamstring

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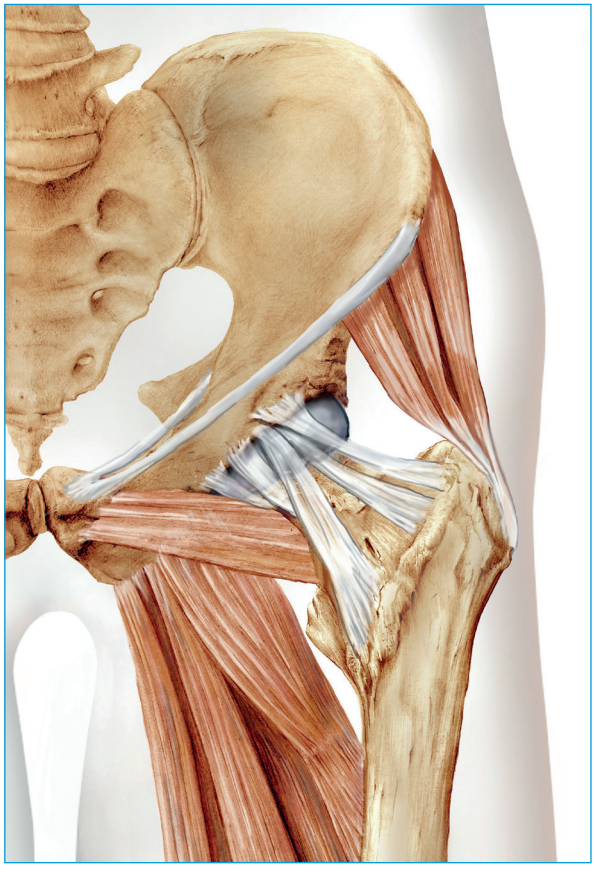

Figure 1. Anterior view of the left hip showing insertion of semimembranosus, semitendinosus and biceps femoris onto the ischial tuberosity.

muscles can be affected in isolation or as a complex triad with varying degrees of inflammation within each proximal tendon (Benazzo et al, 2013). Histological examination in proximal hamstring tendinopathy shows the characteristic morphological changes in tendinosis include rounding of tenocyte nuclei, increased ground substance, collagen disintegration, neovascularization and possible calcification (Lempainen et al, 2015). There may also be fatty degeneration with fat cells infiltrating between the collagen bundles.

Aetiology

Intrinsic factors lead to structural abnormalities within the origin of the proximal hamstrings that predispose the tendon to increased risk of injury and reduced healing potential. Hamstring tendons sampled from older patients show an inferior ability of tendon stem cells to stimulate clonogenicity, adipose inductability and osteogenic inductability (Ruzzini et al, 2014). In perimenopausal women, reduced oestrogen levels may adversely impact tendon haemostasis and healing, leading to progressive, degenerative breakdown of the tendon (Hansen et al, 1985). Other intrinsic factors associated with proximal hamstring tendinopathy include genetic predisposition (e.g. mutations in COL5A1 that encodes for collagen type V), metabolic abnormalities (e.g. lipid level imbalance, glucose intolerance, insulin resistance), hormonal changes and pharmacological agents (e.g. fluoroquinolone antibiotics) (Tsai and Yang, 2011).

Extrinsic factors may promote increased workload and eccentric loading through the proximal hamstrings' origin site, and compression of the tendons at these origins during hip flexion and adduction may exacerbate symptoms (Lempainen et al, 2006). In vivo testing has demonstrated that increased hip flexion leads to greater shear forces between the ischial tuberosity and hamstring tendons with greater displacement of the proximal hamstrings (Hamming et al, 2015). Training errors that increase the volume and duration of training too vigorously or introduce exercise such as lunges, sprint work or hurdling too early may trigger proximal hamstring tendinopathy (Jayaseelan et al, 2014). These activities cause rapid contraction and lengthening of the hamstring while the hip is in flexion, which generates greater tensile and compressive loads at the tendon insertion. Abnormal hip positioning required in pilates and yoga postures may provoke similar symptoms (Jayaseelan et al, 2014).

History

Patients with proximal hamstring tendinopathy often report gradual increase in pain or discomfort over the sub-gluteal or posterior thigh region (Lempainen et al, 2009; Benazzo et al, 2013). This pain is described as 'cramp' or 'tightness' in the deep buttock area and usually progresses over time with no specific inciting trauma or injury. Radiation into the popliteal fossa may lead to pain inhibition and weakness of the hamstring muscles, and difficulty with participation in sporting activities. Symptoms may be exacerbated by repetitive eccentric hamstring loading or prolonged forward flexion of the trunk such as during hamstring stretching exercises, running, and sitting for long periods of time (Fredericson et al, 2005; Lempainen et al, 2009). In more severe cases, fibrosis of the proximal hamstring muscles can tether and compress the sciatic nerve, leading to sharp pain radiating down the posterior thigh into the foot (Fredericson et al, 2005).

Differential diagnosis

The differential diagnoses for proximal hamstring tendinopathy includes the following: piriformis syndrome, stress fractures, ischial tuberosity apophysitis, hamstring tendon avulsion fractures, ischioinguinal bursitis, posterior femoral compartment syndrome, partial hamstring tears, adductor muscle strains, referred pain from the lumbar spine, hip joint or sacroiliac joint, and soft tissue masses or growths (Benazzo et al, 2013). Careful history taking and diagnostic imaging help to determine the correct underlying diagnosis. Piriformis syndrome is caused by a pathologically thickened and hypertrophied piriformis muscle. The resultant

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compression of the sciatic nerve results in buttock pain, exercise-induced leg weakness and infrequent sciatica. On clinical examination, specific provocative tests like Freiberg's sign and Pace's sign, combined with magnetic resonance imaging features of an enlarged piriformis muscle, confirm the diagnosis.

Acute hamstring tears usually have more acute pain, which is localized within the muscle belly itself, and a definite defect may be palpable. Ischiatic bursitis causes a very similar localized pain to proximal hamstring tendinopathy but the pain generally occurs at rest and while sitting. The pain may interrupt sleep and major discomfort results from an inability to find a comfortable, pain-free position when sitting down. Chronic posterior compartment syndrome may cause pain during exercise much like proximal hamstring tendinopathy. Functional overload causes isolated hamstring hypertrophy without distension of its surrounding fascia. This condition causes pain upon physical exertion but not while sitting.

Clinical examination

On examination, patients may have ecchymosis around the posterior thigh, atrophy of the hamstrings bulk (normal hamstring:quadriceps ratio is 65%), and walk with a stiff-legged gait to avoid knee flexion and hip extension. There may be vague tenderness at the origin of the proximal hamstrings with pain aggravated by resistance to knee extension and active stretching of the hamstrings. A palpable mass within the posterior thigh indicates rupture at the musculotendinous junction. There are three specific provocation tests for proximal hamstring tendinopathy that show moderate to high validity and intra-rater reliability for this condition (Cacchio et al, 2012):

1. The Puranen–Orava test is an active test in which the hamstring muscles are actively stretched in the standing position. The hip is flexed to 90° and the knee fully extended with the foot on a support at 90° to the standing position
2. The bent-knee test is performed with the patient in the supine position. The hip and knee are flexed to their end of range and then passively extended by the examiner
3. In the modified bent-knee test, the patient is supine with the legs extended. The examiner then passively flexes the hip and knee to end of range, and rapidly extends the knee.

A positive finding is noted if symptoms are exacerbated by the specific provocation test.

Diagnostic imaging

The most commonly used imaging modalities are ultrasound and magnetic resonance imaging. Ultrasound findings in proximal hamstring tendinopathy include tendon thickening, hypoechoic regions and calcified foci within the tendon, and peritendinous fluid with surrounding oedema. Ultrasound provides dynamic, cost-effective, high-resolution imaging, and anatomical guidance for therapeutic injections. It can also be used to perform serial objective assessments of radiological progress in the outpatient department by trained sonographers. The main drawback is that it is highly operator-dependent and soft tissue images are not as detailed as with magnetic resonance imaging (Wilson et al, 2005).

Magnetic resonance imaging with T1- and T2-weighted images may show thickening of the proximal hamstring tendons, peritendinous oedema and reactive bone marrow changes within the ischial tuberosity (*Figure 2*). A more definitive indication of tendinopathy is a distal feathery pattern of the proximal tendons associated with peritendinous oedema (Lempainen et al, 2015). Magnetic resonance imaging has improved sensitivity and specificity for diagnosing peritendinous oedema in proximal hamstring tendinopathy, and improved resolution of the periarticular soft tissues helps to better exclude other similar differential diagnoses compared to ultrasound alone.

Treatment

Early protected range of movement exercises

The initial treatment of patients diagnosed with proximal hamstring tendinopathy should include rest, ice, compression and elevation with non-steroidal anti-

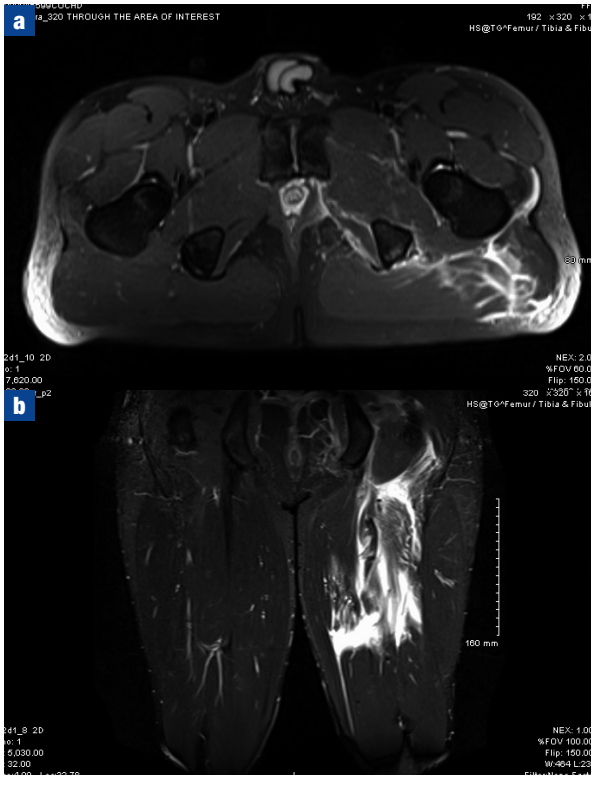

Figure 2. a. Coronal and **(b)** axial magnetic resonance images of a patient with proximal hamstring tendinopathy showing interface failure of the left semimembranosus and conjoint tendons with detachment of the tendon origins from the left ischial tuberosity.

> “Eccentric exercises stimulate collagen fibres within tendons to become more organized and form cross-links, which clinically helps to improve mechanical strength and flexibility.”

inflammatory drugs. Supervised exercises to maintain hip movement within a protected safe range should be undertaken early after confirmation of proximal hamstring tendinopathy diagnosis. These controlled low-intensity range of motion exercises will help to stimulate tendon healing and reduce the formation of scar tissue (Heiderscheit et al, 2010). In vitro studies have shown that low mechanical stretching of tendons may promote differentiation of tenocytes (Zhang and Wang, 2010).

More extensive hamstring stretching exercises should be avoided as these may be detrimental to tendon healing. Large mechanical stretching forces promote tendon stem cells to follow adipogenic, chondrogenic and osteogenic lineages, leading to typical lipid accumulation, mucoid formation and calcification in tendinopathy (Zhang and Wang, 2010). Patients should proceed to the next phase of treatment when they are able to walk without pain and perform pain-free isometric contraction exercises with knee flexion exercises against 50–70% maximum resistance (Heiderscheit et al, 2010).

Eccentric muscle exercises

Eccentric exercises stimulate collagen fibres within tendons to become more organized and form cross-links, which clinically helps to improve mechanical strength and flexibility (Cushman and Rho, 2015). Eccentric hamstring exercises include hamstring curl machines, reverse cable curls, dead lift exercises and kneeling Nordic leg curls. Cushman and Rho (2015) reported a case study of a triathlete with subacute proximal hamstring tendinopathy confirmed on ultrasound treated using a treadmill. The patient stood backwards and eccentrically resisted movement of the belt, leading to improved pain within 2 weeks and return to high-speed training within 12 weeks. There was no recurrence of the injury at 12 months follow-up. Other case reports on patients with proximal hamstring tendinopathy treated with eccentric hamstring loading and lumbopelvic stabilization have shown improved pain and return to full sporting activity within 10 weeks of treatment (Jayaseelan et al, 2014).

Shockwave therapy

The rationale for the use of shockwave therapy in proximal hamstring tendinopathy is that this condition displays similar pathological changes to tendinopathies originating from other anatomical sites where shockwave therapy has been an effective treatment strategy. The exact mechanism of action is not known but it has been postulated that the shockwaves may cause hyperstimulation analgesia through the release of cytokines into the affected tissues. These then disrupt serotonergic activation of the dorsal horns that exert descending inhibitory control over pain (Zhang and Wang, 2010). Cacchio et al (2011) conducted a prospective randomized study on 40 professional athletes with proximal hamstring tendinopathy treated with conservative therapy or shockwave therapy, and found patients in the shockwave group had improved pain and Nirschl phase rating scores at 12 months follow up. The authors commented that shockwave therapy was a safe and effective treatment for proximal hamstring tendinopathy. To the authors' knowledge, this is the only existing level 1 evidence for the use of shockwave therapy in proximal hamstring tendinopathy.

Corticosteroid injections

Corticosteroids help to limit chronic inflammation and therefore reduce tendon scarring and adhesion formation (Zissen et al, 2010). Administering medication under ultrasound-guidance facilitates accurate placement of the injection into the tendon sheath and avoids direct infiltration into the tendon substance. The immediate resolution of symptoms from the local anaesthetic is a helpful diagnostic tool as to the source of the symptoms and indicates that the medication was delivered accurately.

Zissen et al (2010) retrospectively reviewed 65 patients with proximal hamstring tendinopathy undergoing ultrasound-guided corticosteroid injection and found that 50% of patients had moderate to complete resolution of symptoms for at least 1 month with 24% of patients reported symptomatic relief for longer than 6 months. Nicholson et al (2014) followed 18 patients with fluoroscopically-guided corticosteroid injections for proximal hamstring tendinopathy and showed significantly improved pain scores and return to sports participation in all patients at a mean follow-up of 21 months. The authors advocated the use of fluoroscopy for percutaneous injection as it is less restricted by the patient's body habitus.

Platelet-rich plasma injections

Platelet-rich plasma contains regulatory proteins, growth factors, and platelets that inhibit and modulate the action of proinflammatory cells and facilitate more rapid tendon healing. Wetzel et al (2013) reviewed outcomes in 17 patients with proximal hamstring tendinopathy and found that the 12 patients treated with platelet-rich plasma had improved pain and Nirschl phase rating scores compared to the five patients undergoing conventional treatment at 6–12 weeks' follow up. These findings were supported by Fader et al (2014) who showed that 10 of 18 patients treated with ultrasound-guided platelet-rich plasma reported had an 80% improvement in pain scores at 6 months' follow up. More recently, Krauss et al (2016) conducted a prospective study on 14 patients with proximal hamstring tendinopathy treated with ultrasound-guided plasma-rich protein injections and found improvements in pain scores and lower extremity

functional scores at 12 weeks' follow up. Overall, studies using platelet-rich plasma have shown promising results in the initial stages with improvement in pain and functional score at short- to mid-term follow up.

Surgery

Early surgical techniques in the treatment of proximal hamstring tendinopathy described the release of a 'tendon-like thickened band' on the anterolateral side of the biceps femoris muscle. Orava (1997) first described this technique in the treatment of 'hamstring syndrome', and reported good to excellent outcomes within the first 12 months of surgery but recurrence of symptoms in most patients after this period. Lempainen et al (2009) conducted a retrospective study on 103 cases (90 patients) with proximal hamstring tendinopathy treated with semimembranous tenotomy with reattachment to the biceps femoris muscle, and exploration of the sciatic nerve. The study showed excellent outcomes in 62 cases, good outcomes in 30 cases, and fair outcomes in five patients over an average follow-up time of 49 months. The authors reported that 80 of the 90 patients from the study cohort returned to the preinjury level of activity at a mean of 5 months (range 2–12 months) after surgery. The authors concluded that surgery was associated with good functional outcomes and low complication rates for proximal hamstring tendinopathy.

Saikku et al (2010) retrospectively reviewed outcomes in 22 cases (16 patients) treated with surgical release for proximal sciatic nerve entrapment secondary to proximal hamstring tendinopathy. The study showed complete relief of symptoms in 11 cases, good relief in eight cases, and fair relief in three cases at an average of 6 years follow up. Benazzo et al (2013) retrospectively reviewed clinical outcomes in 17 high-level athletes with proximal hamstring tendinopathy refractory to conservative treatment that underwent surgery. The likely hamstring tendon causing proximal hamstring tendinopathy was identified and released intraoperatively by visualizing the myotendinous unit that showed scarring, hypertrophy, and fibrosis. Overall, excellent outcomes were reported in 88% of study patients, good results in 12% of patients, and no patients had poor results. All patients returned to their preinjury level of sporting activity at a mean of 4.4 months after surgery. Acute hamstring tears associated with proximal hamstring tendinopathy in high-level athletes may benefit from suture anchor attachment of the avulsed tendon to the ischial tuberosity or Achilles tendon allograft reconstruction to restore function and aid return to sporting activities (Rust et al, 2014)(*Figure 3*).

Conclusions

Proximal hamstring tendinopathy is a chronic degenerative condition that is caused by repetitive eccentric stress loading at the origin of the hamstrings. Patients often present with gluteal or posterior thigh pain and may have neurological symptoms originating from compression of the sciatic nerve. Both intrinsic structural abnormalities and extrinsic repetitive loading factors contribute to the disease process. Specific provocation tests for proximal hamstring tendinopathy include the Puranen–Orava test, bent-knee stretch test and modified bent-knee stretch test. Diagnostic imaging includes ultrasound or magnetic resonance imaging. Conservative treatment includes eccentric hamstring strengthening exercises, shockwave therapy, local corticosteroid infiltration and platelet-rich plasma injections. Surgical treatment with selective tenotomy of the affected proximal hamstring tendon and decompression of the sciatic nerve has shown promising results in the early phases but the clinical and functional results of longer term studies are awaited. BJHM

KEY POINTS

- Proximal hamstring tendinopathy commonly presents with vague and indolent symptoms around the buttock or posterior thigh, often with no acute precipitating injury.
- The main imaging modalities for proximal hamstring tendinopathy are ultrasound and/or magnetic resonance imaging.
- Specific provocation tests for proximal hamstring tendinopathy include the Puranen–Orava test, bent-knee stretch test and modified bent-knee stretch test.
- Early conservative treatment of proximal hamstring tendinopathy should include supervised physiotherapy to maintain the range of motion and eccentric hamstring loading to aid tendon recovery.
- Symptoms refractory to early function rehabilitation may benefit from shockwave therapy, local corticosteroid infiltration and platelet-rich plasma injections. Functional recovery and clinical outcomes with these treatment modalities is highly variable among patients.
- Surgical treatment with selective tenotomy of the affected proximal hamstring tendon and decompression of the sciatic nerve has shown promising results in the early phases but the clinical and functional results of longer term studies are awaited.

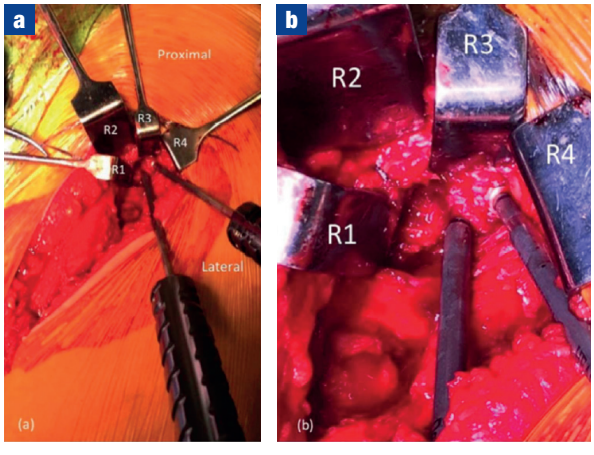

Figure 3. **a.** Suture anchor placement is demonstrated by the anchor awl and tap situated in the ischial tuberosity intraoperatively **(b)** with magnification. The patient is prone and the operative side is right. Retractor 4 (R4) is under gluteus maximus tendon. Retractors 1–3 (R1–3) are retracting tendon origin of biceps femoris and semitendinosus.

Conflict of interest: none.

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