JB&JS
ESSENTIAL SURGICAL TECHNIQUES

SUBSPECIALTY PROCEDURES

Open Hip Abductor Tendon Repair into a Bone Trough

Improved Outcomes for Hip Abductor Tendon Avulsion

Stephen J. Incavo, MD, Katharine D. Harper, MD

Published outcomes of this procedure can be found at: *Orthop Muscul Syst*. 2014;3(3): 170.

Investigation performed at Houston Methodist Orthopedics & Sports Medicine, Houston Methodist Hospital, Houston, Texas

Abstract

Background: Hip abductor tendon tears are a well-recognized entity that results in progressive lateral hip pain, weakness, and limping. These can occur in patients with native hips or in patients following total hip arthroplasty. However, treatment of these 2 distinct groups does not differ. We describe a new repair technique utilizing a longitudinal bone trough in the greater trochanter. We compare our results (focusing on gluteus medius tendon avulsions) and traditional repair with suture anchors or transosseous bone tunnels. Additionally, we propose a classification system that attempts to describe the different types of tears to guide treatment, as the current classification system is not helpful in defining pathology or guiding treatment. Our proposed classification will help to better describe tear types anatomically and thereby guide appropriate surgical interventions based on these types.

Description: Abductor tears were classified, according to our system, as Type I when there was no gluteus medius avulsion from bone (with subtype A indicating a partial tear of the gluteus minimus or gluteus medius; B, a complete tear of the gluteus minimus; and C, a longitudinal tear of the gluteus medius) or Type II when there was a gluteus medius avulsion (with subtype A indicating an avulsion of $<$50% of the insertion into the greater trochanter, and B, an avulsion of $\geq$50% of the insertion). Repair into a bone trough involves (1) freeing up and mobilizing the tendon from overlying fascia, (2) placing 2 evenly spaced Krackow stitches in the tendon, (3) creating a bone trough using a burr in the midline of the greater trochanter, (4) creating bone tunnels out the lateral wall of the trough to pass sutures, and (5) passing sutures through the bone tunnels to allow inset of the tendon into the trough, and later tying the sutures over the lateral osseous bridge.

Disclosure: The authors indicated that no external funding was received for any aspect of this work. On the **Disclosure of Potential Conflicts of Interest** forms, *which are provided with the online version of the article*, one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (http://links.lww.com/JBJSEST/A289).

Alternatives: Alternative treatment options include nonoperative and operative management. Nonoperative treatment choices include physical therapy, nonsteroidal anti-inflammatory drugs, and activity modification with assistive walking devices. Surgical alternatives include endoscopic or open direct soft-tissue repair, suture anchor repair, bone tunnel repair, graft jacket reconstruction, or gluteus maximus muscle transfer.

Rationale: Because of discouraging outcomes experienced by us and others, a new technique (a greater trochanter longitudinal bone trough) was developed to improve surgical results. This technique, utilizing an abductor tendon repair into a bone trough, improved our surgical outcomes for abductor tendon avulsions. We found that outcomes after surgical treatment of abductor tendon tears without avulsion are superior to those after repairs of abductor tendon avulsions, which is an important distinction compared with previous literature on abductor tendon repairs.

Introductory Statement

We describe a repair technique utilizing a longitudinal bone trough in the greater trochanter, which allows for reconstitution of the abductor tendon and improved outcomes compared with the traditional repair with suture anchors or transosseous bone tunnels.

Indications & Contraindications

Indications

- Absolute indications
  - Magnetic resonance imaging (MRI) evidence of gluteus medius and/or complete abductor complex avulsion
- Relative indications
  - Pain and disability for >6 months despite conservative therapy (including nonsteroidal anti-inflammatory drugs [NSAIDs] and physical therapy)
  - MRI evidence of gluteus medius or gluteus minimus tendinitis and/or a partial tear

- In an attempt to describe abductor tendon tear entities with more anatomic accuracy and to guide the appropriate surgical technique, we designed a new classification system (Table I):
  - Type I: No evidence of gluteus medius avulsion from the bone
    - A: Partial tear of the gluteus minimus or gluteus medius tendon
    - B: Complete tear of the gluteus minimus tendon
    - C: Longitudinal tear of the gluteus medius tendon
  - Type II: Evidence of gluteus medius avulsion
    - A: Avulsion of <50% of the insertion into the greater trochanter
    - B: Avulsion of ≥50% of the insertion into the greater trochanter
- We require at least 6 weeks of nonoperative therapy for patients with a Type-I tear.
- In our experience, patients with a Type-II tear demonstrate little benefit from physical therapy or guided home exercise.
  - While pain relief and gait improvement may be seen in these patients, long-term results may worsen as a result of chronic muscle atrophy and fatty infiltration, which can be seen on MRI scans.

Contraindications

- Relative
  - Nonambulatory patients
  - Poor surgical candidates

TABLE I Hip Abductor Muscle Tear Classification System

Abductor Tear Type	Description
Type I	No evidence of gluteus medius avulsion from the bone
A	Partial tear of the gluteus minimus or gluteus medius tendon
B	Complete tear of the gluteus minimus tendon
C	Longitudinal tear of the gluteus medius tendon
Type II	Evidence of gluteus medius avulsion from the bone
A	Avulsion of <50% of the greater trochanter insertion
B	Avulsion of ≥50% of the greater trochanter insertion

Step-by-Step Description of Procedure

Step 1: Positioning and Incision

After placing the patient in the lateral position, make an incision in line with the midline of the femur, dissect down to the iliotibial fascia, and incise the fascia in line with the center of the greater trochanter.

- Place the patient in the lateral position.
- Use a straight, or slightly curved, skin incision, in line with the midline of the femur, beginning approximately 2 cm proximal to the greater trochanter tip and extending 7 cm distally (Fig. 1).
  - The incision is similar to that used for a posterolateral approach to the hip.
- Dissect down to the iliotibial fascia, dissecting off a clean edge for closure at the end of the procedure (Fig. 2).
- Incise the fascia in line with the center of the greater trochanter, taking care to not damage the abductors as the incision is made through the gluteus maximus (Fig. 3).

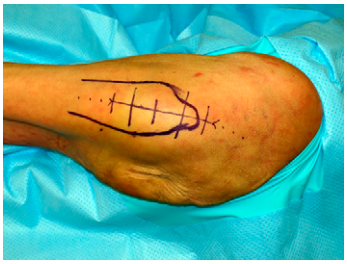


Fig. 1

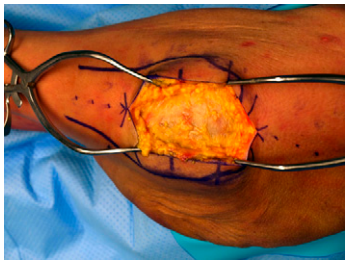


Fig. 2

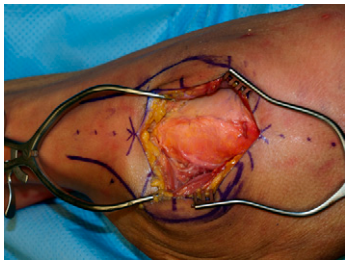


Fig. 3

Fig. 1 The lateral incision marked out on the thigh with the greater trochanter outlined for reference. This incision is easily extended posteriorly for a future or concomitant total hip arthroplasty.

Fig. 2 Dissection through the superficial tissue to expose the underlying iliotibial fascia.

Fig. 3 Retractors are placed after dissection through the iliotibial fascia and gluteus maximus muscle to expose the underlying hip abductor complex (gluteus medius and gluteus minimus tendons).

Step 2: Determine the Extent of the Tear

Carefully examine the gluteus medius insertion, use tenodesis of the gluteus medius to the gluteus minimus tendon for Type-IA or IB tears, and use repair into a bone trough for all avulsion tears of the gluteus medius (Type-IIA or IIB tears).

- Carefully examine the gluteus medius insertion.
  - Check to see if the patient may have a tear that has scarred into bursal tissue.
  - Resect bursal tissue to ensure adequate exposure of the tendon edge.
  - Determine if a Cobb elevator needs to be passed along the tendon edge to free up any scarring.
- Repair the gluteus medius to the gluteus minimus tendon when there are partial-thickness tears of the gluteus medius or minimus (Type IA) or complete tears of the gluteus minimus (Type IB).
- Use repair into a bone trough for all avulsion tears of the gluteus medius (Type IIA or B).

Step 3: Tenodesis Repair of Type-I Tears

Using 2 heavy sutures, perform tenodesis of the gluteus medius to the gluteus minimus with 2 running, looped sutures spanning the width of the gluteal tendons.

- Perform tenodesis of the gluteus medius to the gluteus minimus with 2 running, looped sutures spanning the width of the gluteal tendons (Fig. 4).
- Perform the tenodesis with 2 heavy sutures (e.g., number-5 nonabsorbable suture).
- Place the first suture approximately 1 cm medial to the gluteus medius insertion and pass it deep enough to capture both the gluteus medius and gluteus minimus tendons to pull them together (Fig. 5).
- Begin the stitch distally and advance it proximally, just proximal to the tip of the greater trochanter, in a locked, running fashion, and then return the stitch distally and tie it to itself (Fig. 6).
- Place the second suture approximately 2 cm medial to the first suture and run it in the same described fashion (Fig. 7).
- If the gluteus medius tear is longitudinal (Type IC) in nature, utilize a side-to-side suture to close the tear interval for the full length of the tear.

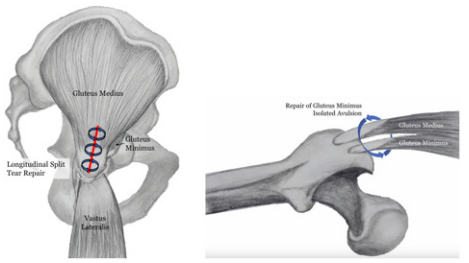


Fig. 4

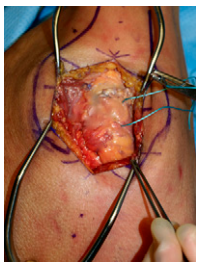
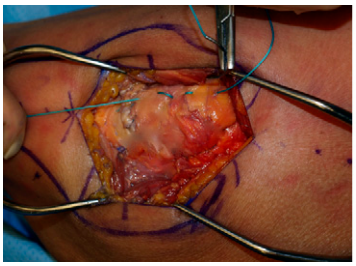


Fig. 5



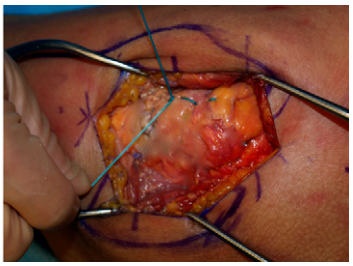


Fig. 6

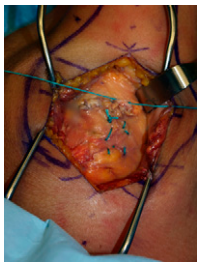


Fig. 7

Fig. 4 Anteroposterior and lateral view of a Type-IB tear repair with tenodesis of the gluteus medius to the gluteus minimus with a running, looped suture spanning the width of the gluteal tendons.
Fig. 5 Passing the first suture from distal to proximal for the full length of the longitudinal tear of the abductor tendon.
Fig. 6 The suture then returns distally once it reaches the most proximal extent of the tear and is tied to itself.
Fig. 7 This process is repeated a second time and again tied to itself for a complete repair of a longitudinal tear.

Step 4: Bone Trough Repair: Mobilizing the Tendon (Video 1)

To begin bone trough repair, mobilize the gluteus medius tendon by performing substantial soft-tissue dissection.

- Note that the avulsed tendon demonstrates exposed (bare) greater trochanter bone (Fig. 8).
- Place surgical clamps on the free edge of the tendon to aid in mobilizing the gluteus medius tendon and reestablishing the tissue planes (Fig. 9).
- To mobilize the tendon, perform substantial soft-tissue dissection, as the retracted abductor tendon will be scarred to overlying iliotibial fascia (Fig. 10).
- In chronic tears, after freeing all soft-tissue adhesions from the overlying fascia, it is occasionally necessary to perform additional dissection off the distal part of the ilium to obtain tendon reduction at the midpoint of the greater trochanter.

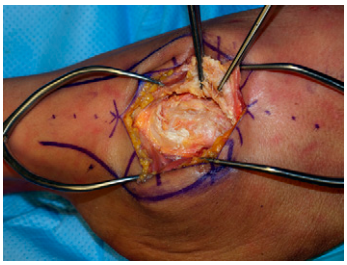


Fig. 8

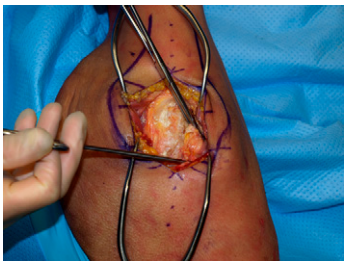


Fig. 9

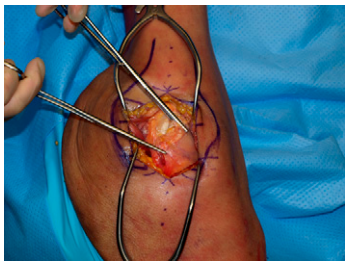


Fig. 10

Fig. 8 An avulsion tear of the hip abductor tendon demonstrates the underlying bare greater trochanter.

Fig. 9 Two Kocher clamps are placed onto the lateral edge of the tendon to allow for dissection above and below the tendon plane to improve tendon mobility.

Fig. 10 Once dissection is complete, lateral mobility of the tendon should allow for complete coverage of the greater trochanter as demonstrated here.

Video 1 A new repair technique utilizing a longitudinal bone trough in the greater trochanter to treat hip abductor tendon avulsion.

Step 5: Bone Trough Repair: Tendon Preparation

Continue bone trough repair by resecting any degenerative tissue and placing 2 Krackow stitches, running medially toward the musculotendinous junction of the gluteus medius, and then repeat with the second Krackow stitch, leaving 4 evenly spaced suture limbs.

- Resect any degenerative or frayed tendon edges to healthy tissue edges.
  - Keep resection to a minimum to ensure adequate tissue for repair.
- Place 2 Krackow stitches, running medially approximately 5 cm (or as medial as possible) toward the musculotendinous junction of the gluteus medius.
  - Place the first suture at the most distal portion of the tear (Fig. 11).
  - Run the suture proximally and return it to exit from the midportion of the tear (Fig. 12).
  - Remove the clamps and use the first 2 suture limbs for control of the tendon edge (Fig. 13).
  - Repeat with the second Krackow stitch such that there are 4 suture limbs evenly spaced, for transosseous fixation into the bone trough (Fig. 14).


Fig. 11


Fig. 12

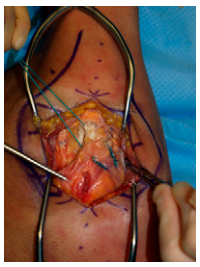


Fig. 13


Fig. 14

Fig. 11 Photograph demonstrating the starting point of the first Krackow stitch at the most distal aspect of the tendon tear.
Fig. 12 Image demonstrating the exit point of the first Krackow stitch at the middle third of the tendon tear.
Fig. 13 Once 2 suture limbs are created, these can be used for tension for the placement of future Krackow stitches.
Fig. 14 The second row of Krackow stitches has been completed with all 4 suture limbs exiting out the lateral edge of the torn tendon.

Step 6: Bone Trough Repair: Formation of the Trough

Using an osteotome or a burr, create the bone trough, which is placed along the longitudinal center of the greater trochanter; then make 3 drill holes, pass the suture limbs through the holes and tie the limbs over the outer cortex of the posterolateral aspect of the trochanter, pulling the tendon edge into the trough.

- Use an osteotome, or preferably a burr (Fig. 15), to create the bone trough, which is approximately 5 to 8 mm deep to expose cancellous bone and is placed along the longitudinal center of the greater trochanter (Fig. 16).
- Make 3 drill holes in the posterior cortex of the greater trochanter, aimed toward the posterior cancellous bone trough (Fig. 17).
- Make an intraosseous tract from the trough to the posterior drill hole with a penetrating towel clamp (Fig. 18).


Fig. 15


Fig. 16

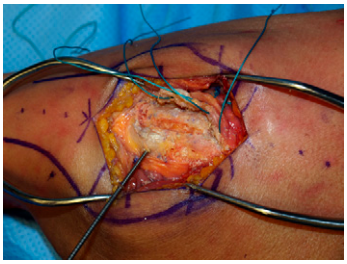


Fig. 17

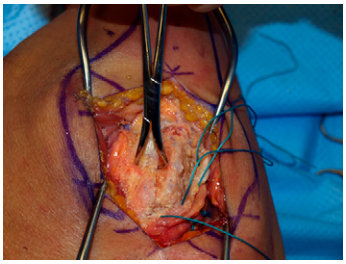


Fig. 18

Fig. 15 Demonstration of the burr technique used to create the bone trough longitudinally within the greater trochanter. This trough is placed within the central portion of the greater trochanter.
Fig. 16 The completed bone trough with a depth of approximately 5 to 8 mm to allow for seating of the lateral edge of the abductor tendon.
Fig. 17 The drill bit is directed from the posterior cortex of the greater trochanter toward the created bone trough.
Fig. 18 A small towel clamp is carefully placed within each tunnel to expand it and allow for ease of suture passing.

- Pass the suture limbs with 2 sutures through the middle drill hole and 1 suture through each outer drill hole (Fig. 19).
- Tie these respective limbs over the outer cortex of the posterolateral aspect of the trochanter, pulling the tendon edge evenly down into the trough (Figs. 20 and 21).
- Ensure that the leg remains in neutral abduction and rotation when the tendon attachment is secured.
- Then place a running suture along the tendon edge, pulling it down to remaining periosteum and muscle fascia to reinforce the repair and remove any rough tendon edges (Fig. 22).
- Perform gentle internal and external rotation of the hip in neutral abduction to confirm that the tendon has been adequately mobilized and repaired (Fig. 23).

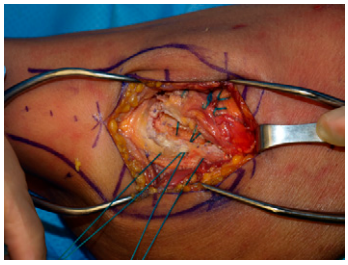


Fig. 19

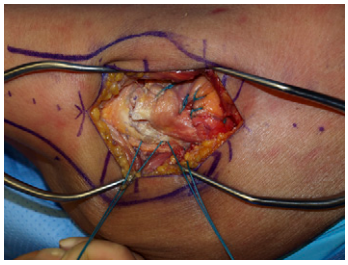


Fig. 20

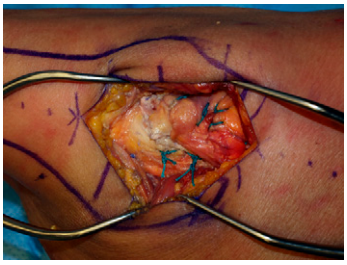


Fig. 21

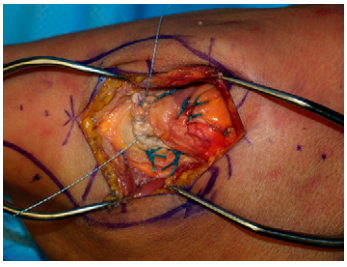


Fig. 22

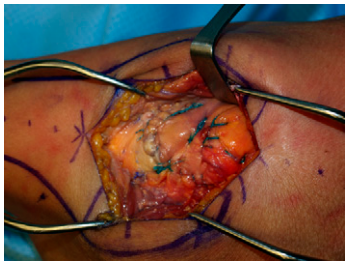


Fig. 23

Fig. 19 Image depicting the 4 suture limbs now passed through the laterally based bone tunnels to prepare for seating of the lateral edge of the tendon into the trough.
Fig. 20 Pulling with equal tension across all suture limbs, it is possible to see the tendon edge seated in the bone trough.
Fig. 21 Suture limbs are tied over bone bridges from lateral bone tunnels by hand and then cut to the appropriate length.
Fig. 22 A running suture is started at the distalmost aspect of the tear and is run over the top of the existing repair for reinforcement.
Fig. 23 The suture is run the full length of the tear, at which point it returns distally and is tied to itself.

Step 7: Postoperative Care

Instruct patients with a Type-I or Type-II tear to bear full weight with use of a walker for 2 or 6 weeks, respectively, and then transition to a cane; to avoid all hip abduction and adduction for 6 or 12 weeks; and to begin exercises to strengthen the hip abductor complex at 12 or 16 weeks.

- Type-I tears (tenodesis)
  - Instruct the patient to bear full weight with the use of a walker at all times.
  - At 2 weeks postoperatively, discontinue the use of the walker and have the patient transition to the use of a cane.
  - Advise the patient that it is important to avoid all hip abduction or adduction for 6 weeks.
  - Allow gentle, patient-directed hip abduction and adduction at 6 weeks postoperatively.
  - Advise the patient to begin exercises to strengthen the hip abductor complex at 12 weeks postoperatively.
- Type-II tears (bone trough repair)
  - Instruct the patient to bear full weight with the use of a walker for 6 weeks.
  - At 6 weeks postoperatively, advise the patient to discontinue the walker as tolerated and transition to the use of a cane for an additional 6 weeks.
  - Instruct the patient that it is mandatory to avoid all hip abduction or adduction for 12 weeks.
  - Allow gentle, patient-directed hip abduction and adduction at 12 weeks postoperatively.
  - Advise the patient to begin exercises to strengthen the hip abductor complex at 16 weeks postoperatively.

Results

This article is based on the surgical repair first described, to our knowledge, by Smith et al., who demonstrated superior outcomes using a bone trough in the setting of abductor tear repair at the time of total hip arthroplasty[1]. Because of discouraging results experienced by us and others[2-4], a new technique (the greater trochanter longitudinal bone trough) was developed in an effort to improve surgical results. Published outcomes for open abductor tendon repair have been limited to small case series[5]. Although this procedure has consistently been reported to provide significant improvement with respect to pain and functional capacity, high rates of retear (6% to 50%) with traditional repair, consisting of decortication and suture fixation, have been reported[2,6,7]. For our technique, we defined failure as no improvement with respect to pain or gait, or the need for repeat surgery, and we found a similar failure rate (40%; 6 of 15 patients) when repairs utilized the traditional decortication and suture fixation techniques. Our experience with the bone trough technique was similar to the outcomes in the original study that described a more transverse bone trough, in which 79% (15) of 19 patients had complete resolution of pain, symptoms, and gait abnormalities[1].

There are many variables that affect the outcomes of abductor tendon repair, including tear size, chronicity, scarring and/or retraction, degenerative muscle fatty infiltration, and the repair technique. The only modifiable factors in these variables would be to diagnose abductor tears earlier in the pathogenesis, avoiding irreversible degeneration prior to repair, and to modify the technique utilized to repair the tendon tear. In evaluating the literature on endoscopic abductor repairs, we found that the majority of outcomes were based on small case series that included a substantial number of small and partial-thickness tears of the gluteus medius or minimus (presumably our Type-I tears)[8-12]. Therefore, when comparing the results of our Type-I tear repairs with those of endoscopic small tear repairs, the reported outcomes mirror our findings in this case series. It should be noted that endoscopic evaluation and repair could address tearing on the undersurface of the tendon insertions[10], in contrast to open repair, which evaluates the lateral surface of the tendon insertion footprint. Therefore, the location of the tear and surgeon preference should be considered when deciding which approach to use. To address avulsion of the gluteus medius and abductor tendon complex, complex salvage operations have been proposed, including the use of mesh, the Ligament Augment and Reconstruction System (LARS; Corin Group), biologic patch augmentation, Achilles allograft reconstruction, gluteus maximus and tensor fascia lata tendon transfers, vastus lateralis transfer, and other variants of these techniques[13-18]. Our experience has included complete or nearly complete avulsions (n = 6) of the abductor tendon insertion (Type IIB), which were repaired into a bone trough. While these patients had some residual lurch following repair, there was a noticeable improvement in the lurch for each of these patients. We believe that repair into a bone trough is an alternative to these large salvage procedures, provided that the tendon can be mobilized and reduced to the bone.

While others have described the utility of MRI scans to define the type and extent of the tear[19,20], terms like "partial tear" can be imprecise. In Figure 24, a preoperative MRI scan, which was reported as a "partial tear of the gluteus minimus insertion," had evidence of intratendinous edema and disruption of tendon fibers. On intraoperative assessment, however, it was found to be an 80% avulsion of the insertion of both the gluteus medius and gluteus minimus tendons, and the patient underwent a bone trough repair. A postoperative MRI scan, acquired 6 months postoperatively, showed complete healing with a small amount of residual trochanteric bursitis (Fig. 25). This is just 1 example of the difficulties with MRI interpretation and the need to heavily weigh clinical correlation with MRI findings.

We believe that gluteus medius avulsions and postoperative tears require open, rather than arthroscopic, treatment. It is our opinion that the best surgical treatment for nonavulsed gluteus medius tears has not been determined. Therefore, we treat both the described Type-I and Type-II tears with open surgical repair. This allows the appropriate treatment to be applied after intraoperative assessment of the tear without a large deviance in surgical plan. A preoperative MRI scan (Fig. 26) and video (Video 2) of an operatively treated patient show a common preoperative dysfunction. A postoperative MRI scan (Fig. 27) and postoperative video (Video 3) show that even with a partial retear of the repair, clinical improvement in function and pain can still be achieved.

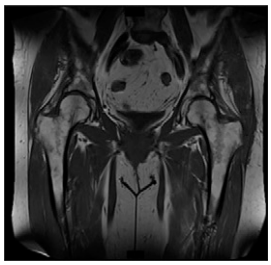


Fig. 24

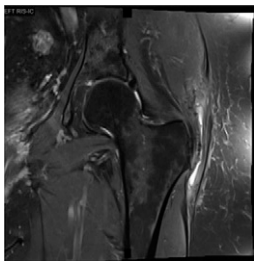


Fig. 25

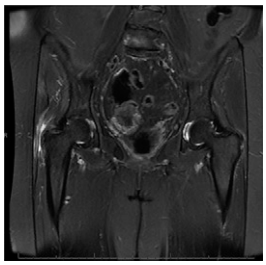


Fig. 26

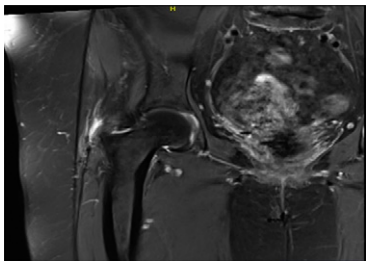


Fig. 27

Fig. 24 A coronal cut, T2-weighted MRI scan showing what is believed to be a partial tear of the gluteus minimus insertion of the left hip with mild edema and irregularities in the tendon fibers.

Fig. 25 A coronal cut, T2-weighted MRI scan showing a bone trough tendon repair 6 months postoperatively with what appears to be complete healing of the tendon into bone, without residual bone edema. Mild trochanteric bursitis persists.

Fig. 26 Preoperative MRI scan showing a chronic high-grade tearing of the gluteus medius and minimus tendons near the greater trochanter with adjacent greater trochanteric bursitis.

Fig. 27 MRI scan made 6 months postoperatively showing a recurrent gluteus medius insertional tear and partial tearing at the myotendinous junction with a partial tear of the posterior margin of the gluteus minimus insertion.

Video 2 Preoperative gait assessment of a patient with a high-grade abductor tendon tear. On evaluation in the operating room, the patient was found to have a complete Type-II avulsion tear.

Video 3 Postoperative gait assessment, performed 6 months after bone trough abductor tendon repair, in the same patient as in Video 2.

Pitfalls & Challenges

- When determining which repair treatment to use, it is important to carefully examine the gluteus medius insertion to eliminate confusion between Type-I tears and Type-II tears, which are more serious.
- The gluteus minimus is not generally visualized with the tenodesis technique, as it is deep to the gluteus medius.
  - The surgeon must ensure that sutures are passed trans-tendinously through the gluteus medius and gluteus minimus with each pass.
- Mobilization of the scarred abductor tendon is a critical portion of Type-II repairs, and therefore care should be taken at this step to ensure adequate mobilization while minimizing damage to the overlying fascial layer.
  - Tendon mobilization is important because our bone trough technique requires some lateral advancement of the tendon into the trough.
  - A substantial portion of the length of the procedure should be dedicated to this step, as adequate mobilization will allow for easy completion of the following steps.
- Ensure that the bone trough is centralized in the greater trochanter and is longitudinal to avoid greater trochanter fracture.
  - Although this placement does not mimic the natural anatomic footprint, we think that this is necessary to avoid weakening the trochanteric bone.
- Patients with a Type-I tear often have rapid, complete pain resolution by 2 weeks.
  - Despite this result, we recommend adherence to the postoperative protocol to ensure complete healing of the repair.

Stephen J. Incavo, MD[1]
Katharine D. Harper, MD[1]
[1]Houston Methodist Orthopedics & Sports Medicine, Houston Methodist Hospital, Houston, Texas

Email address for S.J. Incavo: sjincavo@houstonmethodist.org

ORCID iD for S.J. Incavo: 0000-0002-3435-1891
ORCID iD for K.D. Harper: 0000-0003-2130-2414

References

1. Smith EL, Mattingly D, Chang G, Henry M, Kandil AO. Concomitant repair of idiopathic abductor tears during primary total hip arthroplasty: technique, review and outcomes. Orthop Muscul Syst. 2014;3(3):170.

2. Davies H, Zhaeentan S, Tavakkolizadeh A, Janes G. Surgical repair of chronic tears of the hip abductor mechanism. Hip Int. 2009 Oct-Dec;19(4):372-6.

3. Stähelin T. [Abductor repair failure and nerve damage during hip replacement via the transgluteal approach. Why less invasive methods of joint replacement are needed, and some approaches to solving the problems]. Orthopade. 2006 Dec;35(12):1215-24. German.

4. Odak S, Ivory J. Management of abductor mechanism deficiency following total hip replacement. Bone Joint J. 2013 Mar;95-B(3):343-7.

5. Howell GE, Biggs RE, Bourne RB. Prevalence of abductor mechanism tears of the hips in patients with osteoarthritis. J Arthroplasty. 2001 Jan;16(1):121-3.

6. Bogunovic L, Lee SX, Haro MS, Frank JM, Mather RC 3rd, Bush-Joseph CA, Nho SJ. Application of the Goutallier/Fuchs rotator cuff classification to the evaluation of hip abductor tendon tears and the clinical correlation with outcome after repair. Arthroscopy. 2015 Nov;31(11):2145-51. Epub 2015 Jul 15.

7. Weber M, Berry DJ. Abductor avulsion after primary total hip arthroplasty. Results of repair. J Arthroplasty. 1997 Feb;12(2):202-6.

8. Miozzari HH, Dora C, Clark JM, Nötzli HP. Late repair of abductor avulsion after the transgluteal approach for hip arthroplasty. J Arthroplasty. 2010 Apr; 25(3):450-457.e1. Epub 2009 Mar 17.

9. Chandrasekaran S, Lodhia P, Gui C, Vemula SP, Martin TJ, Domb BG. Outcomes of open versus endoscopic repair of abductor muscle tears of the hip: a systematic review. Arthroscopy. 2015 Oct;31(10):2057-67.e2. Epub 2015 May 29.

10. Domb BG, Nasser RM, Botser IB. Partial-thickness tears of the gluteus medius: rationale and technique for trans-tendinous endoscopic repair. Arthroscopy. 2010 Dec;26(12):1697-705. Epub 2010 Oct 15.

11. Voos JE, Shindle MK, Pruett A, Asnis PD, Kelly BT. Endoscopic repair of gluteus medius tendon tears of the hip. Am J Sports Med. 2009 Apr;37(4):743-7. Epub 2009 Feb 9.

12. McCormick F, Alpaugh K, Nwachukwu BU, Yanke AB, Martin SD. Endoscopic repair of full-thickness abductor tendon tears: surgical technique and outcome at minimum of 1-year follow-up. Arthroscopy. 2013 Dec;29(12):1941-7. Epub 2013 Oct 17.

13. Bajwa AS, Campbell DG, Comely AS, Lewis PL. Gluteal tendon reconstruction in association with hip arthroplasty. Hip Int. 2011 May-Jun;21(3):288-92. Epub 2011 Jun 13.

14. Bucher TA, Darcy P, Ebert JR, Smith A, Janes G. Gluteal tendon repair augmented with a synthetic ligament: surgical technique and a case series. Hip Int. 2014 Mar-Apr;24(2):187-93. Epub 2013 Oct 22.

15. Fink B. [Repair of chronic ruptures of the gluteus medius muscle using a nonresorbable patch]. Oper Orthop Traumatol. 2012 Feb;24(1):23-9. German.

16. Fisher DA, Almand JD, Watts MR. Operative repair of bilateral spontaneous gluteus medius and minimus tendon ruptures. A case report. J Bone Joint Surg Am. 2007 May;89(5):1103-7.

17. Rao BM, Kamal TT, Vafaye J, Taylor L. Surgical repair of hip abductors. A new technique using Graft Jacket allograft acellular human dermal matrix. Int Orthop. 2012 Oct;36(10):2049-53. Epub 2012 Aug 8.

18. Wang K, Cole S, White DC, Armstrong MS. Vastus lateralis transfer for severe hip abductor deficiency: a salvage procedure. Hip Int. 2014 Mar-Apr;24(2): 180-6. Epub 2013 Oct 10.

19. Cvitanic O, Henzie G, Skezas N, Lyons J, Minter J. MRI diagnosis of tears of the hip abductor tendons (gluteus medius and gluteus minimus). AJR Am J Roentgenol. 2004 Jan;182(1):137-43.

20. Hartigan DE, Perets I, Walsh JP, Domb BG. Imaging of abductor tears: stepwise technique for accurate diagnosis. Arthrosc Tech. 2017 Oct 12;6(5): e1523-e1527.