

Implant-Free, Transtibial, Bone Bridge Fixation for Knee Surgery Including Tibial Spine and Meniscal Root Fixation



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Abstract: Fixation over bone bridge is commonly performed during transosseous pullout knee surgeries. This technique requires the drilling of 2 bony tunnels separately. Herein, we describe our technique in which bone bridge fixation is performed with a single bony tunnel. Our technique is described in 4 simple steps. Step 1: A short accessory tunnel is created from a point at least 1 cm away from the aperture of primary bone tunnel and opening into the lumen of the primary tunnel. Step 2: A shuttle suture (PROLENE) loop is passed from the accessory tunnel to the primary tunnel, and the loop is retrieved out of the primary tunnel using an 18-G epidural needle and arthroscopy probe. Step 3: Complimentary limbs of the pullout suture is then shuttled through the accessory tunnel using shuttle suture loop. Step 4: The knots are tied over the intervening bone bridge. Since the sutures are tied over the bone bridge, it has to be strong enough to provide support. This method of fixation is contraindicated when there is severe osteoporosis or if the tunnels are located in metaphysis. A supplemental video demonstration of the technique is included with this article.

Introduction (With Video Illustration)

The transosseous suture pullout technique is a commonly performed procedure for various knee surgeries, such as tibial spine fixation,¹ root repair,² and meniscal repairs.³⁻⁵ Once these transosseous sutures are pulled out through the bone tunnel, they can be secured over a screw, washer, or an endobutton.⁶ However, these fixation techniques of transosseous sutures require an implant, which adds to the cost of surgery. In addition, cases in which these implants are located on the anteromedial aspect of proximal leg, it may be prominent and may require second surgery for their removal. Furthermore, the chances of tissue

irritation and foreign body reaction might be a possibility due to these implants. Tying sutures over a bone bridge is a technique in which there is no need of the fixation implants, but it requires 2 bone tunnels through which the sutures are passed and tied over the bone bridge formed in between 3 tunnels.^{5,7}

Our technique of bone bridge fixation is a modification of the aforementioned bone bridge technique that can be performed even in cases in which only a single tunnel is made. In this technique, an accessory short adjacent tunnel is created from the cortex at least 1 cm away from the primary tunnel aperture. The accessory tunnel is directed toward the primary tunnel and opens into its interior. Once the connection between the 2 tunnels is established, a loop of stiff suture (no. 1 PROLENE; Ethicon, J&J Medical Devices, Somerville, NJ) is passed using an epidural needle into the primary tunnel through the accessory tunnel, and the loop is retrieved out of the primary tunnel to the exterior. This is followed by shuttling of the sutures to be used for fixation from the primary tunnel with the help of the PROLENE loop. The loop is then retrieved out through the accessory tunnel to bring the pullout sutures through the accessory tunnel. Finally, the suture strands exiting from the primary and accessory tunnel are tied over the bone bridge between the 2 tunnels (Video 1).

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Table 1. Instrument and Materials Required for Bone Bridge Technique

Instrument and Materials	Manufacturer
1.8-mm drill bit	DePuy Synthes, J&J Medical Devices, West Chester, PA
18-G Tuohy epidural needle	B. Braun Medical Inc., Irvine, CA
No. 1 PROLENE	Ethicon, J&J Medical Devices, Somerville, NJ
Arthroscopy probe	ACUFEX; Smith & Nephew, Andover, MA

This technique is easy, reproducible, and does not require any extra implant for suture fixation. This technique can be used in all surgeries that require single-tunnel transosseous suture pullout technique for fixation. The relative contraindication of this technique is osteoporotic bones, where there is a possibility of the bone bridge cut out by the sutures. Instruments and materials required for this procedure are listed in [Table 1](#) and are depicted in [Fig 1](#). Indications and contraindications of this technique are summarized in [Table 2](#).

Surgical Technique

In the indicated cases, the structure to be repaired is initially secured with high-strength sutures. This is followed by the free ends of sutures being pulled out through a single primary transosseous tunnel connecting the interior of joint to the aperture at the bone surface. Once the sutures are retrieved out through the primary tunnel, the skin incision previously made might be required to be extended to expose the aperture of primary tunnel and adjacent 1.5 cm of cortex. The bone bridge fixation is performed by executing the following 4 sequential steps:

1. Creating an accessory tunnel;
2. Passage of shuttle suture (PROLENE) from accessory tunnel to the primary tunnel;
3. Shuttling of pull-out sutures through the accessory tunnel using shuttle suture loop; and
4. Knot tying over the bone bridge.

Step 1: Creating an Accessory Tunnel

After adequate exposure of the aperture and its adjacent cortex, a point 1 cm away from the aperture is marked (usually medial or lateral and sometimes proximal if it is not in soft metaphyseal bone). An accessory tunnel is then created from the marked spot using a 1.8-mm drill bit, aiming toward the primary tunnel and exiting to the interior of the primary tunnel ([Fig 2A](#)). The tunnel is created with a minimum of 1-cm bone bridge between the 2 apertures ([Fig 2 A and B](#)). Once the accessory tunnel merges with the primary tunnel, the drill bit is removed and the aperture of accessory tunnel is cleaned to facilitate the passage of sutures.

Step 2: Passage of Shuttle Suture From the Accessory Tunnel to the Primary Tunnel

An 18-G Tuohy epidural needle is taken and its stylet is removed. The free end of a no. 1 PROLENE suture is passed through the lumen of the needle and the limb exiting from the tip is pulled back to form a loop at the tip of needle ([Fig 3 A and B](#)). The epidural needle along with the looped PROLENE is then inserted through the aperture of accessory tunnel pointing the curve of needle toward the primary tunnel ([Fig 3C](#)). Once the tip of needle is inside the primary tunnel, the loop of PROLENE is created by carefully pushing the PROLENE suture to the interior of primary tunnel and simultaneously withdrawing the epidural needle by a few millimeters ([Fig 3D](#)). An arthroscopy probe is then advanced into the primary tunnel until it reaches the needle tip, which is confirmed by the feel of the probe touching the needle tip. The hook of probe is then manipulated to hook the PROLENE loop (achieved by back and forth movement and rotational movement of the probe) ([Fig 3 E and F](#)). Once the loop is captured by the probe, it is retrieved to the exterior through the aperture of primary tunnel ([Fig 3 G and H](#)). Occasionally, the maneuvers of step 2 have to be repeated several times if the hook of probe does not catch the PROLENE loop.

Step 3: Shuttling of Pull-Out Sutures Through the Accessory Tunnel Using the Shuttle Suture Loop

Once the PROLENE loop is out of primary tunnel aperture, the epidural needle is withdrawn, exercising caution to avoid pulling out the PROLENE suture loop ([Fig 4 A and B](#)). One limb of each pair of the pull-out

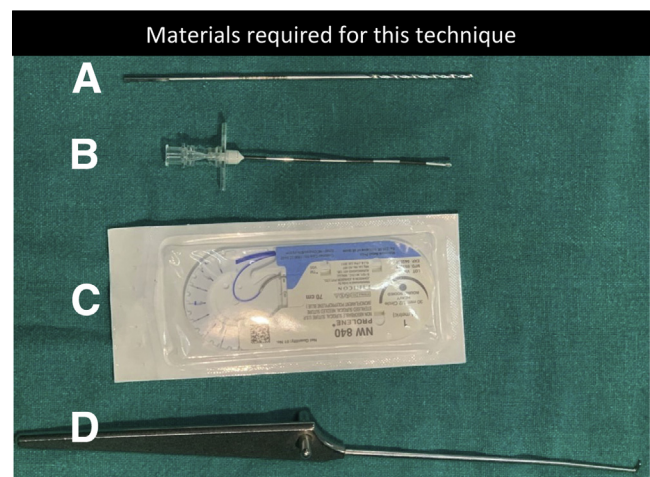


Fig 1. Instruments and materials required for bone bridge fixation in implant-free, transtibial bone bridge fixation for knee surgeries. (A) 1.8-mm drill bit (DePuy Synthes, J&J Medical Devices, West Chester, PA). (B) 18-G Tuohy epidural needle (B. Braun Medical Inc., Irvine, CA). (C) No. 1 PROLENE (Ethicon, J&J Medical Devices, Somerville, NJ). (D) Arthroscopy probe (ACUFEX; Smith & Nephew, Andover, MA).

Table 2. Indications and Contraindications of Bone Bridge Fixation

Indications	Contraindications
1. Meniscal root tears	1. Osteoporotic bone
2. Repair of meniscal tears requiring transosseous tunnel	2. Primary tunnel of diameter smaller than 4 mm
3. ACL avulsion injuries treated with suture pullout technique	
4. PCL avulsion injuries managed with single-tunnel transosseous pullout technique	

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

suture is then passed through the loop of PROLENE (Fig 4 C and D) and pulled out through the accessory tunnel (Fig 4 E-G). If there is more than one pair of pullout sutures, complimentary limbs of each pair are shuttled through the accessory tunnel to have equal and complimentary suture strands in each tunnel. If multiple sutures are used, it is advised to use different-colored sutures or differently marked sutures for easy identification. Fig 4 (A-G) depicts the steps of suture shuttling.

Step 4: Knot Tying Over the Bone Bridge

Once the complimentary strands of sutures have been pulled out through the 2 tunnels, a knot is made by using 2 complimentary limbs of pull-out sutures exiting from each of the tunnels and tied over the bone bridge. If there are multiple sutures, complimentary strands of each marked/same colored sutures exiting from 2 tunnels are identified and tied one by one over the bone bridge. Fig 5 (A-D) depicts steps of knot tying over the bone bridge.

After all knots are tied and cut, subcutaneous absorbable sutures are used to close the soft tissue incision over lying both tunnels. The wound then is closed in layers and sterile dressing is applied.

Discussion

Transosseous suture pull-out technique is a commonly used technique applied to several surgical procedures for various pathologies of knee.^{5,7-9} Once the sutures are pulled out of the transosseous tunnel, there are various ways by which the sutures can be secured. Some commonly used methods being screw post, washer and endobutton fixation.⁶ Although use of these implants for fixation is relatively easy, there are some disadvantages. They may become prominent once postoperative edema subsides and can cause discomfort, especially if they are used on anterior-medial aspect of shin bone in skinny patients. These implants have to be compatible with magnetic resonance imaging (MRI), since some patients might require an MRI scan during the follow-up period. The issue of affordability might be a concern in resource-strained settings, as MRI-compatible implants are expensive. The bone bridge fixation method is a commonly used procedure for securing sutures in transosseous pull-out surgeries. However, it requires 2 separate bone tunnels with an intervening cortical bone between them.⁵ Since creating 2 separate bone tunnels is cumbersome, repair using a single tunnel pull-out and implant fixation is commonly used nowadays. Here, we describe our technique of securing the sutures of a single tunnel transosseous pull-out technique over the bone bridge without the use of implants to secure fixation (Figs 2-5).

Our technique can be used for all the surgeries of knee joint, which is performed by the single-tunnel transosseous suture pull-out technique (Table 1). However, it may be risky to tie over an extremely osteoporotic bone due to fear of bone bridge cut-out. In such cases, an endobutton can be added to secure the fixation by passing the sutures coming out of different tunnels through the lateral holes of the endobutton and the knots being tied over it to protect the bone bridge.⁸ Chahla et al.⁸ used an endobutton to protect the bone

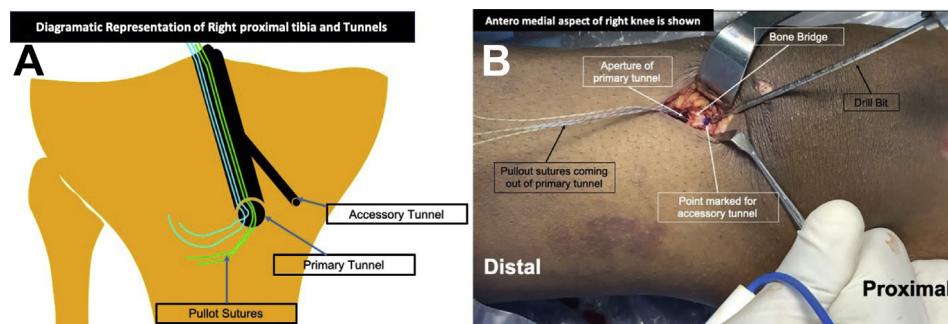


Fig 2. The creation of an accessory tunnel. (A) Diagrammatic representation of primary and accessory tunnels and pullout sutures exiting from the aperture of primary tunnel. (Note: This diagram, with tunnels and sutures, will be used for subsequent elaboration of the technique). (B) Patient is supine and the surgical picture shows anteromedial aspect of the right knee demonstrating the primary tunnel and a point which is 1 cm proximal to the aperture (blue dot) from which the accessory tunnel will be made. Note the direction of drill bit which is angled toward the primary tunnel.

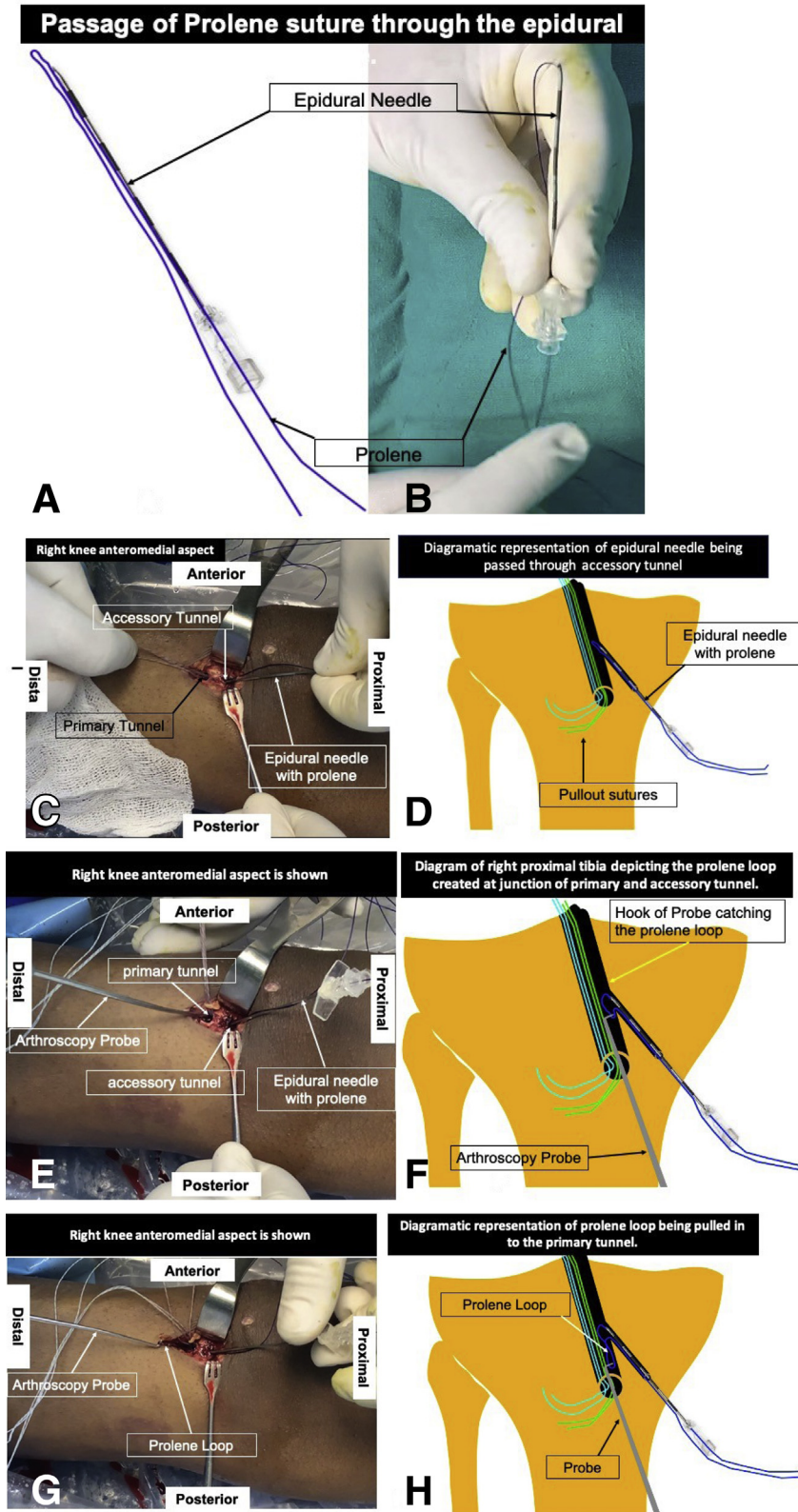
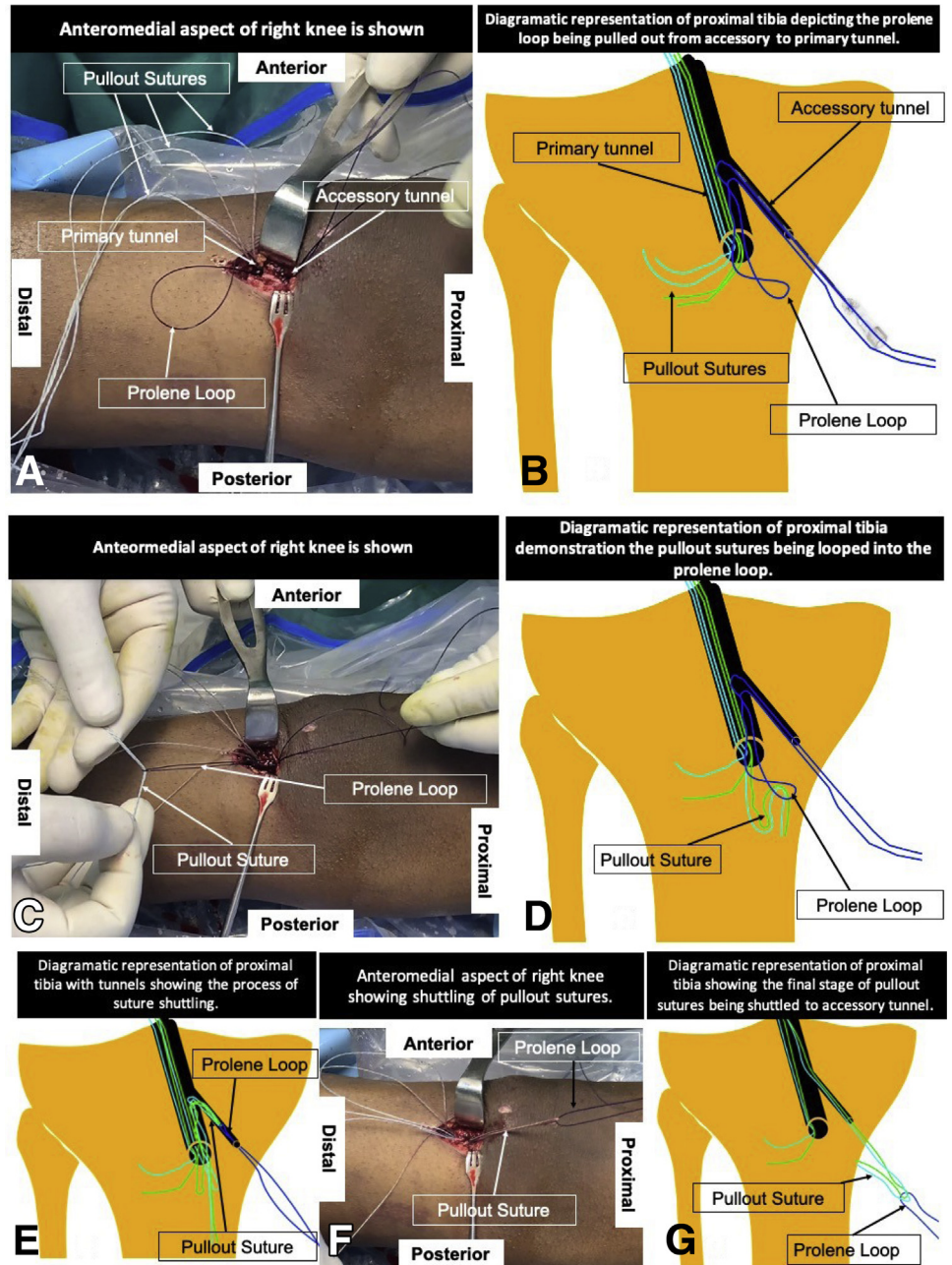


Fig 3. The steps of shuttle suture passage from the accessory tunnel to the primary tunnel. (A) Picture showing passage of PROLENE through the epidural needle to create a loop at the tip of needle. (B) Preoperative picture of the suture being passed through the lumen of epidural needle to create loop at the tip. (C) Intraoperative picture of the right proximal tibia with patient in supine position, showing the epidural needle along with the PROLENE loop inserted through the accessory tunnel and directed towards the primary tunnel. (D) Diagrammatic representation of the right proximal tibia depicting insertion of epidural needle through the accessory tunnel toward the primary tunnel. (E) Intraoperative picture of right knee in a supine patient showing an arthroscopy probe inserted into the primary tunnel up to the tip of epidural needle to hook the loop of PROLENE. (F) Diagrammatic representation of proximal tibia showing the PROLENE loop caught in to the hook of arthroscopy probe. (G) Intraoperative picture of right knee showing probe being pulled of primary tunnel to deliver the loop of PROLENE out through the aperture of primary tunnel. (H) Diagrammatic representation of right proximal tibia depicting the process of the loop being pulled out through the primary tunnel.

bridge cut out even in 2 tunnel transosseous suture pullout technique. Despite the concern of cut-out, several authors have mentioned tying of the sutures

directly over the bone bridge without any implant and have reported no bone bridge cut out and recommend bone bridge fixation for all their cases.^{5,9} This technique

Fig 4. Pictures demonstrating steps of shuttling of pull-out sutures from the primary tunnel to the accessory tunnel. (A) Surgical picture of right knee showing the anteromedial part of the right knee and proximal tibia with the PROLENE (Ethicon, J&J Medical Devices, Somerville, NJ) loop being pulled out through the tibial aperture of primary tunnel. (B) Diagrammatic representation of right proximal tibia with tunnels demonstrating the loop of PROLENE being pulled out of the primary tunnel. (C) Intraoperative picture of anteromedial aspect of right knee showing the pull-out suture being passed through the loop of PROLENE. (D) Schematic diagram of right proximal tibia showing the pull-out suture being passed through the PROLENE loop. (E) Diagrammatic representation of right proximal tibia demonstrating the step of suture shuttling when the sutures are inside the accessory tunnel. (F) Intraoperative picture of right anteromedial part of tibia demonstrating strands of pull-out sutures exiting from the accessory tunnel. (G) Diagrammatic representation of right proximal tibia depicting the pull-out suture being shuttled through the accessory tunnel.



requires a transosseous primary tunnel with a minimum diameter of 4.2 mm to pass an arthroscopy probe retrogradely from aperture to retrieve the loop of PROLENE. We have used our technique for the single-tunnel transosseous technique where the minimum diameter of primary tunnel is less than 4.2 mm. In such cases, we over-ream from the cortex to the point where the tunnel meets the accessory tunnel, which is usually 1 to 1.5 cm from the aperture of the tunnel, and perform the same steps of bone bridge fixation as described previously. If the cortical bone edges are very sharp, it can also cut the sutures. Care should be taken to smoothen the margin of

the aperture before tying the knots. Also, the use of tapes instead of sutures may prevent cutting of pullout sutures by sharp edges of bone tunnels.

Shuttling the sutures from one tunnel to another is usually difficult, especially when there are 2 tunnels at some angle and meeting inside the bone. Our technique of shuttling the sutures from the primary tunnel to the accessory tunnel is very simple and reproducible. Creating a loop of suture and pulling with the help of an arthroscopy probe is often successful. Because of inherent stiffness of PROLENE, the suture can be advanced and a suture loop can easily be formed.

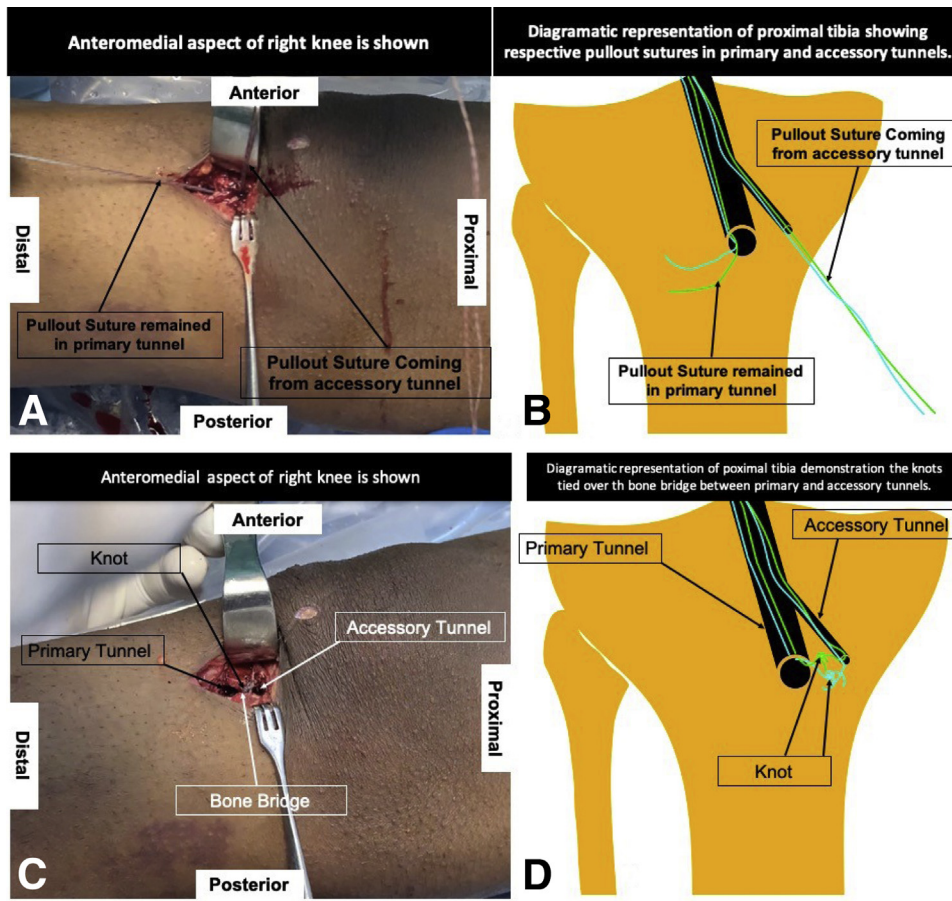


Fig 5. Pictures demonstrating steps of knot tying. (A) Intraoperative picture of right knee with proximal tibia showing half of pullout sutures coming out of the accessory tunnel and the other half remaining in the primary tunnel. (B) Diagram of right proximal tibia demonstrating sutures in primary and accessory tunnel. (C) Intraoperative picture of anteromedial aspect of right proximal tibia showing knots being tied over the bone bridge. (D) Diagrammatic representation of final step where knot is tied over the bone bridge.

Occasionally, repetition of steps by keeping the hook of probe in different direction may be required. Occasionally, an arthroscope can be inserted from the primary tunnel to visualize the location of the PROLENE loop, which aids in directing the tip of probe accordingly to retrieve the loop. The advantages and disadvantages and pearls and pitfalls are summarized in Tables 3 and 4.

Bone bridge fixation is an accepted method of securing sutures of transosseous suture pull-out

Table 3. Advantages and Disadvantages of Our Technique

Advantages	Disadvantages
Low cost—incurring procedure that can be performed with materials and equipment readily available in all operation theaters.	Additional accessory tunnel is required.
Does not require any implants like suture fixation post, button, or discs.	Caution is required if the tunnel is in soft metaphyseal bone and if procedure is performed on severely osteoporotic bone.
Can be performed even if pull-out suture surgery is performed with a single tunnel.	Fetching the loop by the hook of the probe is a blind procedure and occasionally may require repeated attempts.

technique. It avoids additional implants used for fixation and thus, reduces the overall cost of surgery and complications associated with these implants.⁹ Our technique has made bone bridge fixation possible even in single tunnel transosseous suture pull-out surgeries.

Table 4. Risks and Tips to Avoid in Our Technique

Risks	Tips to Avoid
Pullout suture abrasion and wrapping around the drill bit while making the accessory tunnel.	A slow and gradual and slow drilling has to be done to avoid wrapping of pullout sutures around the drill bit.
Small bone bridge may lead to bone bridge collapse and tunnel coalition.	A bone bridge of at least 1 cm has to be created. This can be done by keeping the accessory tunnel at least 1 cm away from the aperture of primary tunnel.
Bone bridge cut out in osteoporotic bones.	In such cases the suture can be passed through the endobutton holes and tied over it.
Suture cut out with sharp cortical edge.	Once the tunnels are made, the edges have to be smoothed to avoid suture cut out. Instead of a suture (ULTRABRAID, Smith & Nephew), FiberTape (Arthrex, Naples, FL) can be used.

It is technically less demanding and does not require any special equipment.

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