



Lesions of the abductors in the hip

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- Abductor tendon lesions and insertional tendinopathy are the most common causes of lateral thigh pain. Gluteal tendon pathology is more prevalent in women and frequency increases with age.
- Chronic atraumatic tears result in altered lower limb biomechanics. The chief complaint is lateral thigh pain. Clinical examination should include evaluation of muscle strength, lumbar spine, hip and fascia lata pathology. The hip lag sign and 30-second single leg stance tests are useful in diagnosing abductor insufficiency.
- Magnetic resonance imaging (MRI) is the gold-standard investigation to identify abductor tendon tears and evaluate the extent of muscle fatty infiltration that has predictive value on the outcome of abductor repair.
- Abductor tendinosis treatment is mainly conservative, including non-steroidal anti-inflammatory medications, activity modification, local corticosteroid injections, plasma-rich protein, physical and radial shockwave therapy. The limited number of available high-quality studies on treatment outcomes and limited evidence between tendinosis and partial ruptures make it difficult to provide definite conclusions regarding the best management of gluteal tendinopathy.
- Surgical management is indicated in complete and partial gluteal tendon tears that are unresponsive to conservative treatment.
- There are various open and arthroscopic surgical procedures for direct repair of abductor tendon tears. There is limited evidence concerning surgical management outcomes. Prerequisites for effective tendon suturing are neurologic integrity and limited muscle fatty infiltration. Chronic irreparable tears with limited muscle atrophy and limited fatty infiltration can be augmented with grafts. Gluteus maximus or/vastus lateralis muscle transfers are salvage reconstruction procedures for the management of chronic end-stage abductor tears with significant tendon insufficiency or gluteal atrophy.

Keywords: arthroscopy; gluteal muscles; gluteus medius; gluteus minimus; greater trochanteric pain syndrome; hip abductors; lateral thigh pain; muscle transfer; tendinopathy; tendon tears

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Introduction

Many terms describe persistent lateral hip pain around the greater trochanter, including trochanteric bursitis, greater trochanteric pain syndrome, and lateral thigh pain.¹ However, the cause of pain encompasses many different pathologies. Lateral thigh pain is frequently associated with trochanteric bursitis, but the use of advanced imaging methods has provided greater awareness that hip abductor injuries can be causative.^{1,2} It is now supported that abductor tendon lesions and non-inflammatory insertional tendinopathy of gluteus medius (GMed) and gluteus minimus (GMin) are the most common cause of lateral thigh pain in both native and prosthetic hips.³ Hip abductor tendinopathy can range from tendinosis to complete tendon rupture, frequently complicated by muscle fat atrophy.⁴ This instructional review aims to present an outline of current literature evidence regarding the anatomy, diagnosis and treatment of hip abductor tendon lesions and specifically of GMed and GMin.

Anatomy and function of gluteal muscles

The hip abductors comprise the GMed, GMin and tensor fasciae latae.⁴ The GMed originates from the anterior superior iliac spine and the outer border of the iliac crest towards the posterior superior iliac spine.⁵ A recent cadaveric study demonstrated three distinct GMed origins: gluteal fossa and aponeurosis, and the posteroinferior edge

of the iliac crest.⁶ The GMin originates from between the anterior and posterior inferior iliac spines along the middle gluteal line.⁵ Both of these are innervated by the superior gluteal nerve;⁵ however, variable primary innervation patterns have been reported.⁶ The GMed has three distinct parts, the anterior, middle and posterior. The muscle fibres of the anterior and middle segments are perpendicularly oriented, initiating hip abduction,⁷ while the posterior fibres of the GMed and GMin have a horizontal orientation, stabilizing the hip joint during gait.⁷

Two discrete GMed insertion sites with different shapes have been recognized⁸ (Fig. 1). The posterior aspect of the GMed and a section of the middle portion are inserted on the posterosuperior facet of the greater trochanter (Fig. 1C). This facet is thick and almost round with a diameter less than 10 mm. The remaining middle and anterior GMed parts are inserted on the lateral trochanteric facet (Fig. 1D). This is wider and trapezoidal with a mean length of 3.5 cm inclined to the femoral axis.⁸ The GMin has fascicular attachments to the anterior hip capsule (Fig. 1B) and the anterior and lateral facets of greater trochanter (Fig. 1A) beneath the GMed. The insertional facets of the GMed and GMin are separated from an area bare of tendon attachments, the so-called 'bald area' (Fig. 1E), serving as an anatomic landmark, particularly for hip arthroscopy.⁸

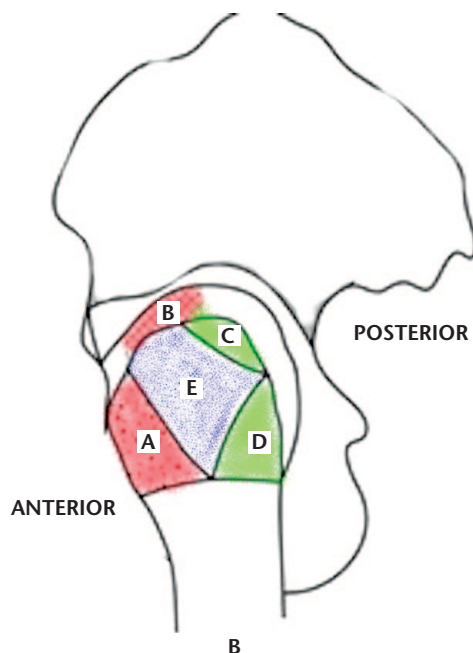


Fig. 1 Insertion sites of the gluteus medius (GMed) and minimus (GMin) into the greater trochanter. A: trochanteric attachment of the GMin, B: capsular attachment of the GMin, C: posterosuperior facet of the GMed, D: lateral facet of the GMed, E: 'bald area'.

Epidemiology

The prevalence of abductor tendon lesions cannot be accurately estimated.² Abductor tendinopathy has been historically under-reported under the term greater trochanteric pain syndrome (GTPS) which has included both trochanteric bursitis and external coxa saltans (snapping hip syndrome).^{9,10} However, half of patients suffering from GTPS demonstrate gluteal tendinosis or ruptures. Also, less than 20% have ultrasound-detected bursitis, which is usually a secondary feature.^{9,11} Besides, less than 10% of patients suffer from bursitis without any other pathology.³

GTPS is more prevalent in women than men and demonstrates peak prevalence between the fourth and sixth decades of life.⁴ The rate of gluteal tendinosis and ruptures increases with age. In an observational study of 185 patients over 50 years old with non-hip-related problems, the incidence of gluteal ruptures increased from 10% in the under the sixties to 50% in the over seventies groups.¹² Importantly, after the age of 70 years, the prevalence of tendinopathy can be over 80% and 60% can demonstrate partial tears.^{12,13}

Aetiopathogenesis

Abductor tendon insufficiency can result in altered lower limb biomechanics. Patients suffering from knee or hip osteoarthritis demonstrated a higher prevalence of abductor pathology.^{11,14} Twenty five per cent of patients undergoing total hip arthroplasty (THA) for end-stage hip osteoarthritis also suffer from gluteal tendons ruptures.^{15,16} Abductor pathology appears related to ageing, mainly attributed to diminished tendon vascularity.¹²

Three distinct clinical scenarios have been described for abductor tendon tears. First, they may be chronic tears. These are often found in the over 70-year-old age group, in patients with persistent lateral hip pain, non-responsive to conservative treatment.¹⁷ The other two scenarios involve atraumatic chronic tears of the anterior GMed part found unexpectedly during hip surgery and iatrogenic avulsion tears of abductor tendons following THA using a transgluteal approach,⁵ due to deficient healing of the disruption site.¹⁸ Svensson et al¹⁸ followed 97 patients for a year undergoing THA through the transgluteal approach using metal markers on both sides of gluteal repair.¹⁸ Twenty-three patients had a separation > 1 cm at two weeks, and 54 had a split > 2.5 cm at one-year postoperatively.¹⁸ Traumatic tears in young adults have also been reported.¹⁹ Excessive wear, osteolysis and especially metallosis following THA may lead to fatigue, inflammatory process and excessive abductor tendon damage and atrophy of the hip abductors.^{20,21} The amount of femoral

offset produced following THA often affects abductor function. A reduction in offset over 5 mm results in reduced abductor strength.²²

Clinical presentation

The effect of abductor tendon pathology on quality of life (QoL) may be similar to or even worse than symptoms from end-stage hip osteoarthritis.^{20,23} The chief complaint is lateral thigh pain aggravated by lying on the affected limb, walking or climbing stairs.⁵ Pain radiating over the fascia lata may also be problematic. Tenderness over the superior and lateral facets of the greater trochanter is typically found on examination. Although described, anterior groin pain is less common, and other reasons for pain should be excluded.²⁴

The patient often shows a slight or moderate limp and a positive Trendelenburg sign. These simple clinical findings have shown sensitivity and specificity of between 73% and 76%, to diagnose abductor tendon tears, respectively.²⁵ The sensitivity and specificity to diagnose abductor tendon tears have been shown to be superior to resisted abduction testing and internal rotation in a study of 24 cases with GTPS.²⁵ A gait analysis study showed increased adduction in single leg stance before lift-off and lowered contralateral hemipelvis position in patients with symptomatic gluteal tendinopathy.²⁶

A detailed clinical examination should be performed including evaluation of muscle strength, neurologic status, lumbar spine and hip or fascia lata pathology. The passive hip range of motion is usually not limited, but hip abductor muscle strength is decreased compared with asymptomatic individuals.²⁷ In patients with THA, the integrity of the prosthetic joint must also be checked.

The hip lag sign is a useful test in diagnosing abductor insufficiency. It is performed with the patient in the lateral position with the affected side up. The clinician passively extends the hip 10 degrees, abducts 20 degrees, and then maximally internally rotates the hip with the knee in 45 degrees of flexion. The leg is then released, and the patient is asked to hold it in an upright position. If the leg drops more than 10 cm, the test is considered positive.²⁸ Hip lag sign demonstrated sensitivity and specificity of 89% and 96% respectively for abductor tendon ruptures, insufficiency and tendinopathy.²⁸

Additional useful tests are the 30-second single leg stance and external derotation tests. In the former, the patient is asked to perform a 30-second single leg stance and no trunk deviation; the test is positive if lateral thigh pain occurs.²⁹ The latter is tested with the patient lying supine with the hip and knee flexed at 90° and the hip in external rotation; the test is positive if pain arises after resisted derotation of the leg.²⁹ Single leg stance test and

resisted external derotation test in supine position had a sensitivity of 100% and 88% respectively and specificity of 97.3% in diagnosing gluteal tendinopathy.²⁹ Internal rotation lag sign showed a weaker correlation to diagnose abductor tears.³⁰

Imaging

Magnetic resonance imaging (MRI) is the gold-standard examination in evaluating abductor muscles and tendon anatomy.⁴ Metal artefact reduction sequences (MARS) and multiple acquisitions with variable-resonance image combinations MRI (MAVRIC) are advanced MRI protocols that enable improved assessments when prosthetic hips are present. The size and shape of muscles, tendinosis, partial or complete tendon defects and fatty infiltration of gluteal muscles can be assessed. An area of hyperintense signal superior or lateral to the greater trochanter, separating the tendon from its attachment on T2 MRI sequence, is reported to have 75% sensitivity and 95% specificity to predict GMed tendon tears.³¹ GMed tendon elongation³¹ or Tensor Fasciae Latae (TFL) hypertrophy³² are other indirect MRI findings related to abductor tendon tears. MRI may under-report tears when compared to intraoperative findings.²⁴ Also, peritrochanteric abnormalities on MRI may be present in 50% of asymptomatic patients, elucidating that clinical presentation should guide treatment³³ (Fig. 2).



Fig. 2 Magnetic resonance imaging (MRI) sequence pictures demonstrating a chronic gluteus medius rupture with extended fatty infiltration of the muscle.



Fig. 3 Standard anteroposterior pelvic radiographs demonstrating greater trochanter enthesophytes greater than 2 mm.

The extent of abductor muscle fatty infiltration has a predictive value on repair outcomes.³⁴ The Goutallier–Fuchs classification rates the degree of abductor fatty infiltration on MRI using a four-scale range. Grade 1 relates to some muscle fatty streaks. Grades 2 and 3 involve muscle fatty infiltration with more muscle and fat, or equal muscle and fat, respectively. Grade 4 demonstrates more fat than muscle on MRI.³⁴ Bogunovic et al correlated greater muscle fatty infiltration (Grade 3–4), higher postoperative pain and failure rate and the lower functional outcomes.³⁴ The prognostic value of abductor muscle fatty infiltration has been confirmed both for open³⁵ and endoscopic repair.³⁶ Although gluteal tears may be present in asymptomatic individuals, they are more common in symptomatic individuals. Fatty infiltration is almost exclusively seen in symptomatic patients.³⁷

Standard hip and pelvic radiographs should also be performed and have an essential role in the initial evaluation. Greater trochanter enthesophytes or surface irregularities > 2 mm have a 90% prognostic value of gluteal tendinopathy³⁸ (Fig. 3). In patients with prosthetic hips, additional radiographs should also evaluate concomitant THA pathology.

Ultrasound also has a role and can effectively diagnose tendinopathy and tears.³⁹ Fearon et al reported 79% sensitivity and 100% positive predictive value for abductor tears using preoperative ultrasound in 19 patients who underwent open abductor repair.⁴⁰ In the setting of THA and the absence of available advanced MRI protocols for artefact reduction, it is useful. However, ultrasound is user-dependent and inferior to MRI in recognizing the degree of fatty infiltration. In patients with painful THA, ultrasound was found to be superior in detecting joint effusion but inferior in evaluating muscle atrophy and pseudotumours compared to MARS MRI.⁴¹

Treatment

Conservative treatment

Initial treatment of abductor tendon pathology is conservative and can include short-term use of non-steroidal anti-inflammatory medications, activity modification, physical therapy and local injections of corticosteroid plus anaesthetic into the trochanteric bursa. If conservative management fails to relieve the symptoms after three months of therapy, surgical treatment may follow.³⁷ However, the limited availability of high-quality studies and the elusive evidence between tendinosis and partial ruptures cannot provide definite conclusions regarding the best management of gluteal tendinopathy. Randomized controlled trials (RCTs) are needed to test the proposed treatment modalities.

Modification of load and mechanical stimulation with exercises is considered beneficial for tendon biochemical processes.¹ However, there are limited clinical studies and no RCTs to assess specific exercise programmes in gluteal tendinopathy. Rompe et al⁴² compared a four-month exercise programme including stretching of the iliotibial band and piriformis and strengthening of muscles in the sagittal plane with corticosteroid and shock-wave therapy (SWT) for gluteal tendinopathy.⁴² This exercise programme was ineffective during the first weeks, and less than half of the patients were improved at four months; however, the response was positive at 15 months for 80% of patients. Further research and better-quality studies are needed.⁴²

Cortisone is one of the most commonly prescribed treatment methods for gluteal tendinopathy.^{14,42–46} Both blind and ultrasound-guided cortisone infiltration of the peritrochanteric region have been used. However, most studies are case series with no controls, and studies with sufficient power are scarce. Besides the pathology of the abductor tendon is rarely confirmed with MRI.^{43,44,46} Corticosteroid injection usually provides substantial immediate pain relief during the first month; however, pain is not entirely alleviated with a positive response for less than half of patients at mid to long term.⁴² An RCT of 120 patients with lateral trochanteric pain for more than one week compared cortisone injection with conservative treatment. Cortisone had superior outcomes regarding pain at three months but no difference at one year. The absence of MRI to specify diagnosis by primary care physicians was a limitation.⁴³ Labrosse et al reported 50% pain reduction and 72% improvement in QoL scores at one month following ultrasound-guided cortisone infiltration in 54 patients with symptomatic gluteal tendinopathy.⁴⁴ However, abductor lesions were not confirmed by MRI. In an RCT comparing fluoro-guided vs. blind cortisone injection for GTPS in 65 cases, no outcome difference was found at one and three months. Although the use of fluoroscopy increased the

cost, it did not necessarily improve outcomes. Poor patient outcomes were related to the diagnosis not being confirmed by MRI.⁴⁶ Other potential drawbacks of corticosteroid injections are the unknown mechanism of action and safety regarding repeated use.¹ Probably the primary mode of action is local analgesic than anti-inflammatory action, interacting with local neuropeptides and neurotransmitters.⁴⁷ The recurrence of pain following injection usually reflects the inability of corticosteroids to address the underlying pathology.⁴⁸

Data concerning the use of plasma-rich protein (PRP) to manage gluteal tendinopathy are limited. Mautner et al performed ultrasound-guided PRP injections in 16 patients with chronic GMed tendinopathy. They reported 82% moderate to complete lateral thigh pain resolution at six months. However, the diagnosis was unclear and not refractory for abductor tendinopathy.⁴⁹ In a non-controlled retrospective study, leukocyte-rich ultrasound-guided PRP injections in 21 patients with tendinosis or partial tendon rupture without atrophy also improved QoL at a mean of 20 months follow-up.⁵⁰ Saltzman et al showed that platelet-rich fibrin matrix post glutei repair was superior to repair alone in terms of early postoperative QoL scores but had otherwise no difference in GMed tendon repair in terms of pain or clinical evidence of retears.⁵¹ In an RCT comparing ultrasound-guided triamcinolone and PRP in 20 patients with GTPS, triamcinolone had better outcomes but no superiority versus PRP at two months.⁵² In a higher-quality prospective RCT that investigated only partial ruptures, ultrasound-guided injection of PRP was superior to cortisone in 70 patients at 12 weeks in terms of modified Harris Hip Score (mHHS).⁵³

Radial SWT is an alternative treatment modality for gluteal tendinopathy. Shock waves can penetrate soft tissues up to 4 cm, providing both analgesia and healing of abductor tendons.⁵⁴ In a non-randomized comparative study, weekly sessions of SWT for three weeks were more beneficial than exercise and corticosteroid injections at four weeks and better than corticosteroids at 15 months.⁴² In a case-control study, Furia et al compared 66 patients with GTPS responsive to lidocaine infiltration who received low energy extracorporeal SWT with 33 controls who underwent traditional conservative treatment. The SWT group had superior HHS and pain scores during the first 12 months.⁵⁵ Although SWT was considered beneficial for the management of GTPS, the information for the control group was unclear.

Surgical treatment

Surgical management is indicated for full gluteal tendon ruptures and partial tears that are non-responsive to conservative treatment, eliciting pain and disability for patients. Analgesia, preservation of function and better QoL of patients are the main goals of surgical treatment.

Preoperative evaluation

Candidates for surgical repair of gluteal tendon tears must undergo a thorough preoperative clinical and radiological evaluation. Special care is needed concerning the following:

Neurologic evaluation

Neurologically intact abductor muscle is a prerequisite for surgical management of abductor tendon tears. Lumbar spine pathology or other sources of neurologic impairment of gluteal muscles should be routinely screened preoperatively. Management of neurologically impaired gluteal muscles usually involves complex reconstruction techniques with muscle transfers.

Fatty infiltration of gluteal muscles

The direct repair of extensively fatty infiltrated abductor muscles (Goutallier classification > 2) is related to inferior outcomes.³⁴ More complex reconstruction techniques such as muscle flaps or grafts are necessary to overcome fatty infiltration.

Existing THA

Infection, aseptic loosening or any other concomitant pathology should be excluded in the presence of THA. Prosthetic infection or excessive wear may inevitably affect the quality of gluteal tendons, and augmented repair or muscle transfer may be needed. Excessive osteolysis of the greater trochanter can make tendon fixation on cancellous bone ambiguous or insufficient.

Fascia lata or iliotibial band tightness

Preoperative and intraoperative evaluation of iliotibial band tightness and fascia lata should be performed, and appropriately corrected with lengthening during abductor tendon repair.

Types of procedures

Various open and arthroscopic procedures for direct repair of abductor tendon tears have been reported. Prerequisites for an efficient non-augmented direct suturing of abductor tendons are neurologic integrity and limited fatty infiltration of muscles. Chronic irreparable tears without atrophy and limited fatty infiltrated abductor tendons can be augmented with synthetic grafts or allografts.^{10,56} Reconstruction techniques are salvage procedures for the management of chronic end-stage abductor tears with significant tendon insufficiency or gluteal atrophy. Unfortunately, the level of evidence of studies concerning surgical management of abductor tears is low and mainly consists of case series. A proposed treatment algorithm for the management of abductor tendon tears is illustrated in Fig. 4.

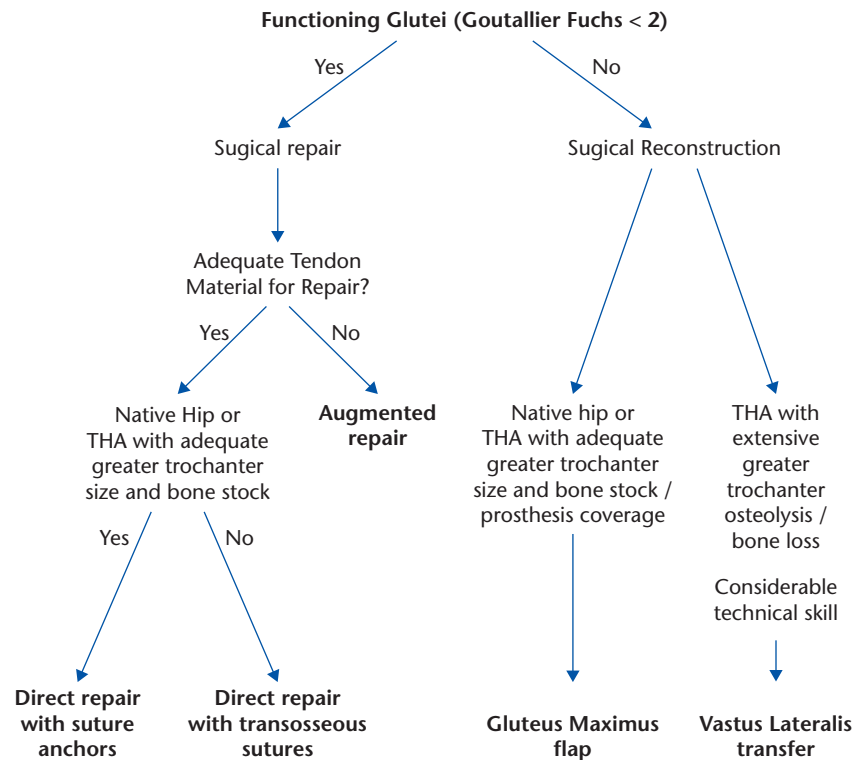


Fig. 4 A proposed treatment algorithm of abductor tendon tears.
 Note. GT, greater trochanter; GMax, gluteus maximus; THA, total hip arthroplasty; VL, vastus lateralis.

Direct open or endoscopic non-augmented repair using bone tunnels or suture anchors

Open or arthroscopic direct non-augmented repairs of full-thickness tears of gluteal tendons have been described (Fig. 5). During open procedures, the patient is usually placed in the lateral decubitus position, and an incision centred over the greater trochanter or a posterolateral approach is used.^{57–59} Following the exposure of the gluteal attachment, the quality, type and extent of the rupture of the gluteal tendons are assessed. Partial-thickness GMed tears often develop in the tendon undersurface, and recognition of the lesion is difficult.¹⁰ Saline injection under the insertion of gluteal tendons may elevate tendinous insertion indicating an undersurface rupture ('bubble sign'). Doubtful lesions are assessed by splitting GMed fibres in line to gain access to the tendon undersurface. In cases of severe tendinosis, an aggressive debridement should be avoided to preserve maximal tendon length and width, preventing tensioning or non-anatomic repair.³⁵ Once the tendon tears have been recognized, the bone bed area should be prepared with a burr or nibbler, taking care not to remove excessive bone, weakening bone adjacent to anchor holes.

The use of both drill holes and suture anchors through the greater trochanter have been described for open techniques.¹⁰ Optimally, four pairs of bone tunnels are drilled on the lateral facet of greater trochanter for full-thickness GMed tears. The number of tunnels is modified accordingly for partial thickness tears.⁵⁷ An additional pair of tunnels is drilled on the anterior tubercle of the greater trochanter for GMin tears.⁵⁷ Bone tunnels for GMed reattachment should be performed perpendicularly to the long axis of footprint, while tunnel(s) for GMin should be done obliquely.⁵⁷ Thick non-absorbable sutures passing through tendon ends, and bone tunnels are used to tie down under maximum tension and reapproximate tendons to their footprint. Additional thin sutures are usually needed to enhance the repair.

The use of suture anchors instead of bone tunnels may preserve the vascular supply of the femoral head in native hips. Two to three proximal anchors are used in a proximal row and another two distally to make a double-row effect; 5–6.5 mm diameter anchors are usually preferred to overcome the tension of the underlying cancellous bone.⁵⁸ Following trochanteric footprint preparation, proximal anchors are placed; sutures are then passed through the GMed flap and tightened, transferring the flap onto the major trochanter with the hip in slight



Fig. 5 (a) Intraoperative picture of gluteus medius tendon rupture (dotted lines). **(b)** Intraoperative picture of the final result of direct open suturing of the tendon.

abduction. Suture placement should account for final tendon positioning and row width, usually 5–10 mm from the tendon edge. After tendon approximation, the distal-row anchors are placed, and new sutures increase tendon compression on the bone. GMin tears are similarly managed using fewer anchors due to the smaller insertion area and capsular attachments of muscle.⁵⁹ When needed, the blunt release of gluteal muscles is performed, taking care to preserve the superior gluteal nerve or elongation of fascia lata using a V-Y technique. Postoperatively, non-weight-bearing or partial weight-bearing walking for six weeks, avoiding active hip abduction, is followed.^{57–59}

Direct open non-augmented repair with sutures is a straightforward technique. However, inadequate mechanics and substantial delay of the repair is related to a high reported failure rate up to 25%.⁶⁰ Davies et al reported improved QoL and muscle strength and no re-tears for five years for open gluteal tendon repairs using transosseous sutures and anchors.³⁵ Poor results were found for highly atrophic and fatty infiltrated muscles. In one of the largest open gluteal tendon repair series using transosseous sutures, Walsh et al followed 72 patients with

different tear types for a minimum of one year. Ninety-five per cent of patients improved in pain and function with a low 5.5% re-tear rate and 8.3% Deep Venous Thrombosis (DVT) rate, although no thromboprophylaxis was used.⁵⁷ Davies et al reported improvement in pain and five failures out of 16 patients who underwent open repair using double-row suture anchors at one-year follow-up.⁶¹ The level of fatty infiltration of muscles was not provided. A re-rupture rate of 8.25% was reported for 12 patients undergoing double-row open repair for partial and complete abductor tendons ruptures followed for a mean of 19 months. Outcomes worsen for higher Goutallier classification scores.⁵⁹ McGonagle et al demonstrated no improvement in tendon and muscle quality postoperatively in 15 patients who underwent open repair with anchors. Again, no preoperative Goutallier grading was provided and tendon quality intraoperatively was not mentioned.⁶² In one of the longest follow-up studies (mean 4.6 years) after open double-row repair for abductor tears in 67 patients, Makridis et al demonstrated improvement in pain and QoL but a 16% re-tear rate.⁶³ Other studies showed outcomes of open techniques for abductor tears with an existing THA.^{58,60,64} In a retrospective study, 12 patients underwent open repair of abductor tears following THA using the lateral Hardinge approach with sutures passing through bone tunnels. Half of the cases had substantial improvement in limping and pain at 38 months, but a 25% failure rate was reported when treating tendon avulsion using a posterior-lateral THA approach with sutures.⁶⁰

Several studies also reported good mid-term results with endoscopic non-augmented repair methods for partial and full-thickness abductor tendon ruptures.^{65–71} Direct distal lateral and proximal portals, as well as accessory anterolateral and posterolateral portals, are usually used to access the peritrochanteric space, facilitate instrumentation and anchor placement.^{65–71} The endoscopic repair has been described even for ruptures found at the musculotendinous junction.⁶⁷ Good results have been reported in the endoscopic double-row repair of full-thickness tears in 10 patients at one-year follow-up⁶⁵ and partial undersurface ruptures in 25 patients with a minimum of 24 months follow-up.⁶⁶ Chandrasekaran et al reported improvement in pain and QoL at two years in 34 patients undergoing endoscopic double-row repair for complete and partial ruptures with no re-tears.⁷⁰ In one of the longest follow-up studies, 14 patients demonstrated good outcomes at mid-term (five years) follow-up following endoscopic repair with concomitant labral repair. However, the study population was inhomogeneous, including both partial and full tears as well as labral repair and excision.⁷¹

The superiority of anchors vs. transosseous sutures, with decortication or not, single vs. double-row repair and open vs. endoscopic methods is unclear due to the absence of high-quality comparative studies. A biomechanical study

showed that double-row repair led to better footprint coverage and a trend for a higher load to failure than single-row constructs.⁷² A cadaveric biomechanical study demonstrated inferior pullout strength in cases with excessive decortication or low Bone Mineral Density (BMD), suggesting caution for osteoporotic patients and avoidance of excessive decortication.⁷³ Unfortunately, no comparative study between open and endoscopic methods of gluteal tear suturing exists in the literature. Two recent systematic reviews reported similar patient-reported outcomes, pain scores, and improvement in abduction strength using open and endoscopic methods for the management of abductor tendon repair.^{74,75} However, open techniques had a higher complication rate (re-tears) than endoscopic ones.⁷⁴

Direct open augmented repair with synthetic grafts or allografts

Synthetic grafts or allografts are used for the management of chronic irreparable abductor tendon tears of non-atrophied muscles with limited fatty infiltration. Grafts cover the repair site, ensuring effective hold on healthy tendon proximally and healthy tendon or bone distally. Either a standard transosseous or suture anchor repair is performed. Different types of synthetic grafts or allografts have been proposed:

Synthetic ligament

Following debridement of the diseased tendon and decortication of the trochanteric footprint, the flattened portion of the synthetic ligament is sutured onto the undersurface of the muscles. Combined transosseous tunnel and suture anchors are used to reattach the augmented GMed.⁷⁶ Bucher et al⁷⁶ reported on clinical and functional results of 22 patients with GMed and GMin tears that were augmented with Ligament Augmentation and Reconstruction System (LARS) synthetic ligament following the previous failure of conservative treatment. However, the degree of atrophy and tendon degeneration was not described. Oxford Hip Score, Short Form (SF)-36 and Visual Analogue Scale (VAS) scores were significantly improved, and all patients were at least satisfied at 12 months postoperatively. There was a minimal complication rate; the LARS was removed from one patient due to lateral thigh pain.⁷⁶ In another prospective cohort study, 110 patients with native hips followed-up for a year following open abductor tendon repair of full-thickness GMed tears were augmented with LARS ligament, bursectomy and iliotibial band lengthening. All scores and strength were improved, and 96% of the patients were satisfied with a 3% failure rate.⁷⁷

Collagen patch

A collagen patch is an appropriately sized non-absorbable graft which is secured over the abductor tendon tear repair with running non-absorbable suture.⁷⁸ This can be

partly secured to the vastus lateralis tendon distally to enhance mechanical integrity.

Fink et al⁷⁸ evaluated the postoperative outcomes of 30 patients with a mean age of 76 years suffering from large GMed tears. Nine patients had a spontaneous tear of the gluteal muscle, and 21 had suffered tearing following THA using the transgluteal approach. The tears were repaired with transosseous fixation using a modified Mason-Allen technique that was augmented with a non-resorbable collagen patch (Covidien, Trèvoux, France). At a mean 24 months, the VAS, HHS and GMed muscle force were significantly improved; 25 patients had mild or no limp at all but five retained a severe limp. Fatty degeneration of muscle > 50% was related to suboptimal functional results, suggesting treatment for these situations should involve such a repair for Goutallier grade < 3 cases.⁷⁸ Good to excellent results for pain and muscle strength were also reported for 11 out of 12 cases of gluteal avulsion post THA that were augmented with a dermal matrix at a mean 22-months follow-up. However, fatty degeneration and tendon stump condition were not specified.⁵⁶

Achilles tendon allograft

This technique is accomplished using fresh-frozen Achilles tendon with an attached calcaneal bone allograft block measuring 2 x 1.5 x 1 cm. The block is fashioned using a saw appropriately to dovetail into a trough made in the greater trochanter outlined to match the allograft size.⁷⁹ Fibrous remnants of tendon insertion are cleaned to create a vascularized bed to increase integration. The GMed and GMin are then mobilized and translated inferiorly. The tendinous part of allograft passes through the GMed almost 3 cm proximal to the ruptured end and is then looped back on itself. Following maximum leg abduction, the bone block is placed into the trough with a press-fit technique and secured with 16-gauge wire or cables. The tendinous allograft part is secured to the GMin, anterior capsule and intact GMed tendon with non-absorbable sutures.⁷⁹ A hip abduction brace is used for six weeks with partial weight-bearing.

Fehm et al⁷⁹ reported the functional results of seven patients who underwent reconstruction of a deficient abductor mechanism following THA with the aforementioned surgical technique. All but one patient had substantial improvement concerning HHS and pain scores at two years; however, five patients still had a positive Trendelenburg sign.⁷⁹

Reconstruction for chronic end-stage abductor tears using muscle transfer

Two main surgical techniques have been proposed using either gluteus maximus (GMax)⁸⁰⁻⁸³ or vastus lateralis (VL) muscle transfer.^{84,85}

Reconstruction with GMax transfer flap

Whiteside originally described this technique for transferring the anterior part of the GMax to replace irreparable tears of hip abductors in five patients.⁸⁰ They had a vast improvement in limping and pain. However, this study did not report on functional scores and muscle strength. Modifications of this technique have been reported.^{81,82} One of these was a two-limb technique where the anterior half of the gluteus maximus was transferred to the greater trochanter and sutured under the vastus lateralis and a separate posterior flap was transferred under the primary flap to substitute for the GMin and capsule⁸¹ in patients during THA. In another modification, the anterior portion of the gluteus maximus and the entire TFL were transferred to the greater trochanter to substitute GMed and GMin for native hips.⁸² Chandrasekaran et al⁸³ proposed a simpler modification of the previous technique. The anterior third of the GMax and posterior third of the TFL were transferred in a flap to the greater trochanter to manage irreparable abductor tears with excessive fatty degeneration in three patients. Postoperatively, two patients had no Trendelenburg gait, and all patients were relieved from pain.

The authors' preference is the Geneva technique. This is a more straightforward modification of the aforementioned GMax transfer techniques. A triangular flap including the anterior third of the GMax is sharply divided anteriorly from fascia lata and posteriorly in line with GMax fibres. The length of the flap is 12 to 15 cm, extending roughly to the middle of the GMax. The proximal part of the VL is incised off the vastus lateralis ridge and mobilized for 2–4 cm. The footprint of GMax re-insertion on the lateral side of the greater trochanter is prepared with a round burr to reveal cancellous bone, facilitating healing. Three 2.6-mm bio-composite corkscrew suture anchors, double-loaded with a row of high-strength sutures, are inserted at the anterior and posterior margins of the footprint to transfer and tighten the GMax flap. Alternatively, six 1.8-mm diameter drill holes are made at the margins of the footprint and large non-absorbable sutures passed through holes and the GMax flap is transferred onto the greater trochanter. Piecrust incisions can be performed to the flap to obtain proper tension. Finally, the upper part of the VL is sutured over the distal end of the GMax with absorbable sutures forming a united flap. Partial weight-bearing and no active abduction is allowed for the first eight postoperative weeks.

Reconstruction with VL flap

Use of a VL flap is another salvage technique to manage non-reparable chronic end-stage abductor tears.^{84,85} The entire VL is mobilized proximally to distally taking care not to injure the neurovascular pedicle of muscle.⁸⁶ The plane between the VL and vastus intermedius must be dissected carefully, preserving the nerve supply of the vastus

intermedius. Once the VL insertion into quadriceps tendon is divided, the VL is mobilized, and the neurovascular pedicle is left within the surrounding fatty tissue. The VL is then sutured proximally to the remaining abductors and with transosseous sutures to the proximal femur with the leg abducted.⁸⁴ Abductor splint and partial weight-bearing are necessary for six postoperative weeks, and abductor exercises are then allowed.

In the largest series using this technique, 11 patients with abductor insufficiency were treated with VL advancement, demonstrating a moderate improvement of functional scores, pain and strength at two-year follow-up.⁸⁴ There was a failure in one patient. Loss of quadriceps strength was a common adverse outcome.⁸⁴ Advantages of this method include the partial restriction of hip flexion, separate neurovascular pedicle, and VL activation in the same part of the gait cycle as hip abductors. The main drawbacks are the complexity of the procedure, decreased quadriceps muscle strength and potential neurovascular damage.^{84,85} Grob et al demonstrated in cadavers that the proximal VL transfer is limited to 13 mm due to overstretching of the neurovascular bundle beyond this.⁸⁵ Betz et al reported fair to functional outcomes in nine patients with a mean follow-up of 33 months. Sixty-nine per cent had reduced pain medication and the use of walking aids. However, the functional results were modest, and the loss of quadriceps strength was reported.⁸⁷

Considerable progress has been made concerning the study of anatomy, epidemiology, clinical presentation and imaging modalities of gluteal tendon lesions; however, further advancement is needed in treatment protocols. The advantages of corticosteroid injections over other conservative treatment, the effectiveness of regenerative treatments such as PRP and the superiority of open vs. endoscopic repair needs further in-depth investigation. The limited current evidence is mainly attributed to the absence of high-level comparative studies and limited studies directly comparing treatment modalities. Table 1 demonstrates current understanding.

Conclusions

Abductor tendon lesions are the most common cause of lateral thigh pain. A high degree of clinical suspicion is demanded for middle-aged or older women with lateral thigh pain. A thorough clinical examination should be performed to exclude lumbar spine, hip, fascia lata or prosthetic joint pathology. MRI is the gold-standard investigation to evaluate lesions and the extent of fatty infiltration of the abductor muscles. The treatment of abductor tendinopathy is mainly conservative, including non-steroidal anti-inflammatory medication, activity

Table 1. Summary of what we already know or not concerning anatomy, epidemiology, aetiopathogenesis, clinical presentation, imaging and treatment of gluteal tendon lesions

Diagnostic tests, modalities, treatments	We know	We don't know	Refs
Cause of lateral thigh pain	x		1–3
How often bursitis is the cause of lateral thigh pain	x		3,9–11
Different facets for insertion of gluteal tendons on the greater trochanter	x		8
The exact aetiopathogenesis of gluteal tendon pathology		x	11,12,14–22
Relation of gluteal tendon pathology with age and sex	x		4,12–13
Clinical presentation and diagnostic tests for gluteal tendinopathy	x		5,20,23–30
The gold-standard examination of gluteal muscles and tendon anatomy	x		4,31–33
Relation of the extent of gluteal muscle fatty infiltration and prediction on repair outcomes	x		34–36
The best treatment modality for gluteal tendinosis		x	42–55
The superiority of cortisone vs. conservative treatment for lateral thigh pain	x		43
The superiority of fluoro-guided vs. blind cortisone injection for lateral thigh pain	x		46
The exact mechanism of action of cortisone on lateral thigh pain		x	1,47,48
Indications of surgical treatment of gluteal tendon tears	x		57–71,76–87
Prerequisites for an efficient tendon suturing	x		34
The superiority of anchors vs. transosseous sutures for gluteal tendon suturing		x	57–64
The superiority of single vs. double-row repair for gluteal tendon suturing		x	72
The superiority of open vs. endoscopic methods for gluteal tendon suturing		x	74,75
The superiority of different surgical techniques over the other concerning direct suturing, augmentation or reconstruction of gluteal tendon tears		x	57–71,76–87

modification, local corticosteroid injections, plasma-rich protein, physical and radial shockwave therapy. However, the limited available high-quality studies and limited evidence of treatment comparisons for tendinosis, partial and complete ruptures mean the best management remains inconclusive. Full gluteal tendon ruptures and partial tears that are non-responsive to conservative treatment may be surgically treated. Chronicity of the lesion, the neurologic integrity and extent of fatty infiltration of gluteal muscles determines the type of surgical treatment. Direct tendon suturing is indicated for recent tendon tears with neurologic integrity and limited gluteal muscle fatty infiltration. Chronic irreparable tears without abductor muscle atrophy and limited fatty infiltration can be augmented with grafts. Salvage reconstruction techniques with muscle transfers are needed for the management of chronic end-stage abductor tears with significant tendon insufficiency or gluteal atrophy.

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