Technical Note

Endoscopic Proximal Hamstring Tendon Repair With Knotless Suture-Bridge Technique

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Abstract: Symptomatic proximal hamstring tendon tears are typically repaired surgically, with open incision and knot-tying technique. An endoscopic, knotless, suture-bridge repair technique is presented. Potential advantages include knotless simplicity, compression over a broad zone to improve tendon–bone healing, and decreased pain secondary to elimination of knots and the open incision and approach.

Proximal hamstring tendon injury can occur via acute, traumatic onset, leading to partial or complete tears with displacement. Alternatively, repetitive stress can result in tendinopathy and nondisplaced avulsions.

Conservative treatment, including activity modifications, physical therapy, and biologics-based treatments such as platelet-rich plasma injection, is recommended for partial tears with lower grade or displacement. Surgical treatment is considered for partial tears with greater severity and displacement, complete tears, and tears that have failed conservative treatment.[1,2]

Surgical repair is typically performed open, through a gluteal-crease or longitudinal incision, with anchors placed in the ischial tuberosity and suture knots tied over the tendon. Endoscopic repair is an emerging surgical option[2-5] and offers the benefits of minimally invasive treatment: decreased pain level and duration, and a smoother, faster recovery.

We report our endoscopic proximal hamstring tendon repair technique with a knotless, suture–bridge construct. We have applied this technique to treat tears ranging from chronic partial tears to complete and displaced ruptures.

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Surgical Technique (With Video Illustration)

Indications

Surgical proximal hamstring tendon repair is recommended for complete ruptures, high-grade partial tears of >2 cm displacement, and chronic tendinopathy/partial tears that remain symptomatic despite extensive conservative treatment.[5] In displaced tears, tendon mobilization to permit reduction to the ischial tuberosity is essential for success. Significant distal retraction, tear chronicity, and suspicion of sciatic nerve entrapment in scar tissue requiring extensive dissection are relative contraindications for endoscopic treatment.

Patient Evaluation and Imaging

Traumatic proximal hamstring tears typically occur with an acute eccentric–contracture mechanism. Common symptoms include feeling a pop, ischial tuberosity and proximal posterior thigh pain, and weakness of the hamstring complex. Examination typically reveals posterior thigh ecchymosis, pain, and weakness with resisted hip extension and knee flexion, ischial tuberosity tenderness, and in complete tears, distally displaced tendon mass during hamstring activation.[6]

With chronic tendinopathy and associated tears, there may be exacerbating events superimposed on progressive tenderness and pain that make daily activities and sports challenging, but the onset is typically not clear-cut. Radiographs are often normal, but may reveal bony avulsion from the ischial tuberosity. Magnetic resonance imaging of the hip and proximal thigh typically reveals the nature and displacement extent of the tear (Fig 1).

Patient Positioning and Initial Endoscopic Approach

After general anesthesia, position the patient prone, with prominent areas abundantly padded and protected. Position the hips with approximately 20° of flexion, and knees with 30° flexion, to expose the ischial tuberosity and relax the hamstring musculature.

Prep and drape an oval operative field, proximally just distal to the posterior superior iliac spine, distally to mid-posterior thigh, medially just lateral to the midline, and laterally low (anterior) on the hip and thigh. Although the foot is not prepped, it must be easily palpable under the drape, to not obscure lower-extremity muscle activation if endoscopic maneuvers, especially electrocautery, encroach upon the sciatic nerve. We have not found it necessary to prep out the entire lower extremity unless extensive distal dissection is anticipated for a highly displaced tear, in which case the operative plan is typically not endoscopic.

Palpate and mark out the ischial tuberosity. Direct a spinal needle straight down, onto the distal portion of the tuberosity. Once bone is encountered, serially redirect the spinal needle until the distal end point of the tuberosity is identified.

Make a small transverse portal incision in the gluteal crease (distal portal), in line with the ischial tuberosity and the superior entry spot of the spinal needle (Fig 2). Bluntly dissect with a straight hemostat toward the ischial tuberosity. Once the spinal needle and hemostat make contact in the vicinity of ischial tuberosity, switch out the hemostat with a Wissenger rod and replicate the contact with the spinal needle.

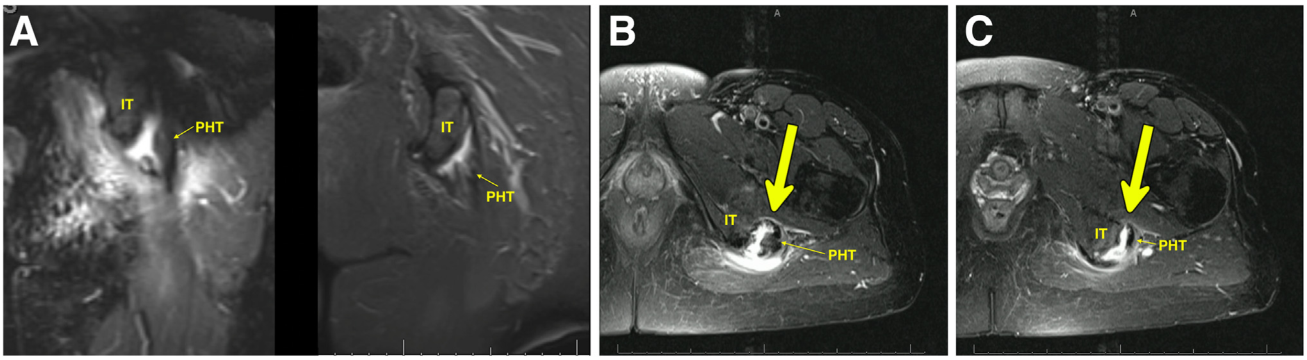

Fig 1. Magnetic resonance imaging (MRI) images of left hip. (A) Two coronal views and (B-C) two axial views showing the proximal hamstring tendon (PHT) is separated from ischial tuberosity (IT) (large yellow arrows), but with minimal displacement, consistent with chronic tendinopathy with partial avulsion.

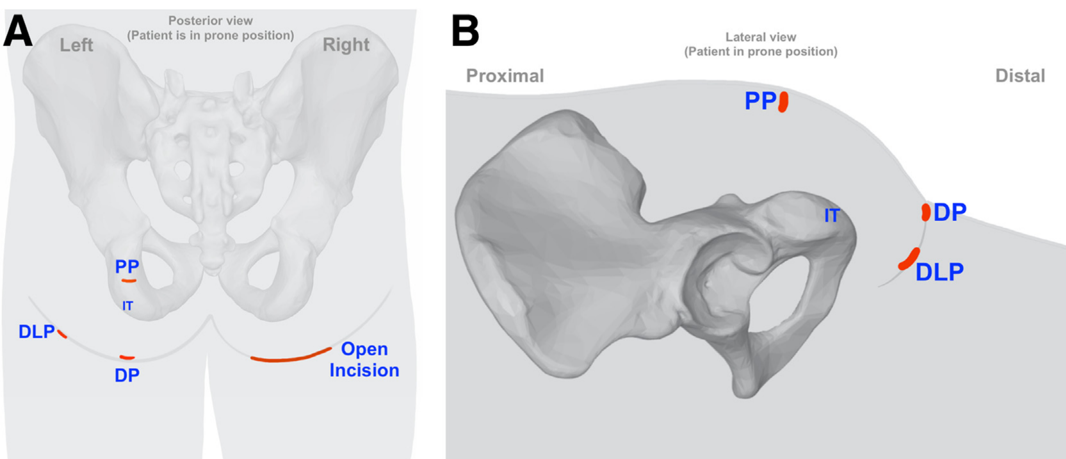

Fig 2. Hip/pelvis, diagrams to illustrate the portal/incision locations. (A) Posterior view. On the left side, the 3 endoscopic portals, in order of placement: distal portal (DP), proximal portal (PP), and distal-lateral portal (DLP). Note that PP, distal aspect of ischial tuberosity (IT), and DP are roughly in a straight line, to facilitate endoscopic orientation, especially helpful in the initial stage of the procedure. DP and DLP are both in the gluteal crease; thus, they can be incorporated into the distal incision if conversion to open repair is indicated. On the right, typical incision for open approach to the proximal hamstring footprint on the ischial tuberosity. (B) Pelvis, left lateral view. The 3 portals (PP, DP, and DLP) are illustrated.

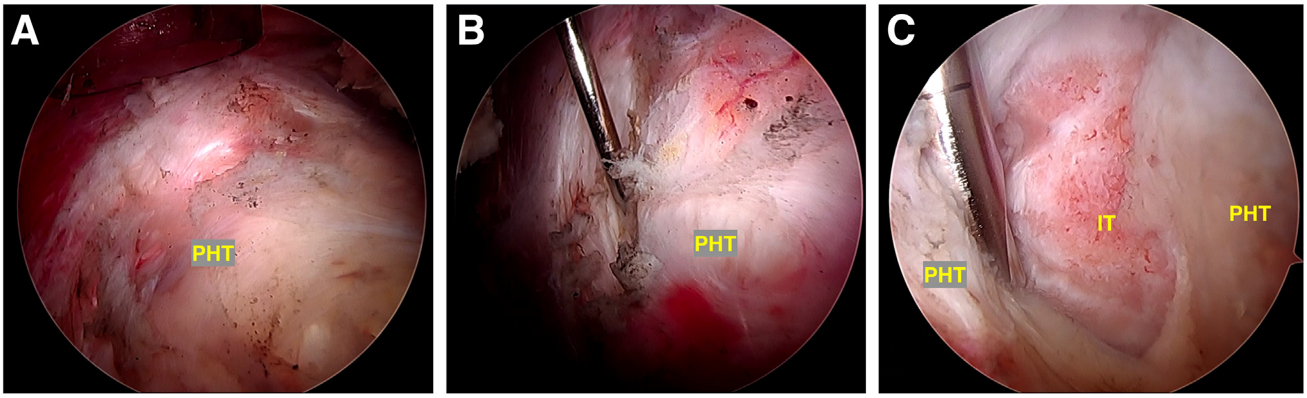

Fig 3. Left hip, prone position, endoscopic view from the distal portal. (A) The proximal hamstring tendon (PHT) at the ischial tuberosity footprint is superficially intact. (B) The weak spot in the proximal hamstring tendon is identified and is penetrated easily with a probe. (C) The weak spot is developed longitudinally, parallel to the tendon fibers, and the separation space between the PHT and the underlying ischial tuberosity (IT) is debrided, to clear off soft tissue and to determine the boundary of the tendon–bone separation zone.

Slide the cannula for the arthroscope over the Wissenger rod, then switch out the rod for the arthroscope. The spinal needle will be easily visualized as soon as the scope is placed.

Make a small transverse portal incision near the spinal needle insertion spot (proximal portal), and insert the Wissenger rod parallel to the spinal needle until the rod is visualized (Fig 2). Insert an arthroscopy cannula.

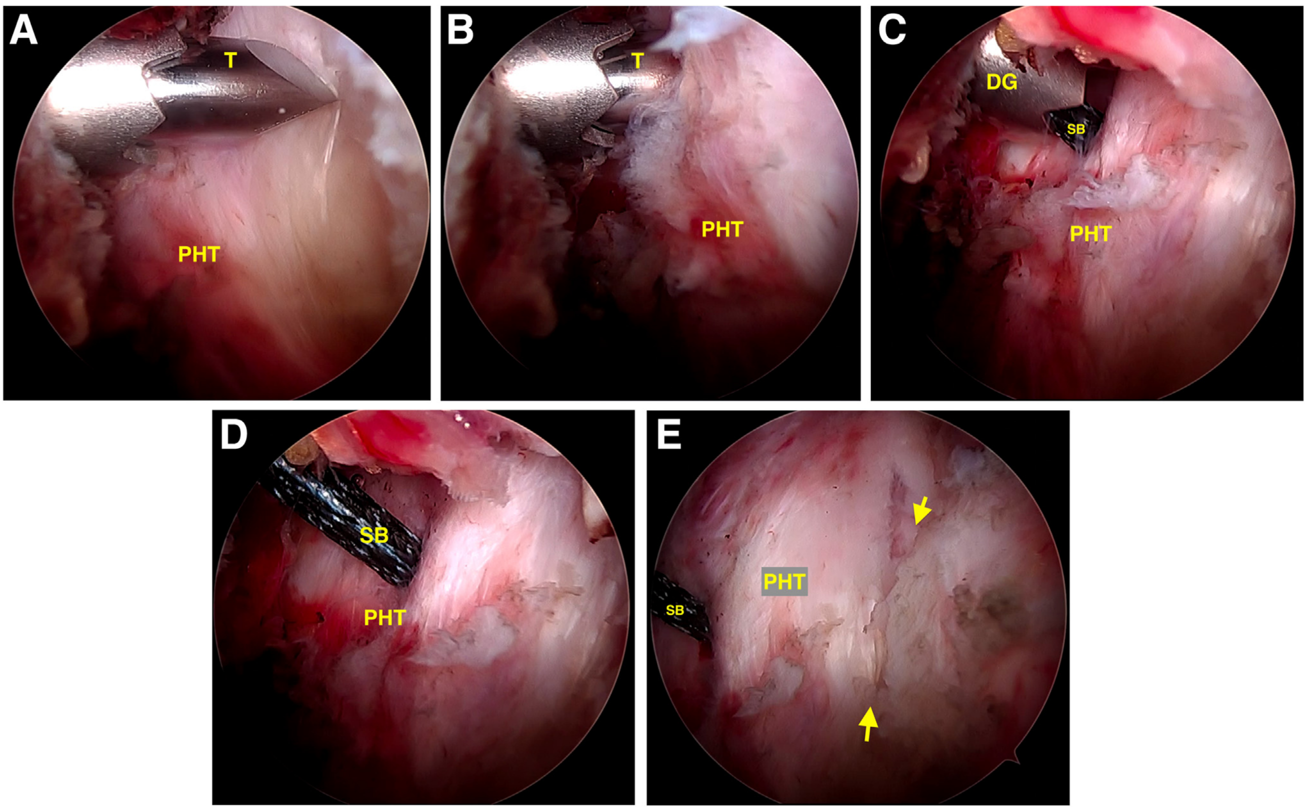

Fig 4. Left hip, prone position, endoscopic view from the distal portal. (A-B) The sharp trocar (T) of the 2.6 Knotless FiberTak RC (Arthrex) helps with placement of the trocar and drill guide through the proximal hamstring tendon (PHT), then directly into bone. (C-D) Once FiberTak is placed into bone and drill guide (DG) withdrawn, the suture bundle (SB) of the FiberTak is already passed through the PHT, saving a passing suture/retrieval/passage step. (E) Note the location of the suture bundle (SB), lateral relative to the tendon split (arrows). The next anchor will be medial to the split.

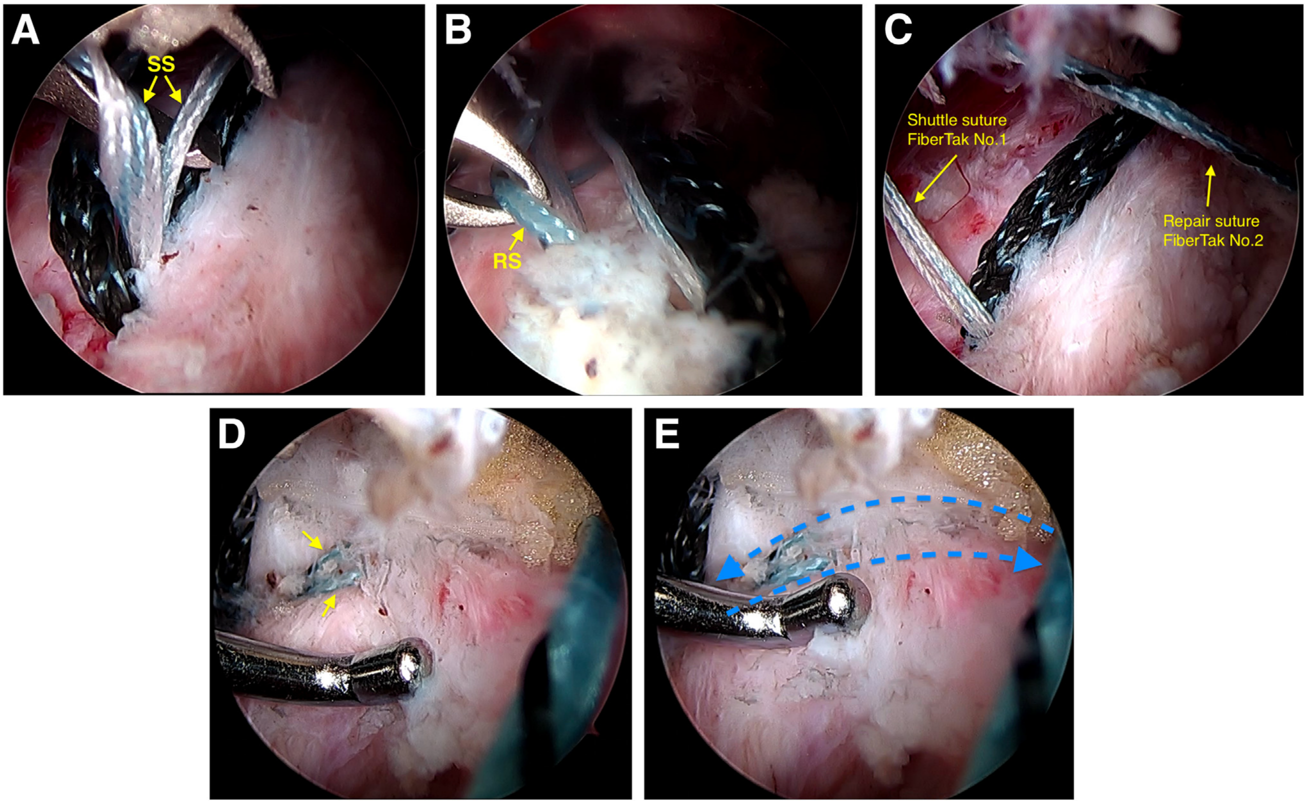

Fig 5. Left hip, prone position, endoscopic view from the distal portal. (A) The 2 limbs of the blue/white shuttle suture (SS) of the lateral FiberTak are retrieved. (B) The all-blue repair suture (RS) of the medial FiberTak is retrieved. (C) Another view of the shuttle suture and repair suture once both are retrieved (see labels in figure: "FiberTak No.1" refers to the more lateral anchor, and "FiberTak No.2" refers to the more medial anchor). (D) The medial repair suture is shuttled through the lateral FiberTak, and the process is repeated in reverse with the remaining repair suture of the lateral FiberTak and the shuttle suture of the medial FiberTak, completing the twin-suture interlink (arrowheads). (E) the courses of the 2 repair sutures, constituting the distal row, are illustrated (blue dashed arrows).

Use low-pressure, 25-30 mm Hg insufflation to minimize tissue swelling and maximize time window of adequate visualization. Evacuate the hematoma if an acute tear. Use blunt dissection, shaver, and bipolar electrocautery to debride the bursal tissue overlying the ischial tuberosity, being careful to maintain hemostasis. The tendon footprint will be seen along the posterolateral surface.

Sciatic Nerve Protection

The sciatic nerve is typically located anterolateral (deep in the operative field with the patient in prone position) to the proximal hamstring tendon footprint on the ischial tuberosity.[7,8] Its identification is important, especially in complete tear and subacute repair, since adhesions may encircle and tether the sciatic nerve, increasing the risk of sciatic nerve injury. An assistant's hand should be on the ipsilateral foot whenever the operative maneuvers are occurring lateral to the ischial tuberosity to detect foot movement.[9] Electrocautery dissection may be beneficial, as there will typically be an early warning of foot movement if the dissection nears the sciatic nerve. Sciatic neurolysis is performed if there are preoperative symptoms consistent with nerve tethering.[10]

Tendon Mobilization

For complete, displaced tears, after the ischial tuberosity is exposed, switch the arthroscope to the proximal portal to visualize the distally displaced tendon. Place a traction suture in the tendon and shuttle the suture out the proximal portal.

Place a distal lateral portal, also within the gluteal crease, using a spinal needle for outside-in localization. This will aid in anchor-placement access to the ischium and distal access for tendon mobilization (Fig 2).

The displaced tendon is usually tethered distally by a circumferential gutter-like layer of scar tissue at the distal extent of the initial traumatic hematoma/seroma space. With traction on the tendon, methodically release the scar tissue under tension with electrocautery and blunt dissection, starting on the safer posterior (superior) edge. Carefully monitor the ipsilateral foot

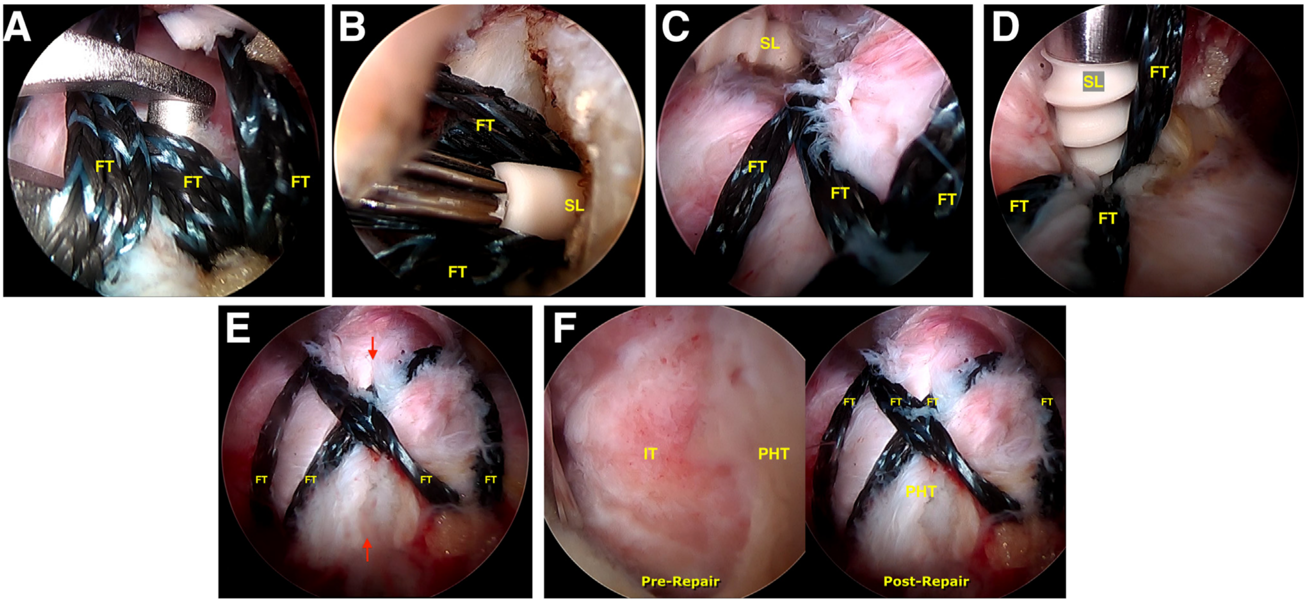

Fig 6. Left hip, prone position, endoscopic view from the distal portal. (A) The FiberTapes (FT) of the anchors are separated into 2 pairs, each pair with one tape from each anchor, and retrieved together. (B) The FT pair is threaded through the tip eyelet of a SwiveLock (SL) (Arthrex), then tensioned before inserting the tip into a pilot hole at a location that best spreads out the fixation construct over the tear zone. (C) Once the FTs are tensioned appropriately, the tip of the SL is fully impacted and the anchor twisted in, to lock in the fixation. (D) The FT tensioning and SL placement steps are repeated with the remaining FTs and another SL. (E) Final appearance of the knotless suture—bridge construct, with FT in crossing pattern and interlinked repair sutures for distal row, and the repair zone spreads well beyond the tendon split (arrows). (F) Side-by-side view of the tear before repair with ischial tuberosity (IT) exposed and proximal hamstring tendon (PHT) separated from bone, and after repair with PHT defect closed and compression applied by the FTs and the repair sutures distally (not shown) on the tendon—bone separation zone.

for twitches, especially when dissecting laterally and anteriorly near the sciatic nerve. Proximal mobilization is sufficient once the tendon can be restored to the level of its footprint without substantial traction force.

In chronic high-grade partial tears, the proximal hamstring tendon may appear normal (Fig 3A), but blunt palpation reveals tendon—bone separation, and a weak interval is usually identified posterolaterally (Fig 3B). Develop this interval longitudinally to access the ischium—tendon separation space. Debride the bony surface to enhance healing and fully identify the tendon—bone separation zone to help determine anchor placement locations (Fig 3C). This tendon—bone separation space is safer to debride within, as the sciatic nerve is outside it and protected by the tendon layer.

Knotless Suture Bridge Repair

Place the distal anchors first. We typically use the 2.6-mm Knotless FiberTak RC all-suture anchor (Arthrex, Naples, FL) since it has a small footprint permitting more anchors placement if needed, and contains both a #2 FiberWire knotless repair mechanism and two 1.7-mm FiberTape (Fig 4A-E). In addition, the all-suture anchor can be placed through the tendon and directly into bone, bypassing a separate suture bundle passage step. The SwiveLock (Arthrex) anchor with knotless repair mechanism can also work, if a FiberTape is threaded through the eyelet.

With displaced tears, apply proximal traction to reduce the tendon. Place 2 anchors, one anterior and one posterior, in the distal footprint, then pass their suture bundles separately through the tendon at locations affording satisfactory reduction without excess tension.

Retrieve the repair suture of one anchor, and the shuttle suture of the other anchor (Fig 5A-C). Shuttle the repair suture through the other anchor, for the first interlink. Retrieve the remaining repair suture and shuttle suture, then shuttle that repair suture through the opposing anchor. With pull on the traction suture to reduce the tendon, pull the interlinked repair sutures to secure the tendon to the ischial tuberosity, forming a knotless, interlinked distal row, analogous to the medial row in a knotless suture-bridge rotator cuff repair. Leave the excess repair sutures for now (Fig 5D-E).

Sort the FiberTape strands into 2 pairs, each pair with one tape from each anchor (Fig 6A). Punch/tap the ischium and secure the pairs of tapes under tension into bone proximally, with 2 SwiveLock anchors (Arthrex), in locations selected to best cover the tendon detachment zone (Fig 6B-F).

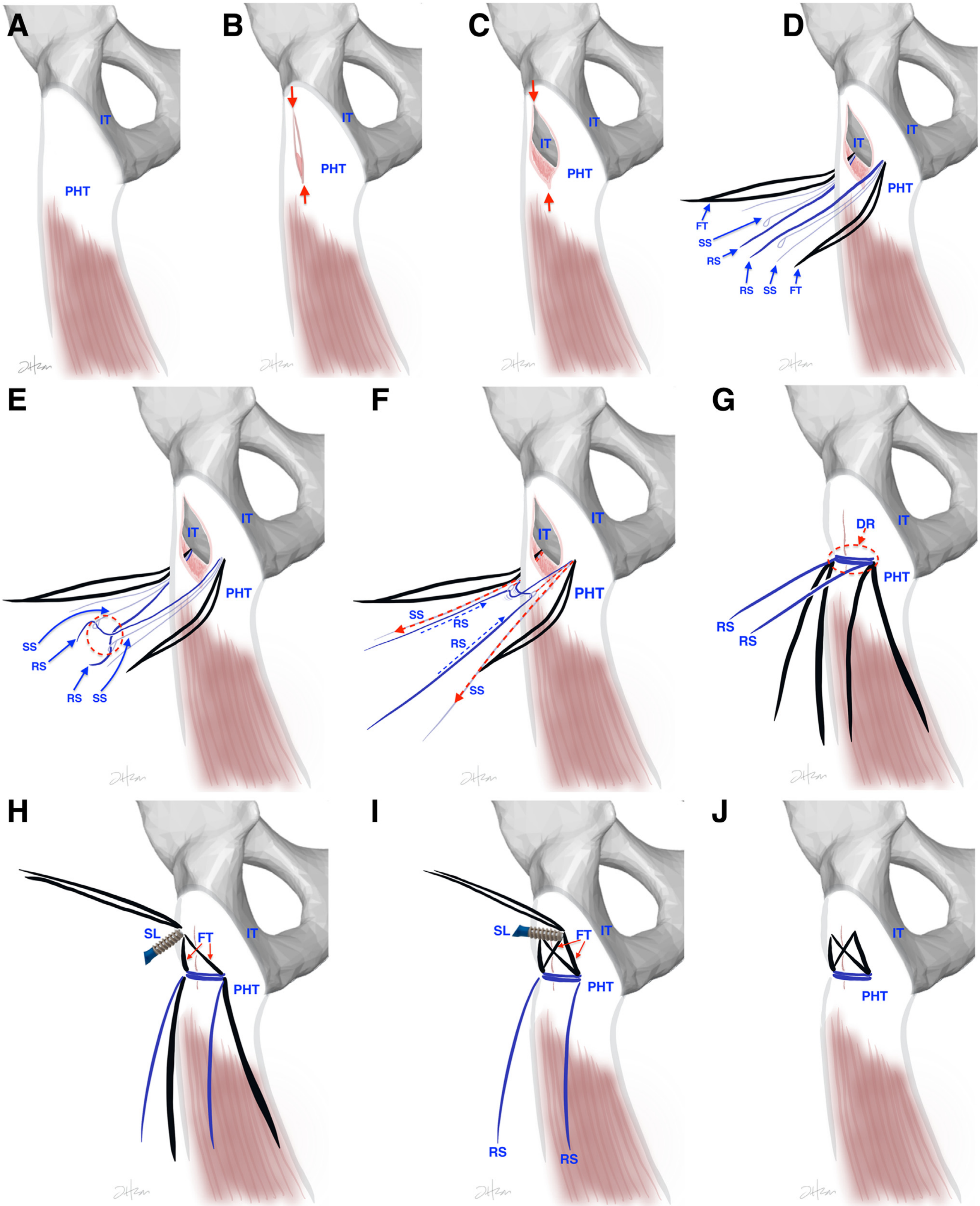

Fig 7. Left hip and pelvis, posterior view, step-wise illustrations to represent the procedure as performed in the video. (A) Initial inspection shows the proximal hamstring tendon (PHT) is intact superficially at its origin on the ischial tuberosity (IT). (B) With blunt probing, a weak spot in the tendon is identified and developed longitudinally (arrowheads). (C) The split (arrowheads) allows for inspection of the extent of proximal hamstring tendon (PHT) and bone separation, and debridement of the underlying IT bone surface. (D) Two knotless 2.6 FiberTak RC all-suture anchors (Arthrex) are placed at the distal aspect of the tear zone in

Table 1. Pitfalls and Pearls

- Pitfall: Time-dependent tissue swelling can make visualization and endoscopic suture and implant management challenging, limiting surgical time.
- Pearl: Limit inflow fluid pressure down to 25 to 30 mm Hg, and prioritize tuberosity exposure early in the procedure, so the anchors can be placed endoscopically if conversion to open repair is needed for the rest of the procedure.
- Pitfall: The proximal hamstring tendon is thicker than rotator cuff tendon; thus, the typical jaw-based suture passers for cuff repair may not be large enough in their jaw openings for a full-thickness bite.
- Pearls:
  - Consider using penetrating suture passers and retrievers (SutureLasso, Arthrex, for example) from the distal lateral portal, directed medially and proximally, away from the sciatic nerve, to place passing loop sutures.
  - Alternative one-step anchor placement and suture passage: with tension or counterpressure on the tendon, the sharp trocar and drill sleeve combination of the 2.6 FiberTak can be carefully advanced through the tendon with a twisting motion, and then placed on the desired spot on the ischial tuberosity for FiberTak placement. Once FiberTak is placed and its drill sleeve withdrawn, the suture bundle is already through the tendon.
- Pitfall: Prone positioning adds to the orientation challenges in this less frequently encountered endoscopic environment.
- Pearls:
  - In preoperative planning, rotate the axial-view MRI images 180°, which simulates placing the patient in the prone position, to help familiarize the operative approach, visualize anchor placement trajectory, and measure the intraosseous distance of the ischial tuberosity to ensure the anchors will not penetrate the far cortex, which could compromise anchor security and increase potential for complications.
  - In patient positioning, make sure the pelvis is positioned level and neutral in the axial plane: a small amount of rotation can add to orientation challenges and lead to anchor placement trajectory inaccuracy that could compromise fixation security.
  - Position the primary viewing monitor at the head of the bed, in line with the distal portal, ischial tuberosity, and the superior portal, to assist with orientation. Having another monitor toward the foot of the bed is helpful when the arthroscope is placed in the proximal portal to view the operative field and the tendon distally.
- Pitfall: While tensioning the distal repair suture interlink, the suture becomes twisted, does not fully shuttle through the anchor, and thus does not fully seat down on the tendon.
- Pearls:
  - The knotless repair mechanism works best when the shuttling and tensioning trajectory approximates the original anchor placement trajectory. Therefore, plan the suture management steps to shuttle and tension through the same endoscopy portal used to place the anchor.
  - During tensioning, friction within the knotless anchor can induce twists knots in the repair suture. If spotted before full cinching, the twists are easily resolved by pulling back on the twisted loop with a suture retriever to straighten the loop.
  - Make sure the repair suture strand being pulled out is not coursing through the shortening repair suture loop, as this introduces an unintended half-hitch knot that can tighten and impede full suture excursion for maximal tensioning.
- Pitfall: Distal-row interlinking repair sutures do not fully compress the tendon to bone.
- Pearl: Perform the distal-row repair suture interlinkage before the tape sutures are secured proximally. Use the tape sutures as traction sutures, pulling proximally during distal-row repair suture tensioning. After the tape sutures are secured proximally, if repair suture limbs have not been cut earlier, the distal row can be re-tensioned if desired.

MRI, magnetic resonance imaging.

Confirm suture−bridge construct security. If necessary, further tension the “distal row” repair sutures. Cut the excess sutures flush with the tendon surface. Check to ensure hemostasis is achieved. Close the portal incisions. Apply small impervious dressing to the portal sites. The surgical procedure is demonstrated in Video 1 and illustrated in Figure 7. Pitfalls and their corresponding Pearls are summarized in Table 1.

Rehabilitation

Limit weight-bearing to toe-touch for the first 4 weeks. After that, initiate physical therapy to advance weight-bearing safely, normalize gait, and increase daily activity tolerance, strength, and endurance. At 4 months’ postoperatively, gradually introduce and advance dynamic activities according to tolerance, with the goal of returning to full activities by 5 to 6 months’ postoperatively.

Discussion

The first report of proximal hamstring tendon repair by Ishikawa et al.[11] in 1988 was performed through an extended posterior incision with transosseous-tunnel sutures. Since then, surgical options for proximal hamstring tendon repair have continued to grow,

the ischial tuberosity (IT), and their suture bundles, each anchor’s bundle containing FiberTape (FT), repair suture (RS), and shuttle suture (SS), are passed through the PHT layer (E) The two #2 FiberWire repair sutures (RS) are fed (red dashed oval) through the shuttle sutures (SS) of the opposing anchors. (F) As the 2 SS are pulled out (red arrows), the RS are pulled in and through the opposite FiberTaks (blue arrows). (G) Once fully tensioned, the 2 RS create the distal-row (DR) interlink between the FiberTaks. (H) Two FT, one from each FiberTak, are secured proximally under tension with a SwiveLock (SL) (Arthrex). I: The 2 remaining FT are secured proximally under tension with another SL. Note the RS are kept intact for final tensioning of the distal row. (J) After final tensioning and suture cutting, the appearance of the final knotless, suture−bridge construct.

Table 2. Advantages and Disadvantages

Advantages
1. Endoscopic surgical approach and knotless repair construct combine to decrease sitting discomfort related to incision location and bulky knots.
2. A knotless, suture—bridge construct may be faster to complete than traditional, individual suture passage and knot-tying fixation technique.
3. Increased fixation efficiency and consistency with the knotless suture bridge construct, providing compression over a broad area, instead of the single-point-per-anchor fixation mode in a knot-tying construct.
4. Use of smaller, 2.6-mm all-suture anchors for distal fixation permits placement of more than 2 anchors distally if needed.
5. Starting the procedure endoscopically does not hinder mid-procedure conversion to open repair if necessary.
6. Endoscopic approach may expand proximal hamstring tear treatment for patients experiencing symptoms from chronic tendinopathy.
Disadvantages
1. The endoscopic operative environment unfamiliar for most surgeons.
2. Operating in a low-pressure inflow environment raises endoscopic challenges.
3. Progressive tissue swelling can limit operative time.
4. Risk of neurovascular injury, especially of the sciatic nerve, is abated but not eliminated.
5. Potential of increased implant costs.
6. Long-term follow-up needed to validate benefits.

particularly in the directions of surgical exposure minimization and application of newly available fixation techniques. Our report of an endoscopic repair technique with a knotless, suture bridge construct adds to the available surgical technique options.

In clinical studies, endoscopic proximal hamstring tendon repair has demonstrated overall excellent improvement in objective outcomes, high rate of return to work and sports, and overall low rate of complications,[12] including for chronic tears.[13]

During sitting, the ischial tuberosity directly bears down on the incision area for the open approach, contributing to the sitting discomfort reported by 50% to 60% of patients after open proximal hamstring tendon repair.[14,15] In comparison, the endoscopic technique has been associated with a substantially lower rate of sitting discomfort.[12] By eliminating permanent-suture knots, we believe that our knotless repair construct can further minimize postrepair sitting discomfort.

In rotator cuff repair, the double-row/suture bridge construct leads to increased tendon—bone contact force and area[16] and is associated with decreased retear rates and improved clinical outcomes[17,18] over knotted, unlinked repairs. When tested biomechanically for proximal hamstring repair, the knotless suture bridge construct demonstrated superior fixation security over knotted, unlinked constructs and equaled the strength of native tendon.[19]

The knotless suture bridge construct is associated with shorter operative times compared with knot-tying rotator cuff repairs.[20] This potential benefit is highly relevant for the endoscopic repair technique, since time-dependent tissue swelling can compromise endoscopic visualization. Knotless techniques have also demonstrated improved strength consistency over knot-tying constructs.[21] Furthermore, knots are a known source of fixation strength variability, even in experienced hands.[22]

In acute, high-grade complete proximal hamstring tears with sudden-onset pain and abrupt loss of function, surgical repair is often the clear choice. For chronic tendinopathy and partial tearing refractory to conservative treatment, however, repair has traditionally been a tough treatment to recommend, given the open repair's reputation as a painful surgery with a difficult recovery and relatively high complication rate.[23,24] Endoscopic repair offers a viable option in these particularly challenging cases.[25]

If conversion to open repair becomes necessary, starting with an endoscopic surgical approach does not hinder the conversion, as there is no need to reposition or re-prep/drape the patient, and the endoscopic portals in the gluteal crease can be easily incorporated into the open incision. Also, whatever can be accomplished endoscopically, especially placing the suture anchors in the ischial tuberosity, helps the subsequent open repair, as that is often the step in open repair that requires the most effort and assistance for deep and prolonged retraction to allow satisfactory direct visualization.

Despite the potential advantages, open repair currently remains the established surgical option for proximal hamstring tears. A major factor is the unfamiliarity of most surgeons with this endoscopic approach and that tendon displacement and adhesion are commonly encountered. However, these current disadvantages are not insurmountable barriers, and resemble the initial hurdles to arthroscopic treatment such as rotator cuff repair that became less daunting as our collective arthroscopic experience grew.

Other disadvantages and challenges include endoscopic suture management; time-based tissue swelling that negatively impacts the time window for adequate endoscopic visualization; the low-pressure fluid inflow setup to prolong that visualization window; potential for increased implant costs; and the need for long-term studies to validate the durability of early promising outcomes.

In summary, we demonstrate the feasibility of the knotless suture-bridge technique for endoscopic proximal hamstring repair and expand upon the fixation options available for this emerging minimally invasive approach. Advantages and disadvantages are summarized in Table 2.

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