Technical Note

Optimization of Graft Position at the Tibia Footprint in Anterior Cruciate Ligament Revision—Lasso Technique

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Abstract: In anterior cruciate ligament (ACL) revision cases, the resultant bigger aperture at the tibia footprint can cause graft instability. The increased movement hinders bone-graft integration and leads to graft abrasion. This article describes a technique to optimize graft stability when using a soft tissue graft for ACL revision. The technique is used when there is suspicion of size mismatch between the new tibia footprint aperture and the graft. The first stage involves passing a suture via an anterolateral tibial tunnel connecting with the revision tibia tunnel distal to the tibia footprint aperture. The new graft is subsequently deployed, and the potential discrepancy between graft diameter and aperture is confirmed. The second stage involves placing 2 pulling sutures on the new graft and passing them into the anterolateral tibial tunnel. The tensioned and anchored pulling sutures secure graft stability at the tibia footprint, and the graft distal to that is fixed routinely. The lasso technique stabilizes the new graft at the tibia footprint by tensioning it in a distal and anterolateral direction. For selected cases, this technique enables a 1-stage ACL revision with a soft tissue graft when faced with graft instability at the tibia footprint.

In revision anterior cruciate ligament (ACL) surgery, it is essential for the new graft to be optimally sited at the anatomical tibia footprint to achieve a good functional outcome.[1,2] In a primary ACL reconstruction, the aperture at the tibia footprint is generally oval because of the tunnel angulation to the articular surface. In revision ACL reconstruction, a larger tunnel diameter is routinely required to achieve a tunnel wall of good quality bone, and this results in a bigger aperture[3,4] at the tibia footprint. A new and more acutely angulated revision tibia tunnel to the articular surface also enlarges the tibia footprint aperture. A similar observation is made when there is partial overlap of the new and pre-existing tibia footprint apertures. Such instances result in a size and shape discrepancy between the tibia footprint aperture and the new graft. Tensioning of the unstable new graft results in medialization with a suboptimal shorter working length, and this affects the overall knee function. A reliable option in such a situation is to stage the surgery, but this prolongs the treatment period, as well as delays the return to an active lifestyle.[5] The total medical cost[4] is also increased. Another alternative option is using a graft with bone plug to offset the size discrepancy between the tibia footprint aperture and graft diameter.[6] With the increasing number of primary ACL reconstructions[7] over the years, there is a corresponding increase in numbers of ACL revisions[8] and potentially such a technical challenge. For selected cases using a soft tissue graft in the new anteromedial (AM) tibia graft tunnel with mild size discrepancy between the tibia footprint aperture and the graft, the authors propose a salvage technique to optimize graft position and stability in a 1-stage ACL revision surgery.

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Surgical Technique

The technique is described on a left knee with an existing AM tibia graft tunnel from the primary ACL reconstruction (Video 1). The pearls and pitfalls, as well as the advantages and disadvantages of this technique, are presented in Tables 1 and 2, respectively.

Table 1. Pearls and Pitfalls

Pearls	
	Anticipate instability and drill the anterolateral tunnel before graft passage.
	Anterolateral tunnel's entry point into the knee joint is below the joint line in the tibial footprint aperture.
	The distal pulling suture is looped around the graft to allow for a lasso effect when tensioned.
Pitfalls	
	If the gap between the new graft and medial rim of the tibia footprint aperture is greater than 5 mm, this technique may not be appropriate.
	If graft stability is not achieved with this salvage technique, a more complex staged revision surgery may be required.

The patient is in the supine position and placed under general anesthesia. An examination with the patient under anesthesia is performed. A tourniquet of appropriate size is applied onto the proximal thigh, and the patient is cleaned and draped. The previous portals are used if suitable. When indicated, new AL (anterolateral) and AM portals are created. Diagnostic arthroscopy is performed. The cartilage and meniscus pathologies if present are addressed before ACL graft revision. The femur socket intra-articular aperture is identified. It is assessed, and a new socket is reamed. This is done by dilating an existing socket or reaming a new socket.

The current technique is described using a soft tissue allograft in an AM tibia graft tunnel for revision ACL reconstruction. The length and diameter required of the allograft is prepared according to the dimensions of the revised femur and tibia sockets. A double-folded graft of a minimal length of 100 mm and a minimal diameter of 10 mm is routinely required. It is prepared and soaked in vancomycin. The choice of a new AM tibia graft tunnel revision technique is decided on a case-by-case assessment of factors such as the position and size of the primary tibia graft tunnel. After the new AM tibia graft tunnel is reamed, the tibia footprint aperture is carefully assessed with different views via the AM and AL portals. When the gap between the new graft and medial rim of the tibia footprint aperture (Fig 1) is within 5 mm and the possibility of graft instability cannot be ruled out, this technical option is considered.

Table 2. Advantages and Disadvantages

Advantages	
	One-stage procedure that potentially obviates a staged revision surgery
	No wastage of prepared graft
	Preserve reamed tibia tunnel
	Minimize cost, recovery time, and morbidity from a staged surgery
Disadvantages	
	Graft instability has to be anticipated and the AL tunnel drilled prior to graft entry.
	Only selected cases are appropriate for this technique to be used.
	In the event that there is no graft instability and pulling sutures are not required, the AL tunnel would have been drilled in vain.

AL, anterolateral.

The tibia jig at 55° angulation with a tip aimer is inserted via the AL portal. The tibia jig bullet is placed firmly on the proximal anterolateral tibia outer cortex after making the skin incision. The tip aimer is placed at 10 mm below the tibia entry aperture (Fig 2). A guidewire is drilled and followed by a cortex breaker (4.8 mm). The passing suture is threaded into the anterolateral (AL) tibia suture tunnel and pulled out via the AM portal for later deployment.

The graft construct is pulled through the new AM tibia graft tunnel into the joint. The femur adjustable loop device (UltraButton adjustable fixation device; Smith & Nephew, London, UK) is deployed, and the graft is pulled into the femur socket to the predetermined length marked on the graft.

Via the AM portal, the Onepass ST (self capture; Smith & Nephew ArthroCare, London, UK) is used to thread the proximal pulling suture (Ultrabraid no. 2 white; Smith & Nephew) into the graft substance about 10 mm above the tibia footprint aperture (Figs 3 and 4). The distal pulling suture (Ultrabraid no. 2 Cobraid) is passed around the graft circumference. Both pulling sutures are now transferred to the AM portal (same portal as the passing suture) (Fig 5). Suture discipline is strictly observed to prevent entanglement and soft tissue interposition. The 2 pulling sutures are then pulled into the AL tibia suture tunnel (Fig 6). The proximal pulling suture is tensioned and fixed on the tibia anterolateral outer cortex (Footprint Ultra PK suture anchor 4.5; Smith & Nephew) with the knee in full extension. The distal pulling suture is subsequently deployed in a similar fashion and a tibia screw of appropriate size is used for distal fixation in the new AM tibia graft tunnel. The femur adjustable loop device is additionally tensioned when required. The stability, passive range of motion, and impingement of the graft are checked. Figure 7 demonstrates the overall schematics of this technique. The knee is cycled, and check radiography is performed at this stage (Fig 8). The incisions are closed with Prolene sutures. A Cryo-cuff (Aircast Foundation, Inc., Naples, FL) and a knee brace are applied and locked in extension. The neurovascular status is checked before the patient is transferred to the recovery unit.

Postsurgery Rehabilitation

The surgery requires less than a 24-hour inpatient stay. In an isolated ACL revision, the patient is started immediately on partial weightbearing for 6 weeks and allowed active range of motion as tolerated. When there is a concurrent cartilage, meniscal, or posterior cruciate ligament surgery, the rehabilitation protocol is according to the concurrent latter conditions.

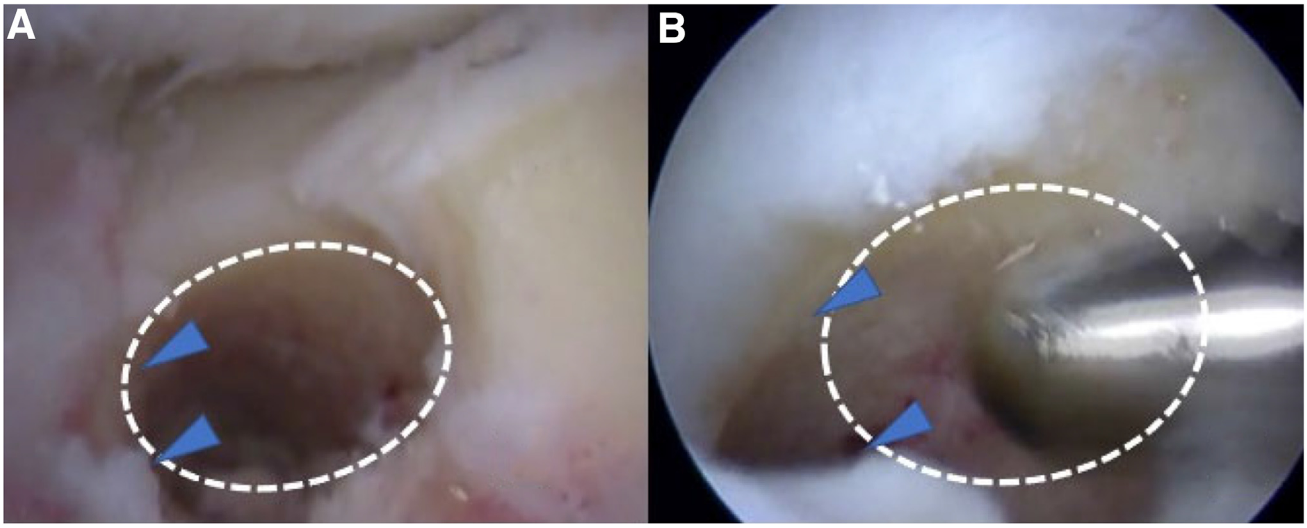

Fig 1. (A) Tibia footprint aperture viewed from the anterolateral portal. (B) Tibia footprint aperture viewed from the anteromedial portal. Dashed white circles indicate the intended tibia footprint aperture. Blue arrowheads indicate the region where the aperture rim broke.

Discussion

Achieving an optimal graft position and stability at the AM tibia graft tunnel is critical to the overall success of a revision ACL surgery in restoring knee stability. There are many techniques described that aim to accomplish this objective. These include tunnel dilation, converging new with pre-existing tunnels, and staged reconstruction with bone grafting in the first stage.[7] The tunnel dilation technique results in a tunnel diameter larger than that in the primary surgery, and this potentially leads to bone loss at the superior tunnel wall at the tibia footprint aperture. When a revision tibia tunnel converges with the primary tunnel, it can also result in a similar observation, especially when the new tunnel is angulated more acutely to the articular surface.[9] A fragment of the thinner superior tunnel wall can break off when tension is applied. This causes increased movement of the new graft at the tibia footprint

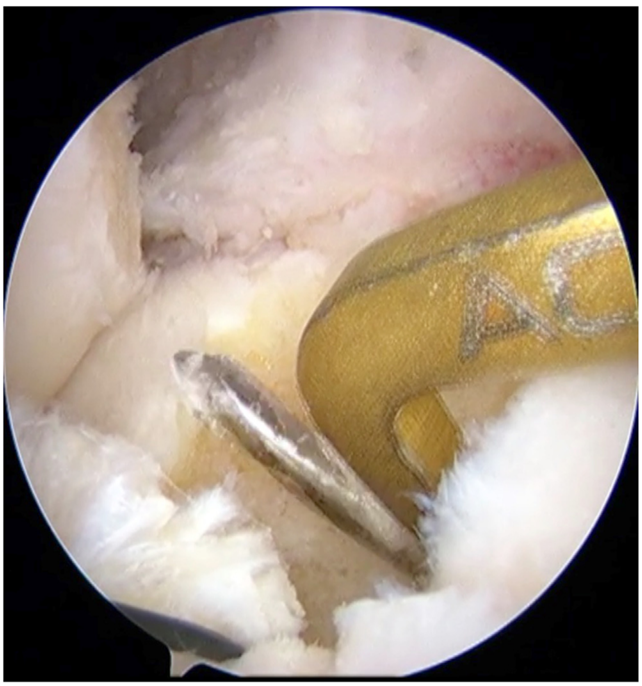

Fig 2. Tibia jig tip aimer positioned below the articular surface.

Fig 3. Proximal pulling suture is threaded.

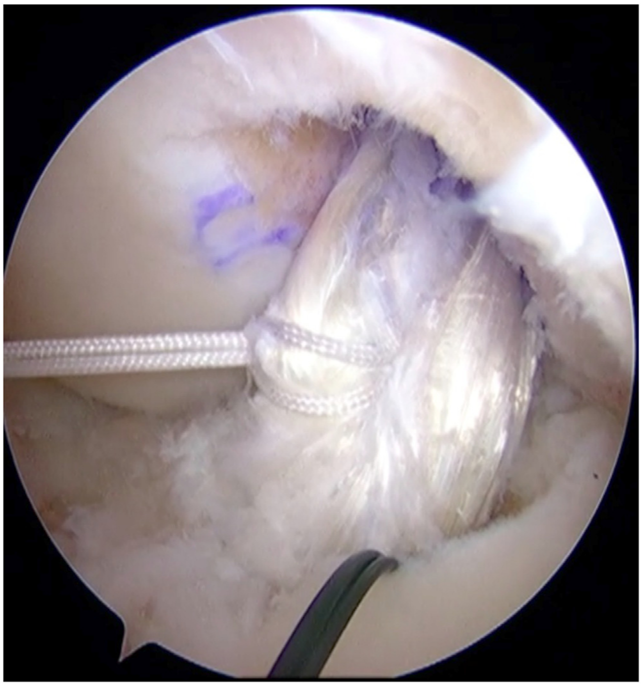

Fig 4. Proximal anchoring suture in situ.

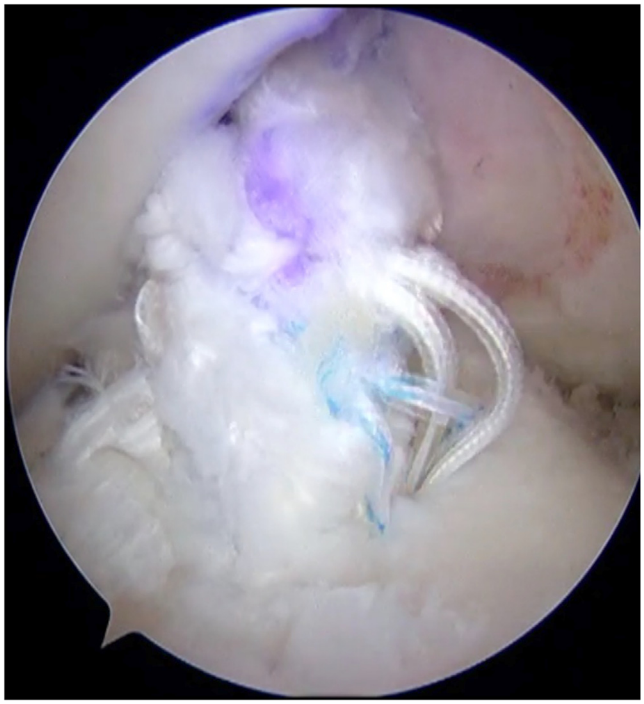

Fig 6. New graft pulled into the anteromedial tibia graft tunnel.

aperture and alters the effective intra-articular length.[10] This potentially affects daily activities such as kneeling and squatting where high knee flexion is required.

It is an option to use a graft with bone plug to offset the graft position at the tibia footprint aperture.[7] This decision might result in graft wastage (if a soft tissue graft had already been prepared) and increases the

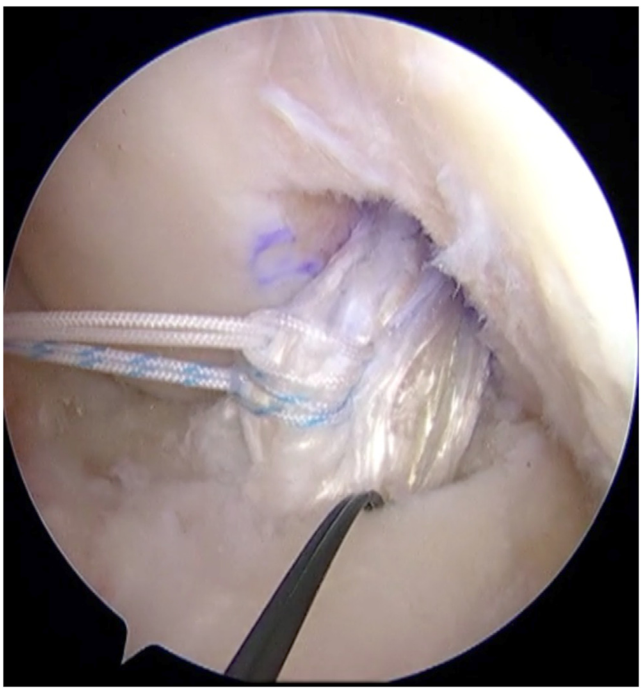

Fig 5. Proximal and distal pulling sutures in situ

operating time with the new graft preparation. The additional donor morbidity from a second autograft needs to be seriously considered when an allograft option is not available. Packing the tibia tunnel with bone graft and staging the revision surgery is another reliable alternative option. However, a one-stage revision is preferred because it decreases the recovery period and medical cost and enables earlier return to an active lifestyle.[5]

Before using this lasso technique, an accurate assessment of the tibia footprint aperture is needed. This technique is applied when there is an expected discrepancy of up to 5 mm between the diameters of the new graft and tibia footprint aperture. The first part of this technique needs to be performed when assessment indicates a possible gap between the rim of the tibia footprint aperture and the new graft. This involves drilling the AL tibia suture tunnel and threading the passing suture into position. When the new graft is inside the AM tibia graft tunnel and instability is confirmed, the second part of the technique is carried out.

The entry of the 2 pulling sutures is approximately 10 mm distal to the level of the tibia footprint aperture and the proximal pulling suture is stitched on the graft approximately 10 mm above the tibia footprint aperture. This results in a working length of approximately 20 mm during graft tensioning. The tensioning of the pulling sutures is directed in a distal and anterolateral direction to counter the graft shifting medially. The

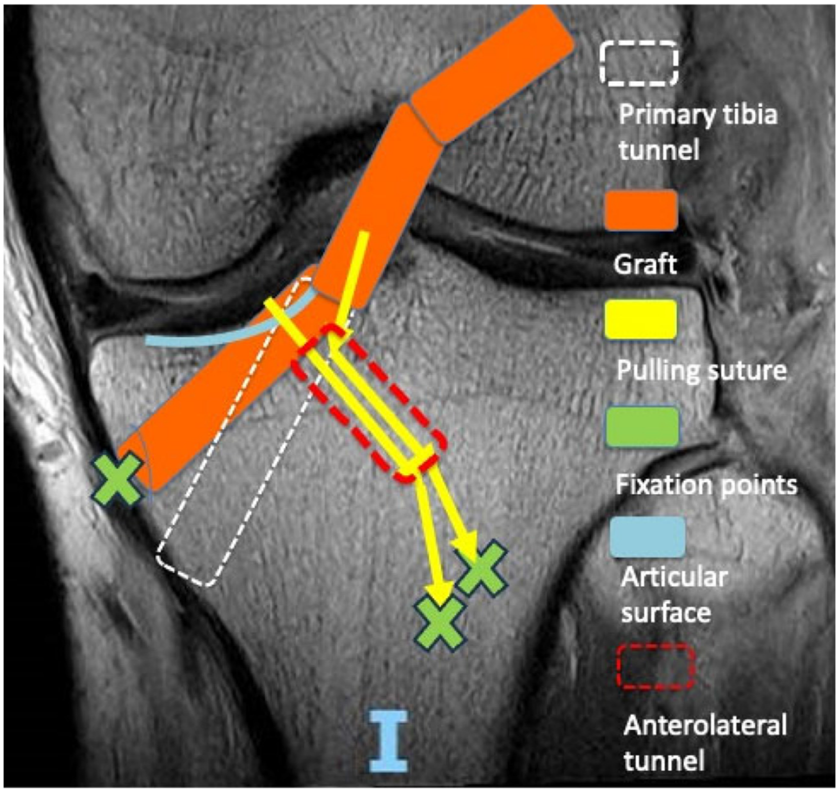

Fig 7. Schematic of the Lasso technique. Dotted lines represent the tibia graft tunnel of the primary surgery. Orange band marks out the path of the new graft. The 2 pulling sutures are represented by the yellow arrows. The 3 Xs represent the 3 fixation points of the new graft. The blue line shows the tibia articular surface breached by the new anteromedial tibia graft tunnel. The technique enables proximal fixation close to the tibia footprint aperture in addition to the standard distal fixation of the new graft.

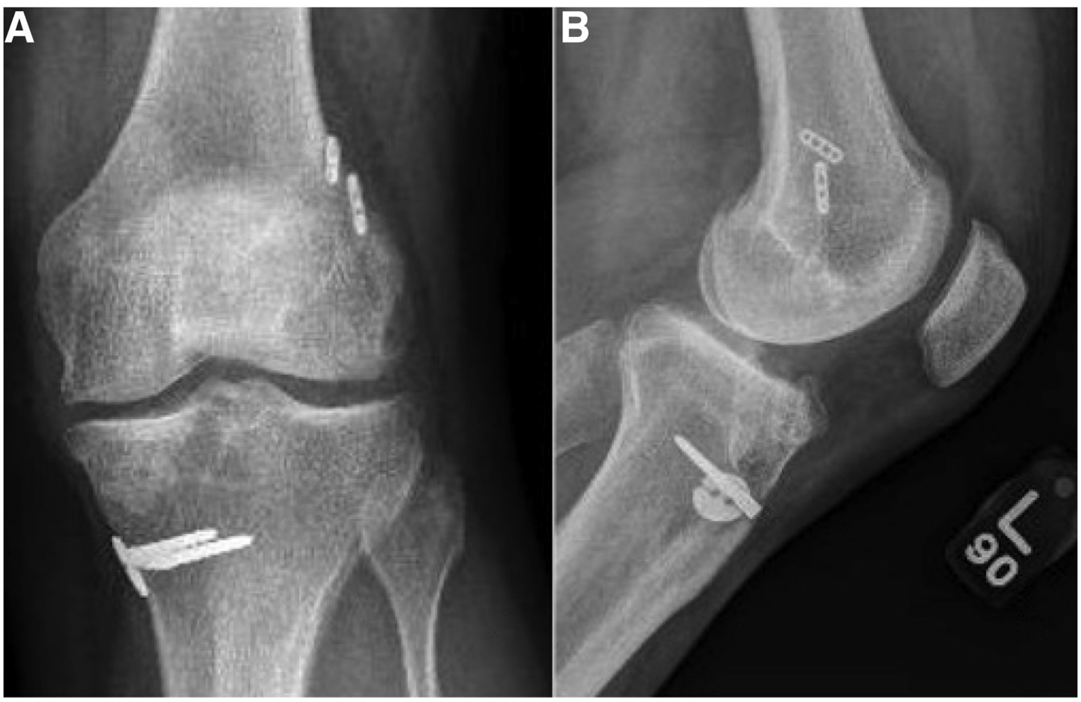

Fig 8. (A) Postoperative anteroposterior x-ray film. (B) Postoperative lateral x-ray film. The femoral suspensory button and tibia stapler of the primary surgery were not removed because they were not in the way. The adjustable femoral suspensory button used in the revision surgery is positioned next to that of the primary surgery. A suspensory device was used for tibia fixation.

distal suture is looped around the graft to provide a second and more distal point of anchor for the graft inside the AM tibia graft tunnel. The proximal pulling suture is not looped around the graft to avoid convergence with the distal loop. These 2 separate pulling suture points on the new graft stabilize a segment of the proximal graft rather than provide a single fixation point in the proximal part of the AM tibia graft tunnel. This provides better bone graft contact and integration. Furthermore, this technique provides 2 points of fixation to stabilize the graft in the new tibia tunnel. Proximally at the tibia footprint aperture and distally at the tibia outer cortex. Finally, it is important to reassess that reliable graft stability at the tibia footprint aperture has been achieved with this salvage method. If this is not the case, a staged revision is necessary.

The authors recognize several disadvantages with this technique. First, graft instability has to be anticipated and the AL tunnel drilled before graft entry. Second, only selected cases are appropriate for this technique to be used. Finally, in the event that there is no graft instability and pulling sutures are not required, the AL tunnel would have been drilled in vain. The authors also recognize the lack of long-term outcome clinical case series as a potential limitation of this Technical Note.

In conclusion, when performing revision ACL surgery, the revision tibia footprint aperture can be bigger than intended, leading to instability, as well as nonanatomical position of the revision graft at the tibia footprint aperture. With careful assessment of selected cases, the lasso technique is a salvage procedure that enables proximal fixation of the new graft at the tibia footprint aperture in addition to distal fixation. It enables a one stage surgery with no change in the chosen soft tissue graft. This minimizes patient morbidity, medical cost, and recovery time.

Disclosures

The authors report the following potential conflicts of interest or sources of funding: S-Y.J.L. reports personal fees from Smith & Nephew outside the submitted work. All other authors (Y-Y.T.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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