

# Minimally Invasive Harvesting of Triple-Fold Superficial Layer Quadriceps Autograft for Knee Ligament Reconstruction



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**Abstract:** Graft selection plays a critical role in anterior cruciate ligament reconstruction. Autograft options, including hamstrings, bone–patellar tendon–bone, and quadriceps, offer distinct advantages and disadvantages. Soft tissue quadriceps tendon autografts are increasingly favored due to their strength, size compatibility, and potential for enhanced graft healing. This technique offers minimal skin incision, a longer graft, and reduced morbidity, as it specifically targets the superficial band of the quadriceps tendon.

Graft selection is a critical decision in procedures such as anterior cruciate ligament (ACL) reconstruction. There are many autograft options for ACL reconstruction such as hamstring, bone–patellar tendon–bone (BPTB), and quadriceps graft, each with its own advantages and disadvantages.<sup>1–3</sup> Hamstring grafts are autografts harvested from the patient's own hamstring tendons. One of the primary advantages of hamstring grafts is the abundance of tissue, allowing for multiple grafts if necessary. They also offer good cosmesis and relatively low donor site morbidity.<sup>4,5</sup> However, hamstring grafts may have increased laxity and enlargement of femoral tunnel aperture over time,<sup>6</sup>

and they can be associated with postoperative hamstring weakness or saphenous nerve injury during harvest.<sup>7,8</sup> BPTB grafts involve using a strip of bone and attached patellar tendon from the patient's own knee. This type of graft provides excellent initial stability due to the bone-tendon-bone construct.<sup>9</sup> BPTB grafts also have a high success rate and a low risk of rerupture.<sup>10</sup> However, they can cause anterior knee pain, patellar fracture, kneeling difficulties, and saphenous nerve injury during harvest.<sup>11–13</sup> The harvest site may also have increased morbidity, such as patellar tendonitis.<sup>13</sup>

Soft tissue quadriceps tendon autografts have gained popularity as an alternative to hamstring or BPTB grafts because of their excellent strength and size match for ACL reconstruction.<sup>14,15</sup> Additionally, the quadriceps tendon contains a higher collagen content, potentially enhancing graft healing.<sup>16,17</sup> However, the standard quadriceps autograft typically consists of only 1 tendon band, which limits the available fixation techniques for the graft. This Technical Note presents a technique for minimally invasive harvesting of superficial quadriceps autografts, offering advantages such as minimal skin incision, reduced donor site morbidity, and a wider range of fixation options.

## Surgical Technique (With Video Illustration)

### Step 1: Patient Position

In the supine position, the leg is held away from the operating table and positioned on the

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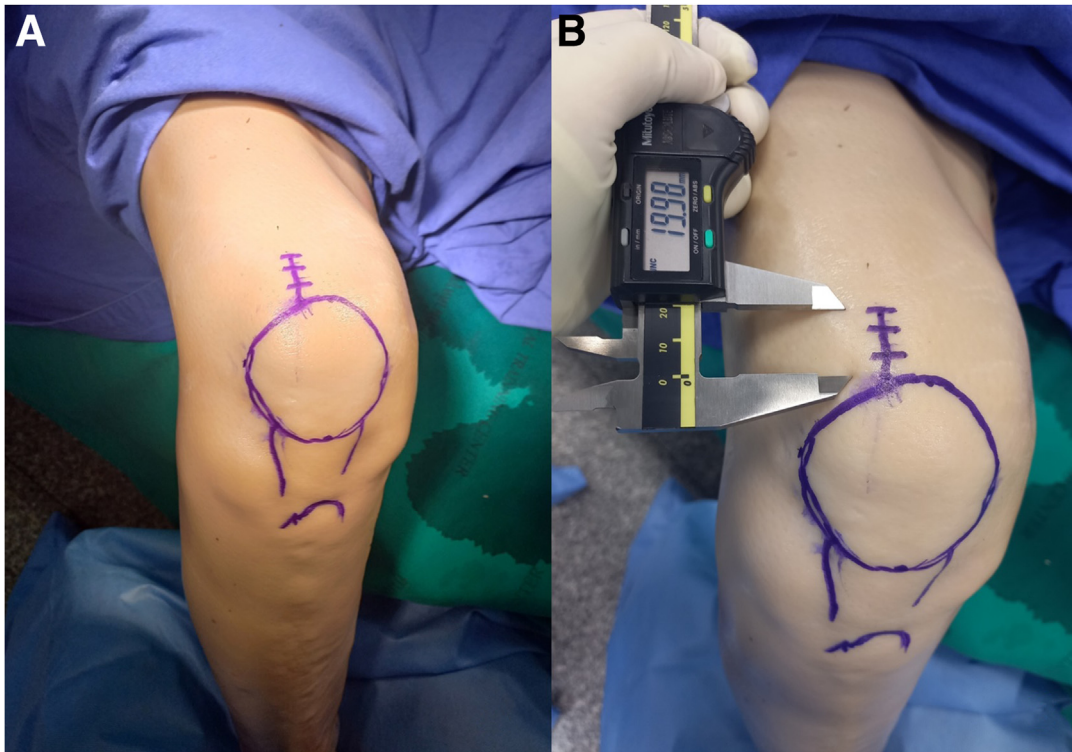
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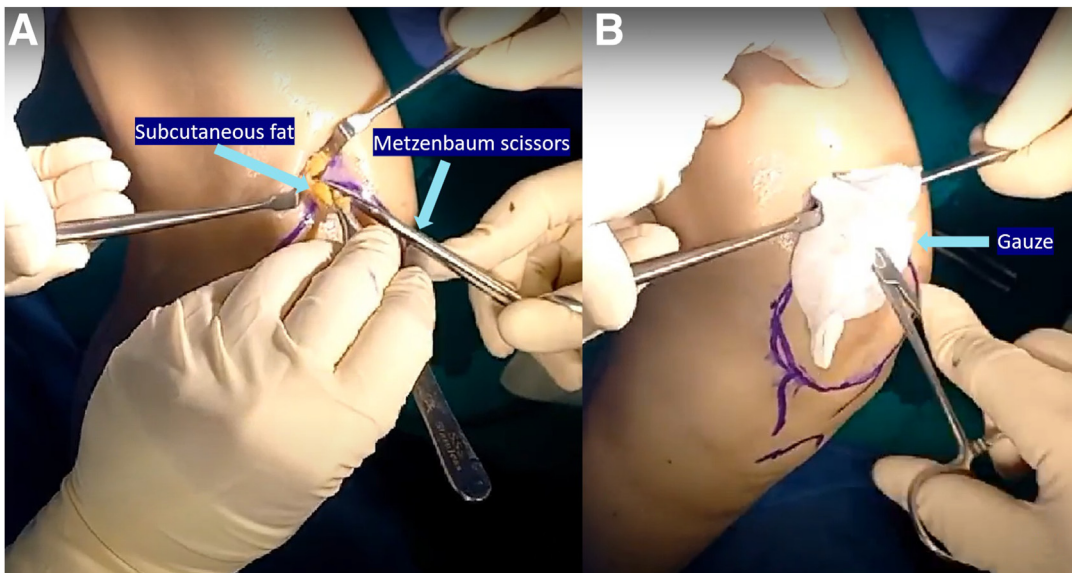


**Fig 1.** Right soft cadaveric knee, supine position. The skin is marked using a skin marker in preparation for making an incision to harvest the quadriceps autograft. (A) The leg is held away from the operating table and positioned on the surgeon's thighs. (B) A 2-cm vertical skin incision is made over the superior pole of the lateral one-third of the patella for graft harvesting.

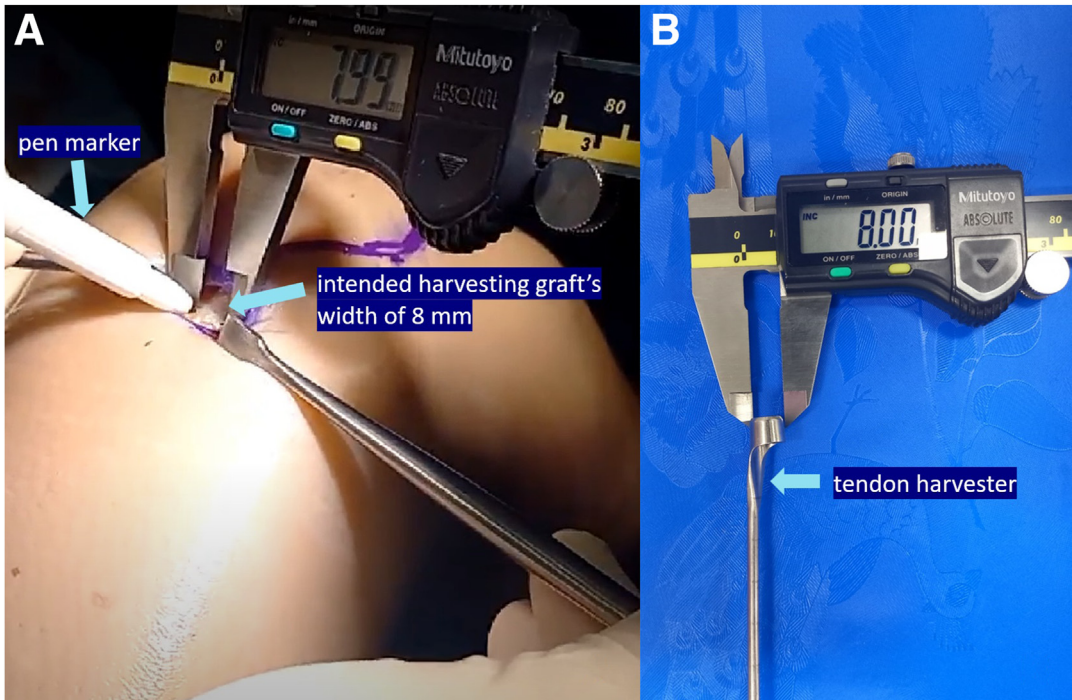
surgeon's thighs. The surgeon then places the left knee into a 90° angle, facilitating manipulation by both the surgeon and the assistant (Fig 1A, Video 1).

### Step 2: Incision

A 2-cm vertical skin incision is made over the superior pole of the lateral one-third of the patella for graft harvesting (Fig 1B, Video 1).



**Fig 2.** Right soft cadaveric knee, supine position. After making the initial incision to harvest the quadriceps autograft, (A) the subcutaneous fat is removed using Metzenbaum scissors to reveal the quadriceps level. (B) Gauze is inserted through the incision at the level of the quadriceps tendon to create a soft tissue tunnel.

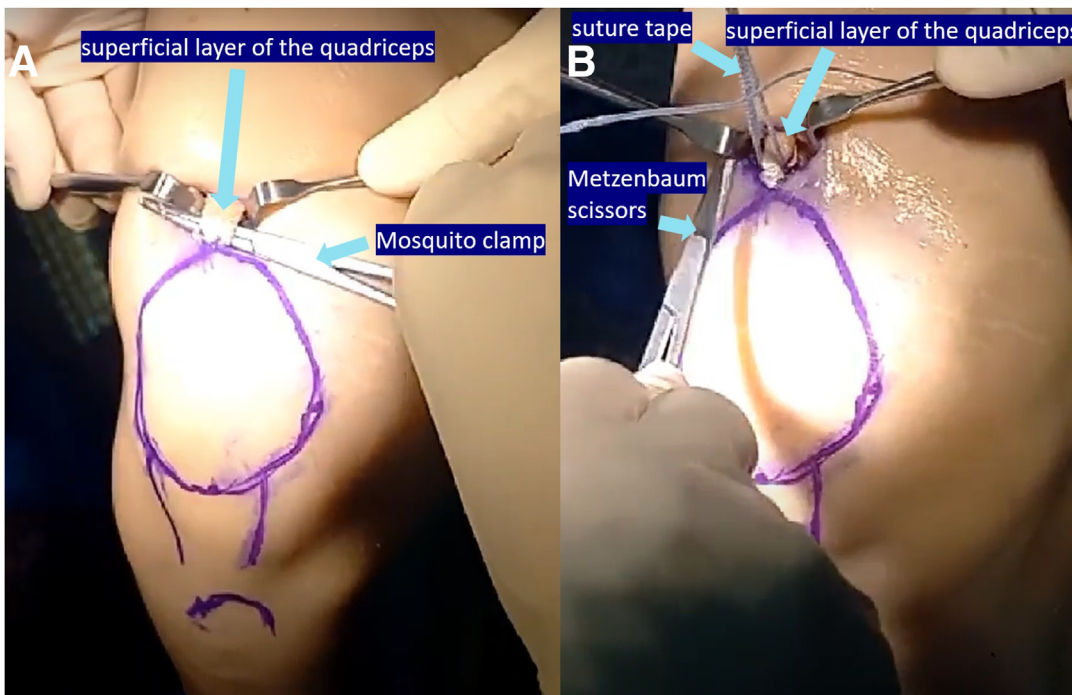


**Fig 3.** (A) Right soft cadaveric knee, supine position. A pen marker is employed to indicate the intended harvesting quadriceps graft's width of 8 mm. (B) The width of 8 mm corresponds to the diameter of the tendon harvester (Arthrex).

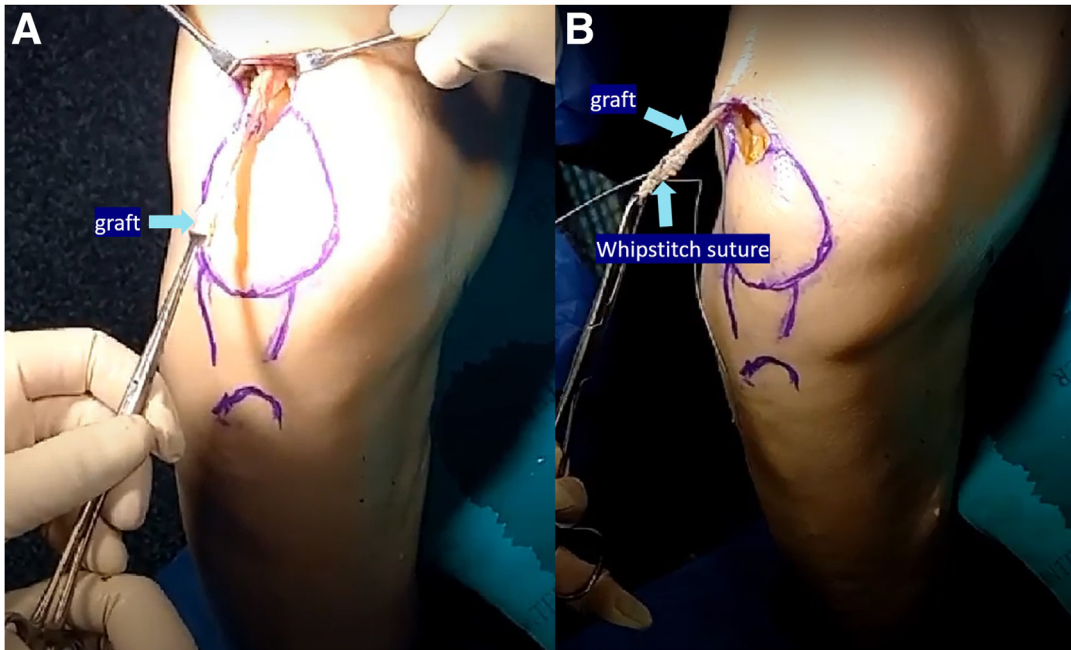
**Step 3: Dissection**

The incision passes through the subcutaneous tissue and is followed by its dissection. Subsequently, the subcutaneous fat is removed using Metzenbaum

scissors to reveal the quadriceps level (Fig 2A, Video 1). Gauze is inserted through the incision at the level of the quadriceps tendon to create a soft tissue tunnel (Fig 2B, Video 1).



**Fig 4.** Right soft cadaveric knee, supine position. After making the incision on the quadriceps tendon, (A) the Mosquito clamp is used to separate the superficial layer of the quadriceps approximately 2 cm proximal to the patellar insertion. (B) The suture tape is looped around the separated superficial layer of the quadriceps graft, and then the Metzenbaum scissors are used to release the adhesion band that is attached to the deep layer.

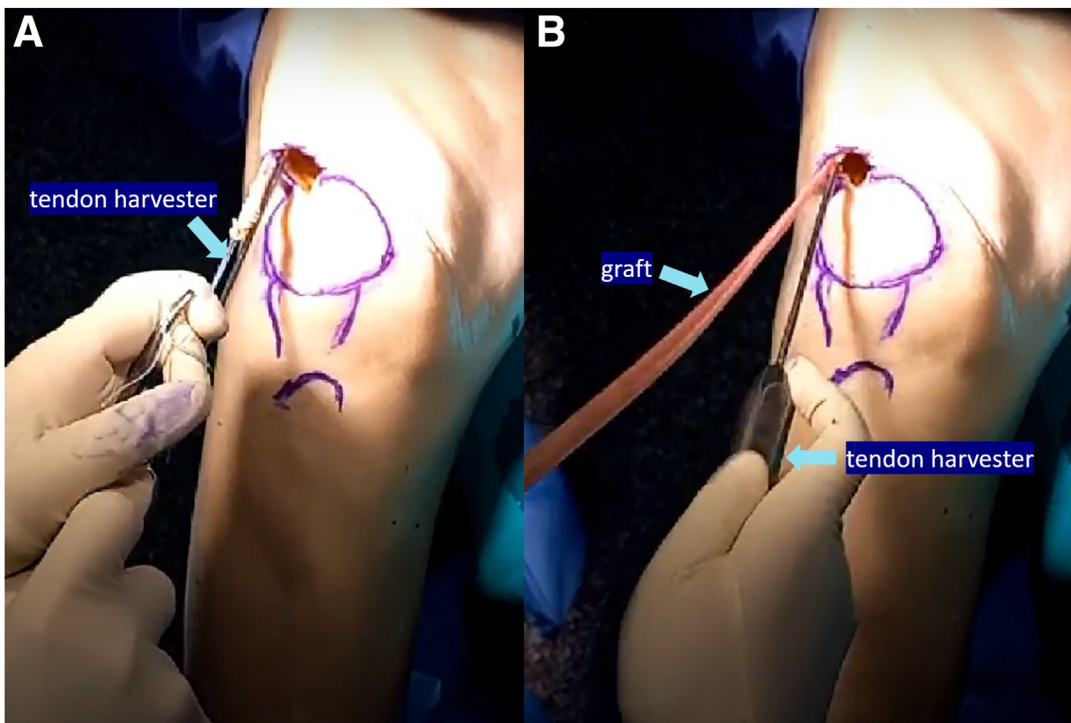


**Fig 5.** Right soft cadaveric knee, supine position. To harvest the quadriceps autograft, the superficial band of the quadriceps tendon is appropriately mobilized. After that, (A) the graft is released directly from its attachment on the superior pole of the patella. (B) The graft is sutured using the whipstitch technique.

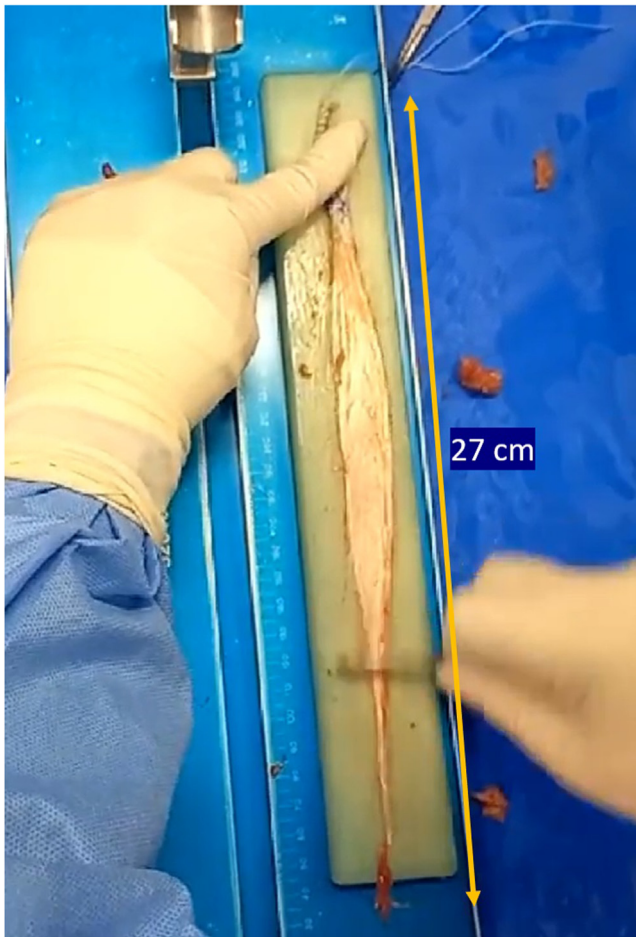
#### Step 4: Separating the Superficial Layer of Quadriceps Tendon

After the quadriceps tendon becomes visible, a surgical pen marker is employed to indicate the intended harvesting graft's width of 8 mm (Fig 3A, Video 1). The

width of 8 mm corresponds to the diameter of the tendon harvester (Arthrex) (Fig 3B, Video 1). The No. 15 scalpel blade is used to make an incision on the lateral one-third of the quadriceps tendon. Then, the Mosquito clamp is used to separate the superficial layer



**Fig 6.** Right soft cadaveric knee, supine position. To harvest the quadriceps autograft, (A) the 8-mm tendon harvester is used to strip the graft. (B) The superficial quadriceps graft is harvested through a limited incision.



**Fig 7.** After removing the superficial band of the quadriceps tendon using a tendon stripper (Arthrex), this minimally invasive technique harvests a 27-cm-long superficial quadriceps autograft.

of the quadriceps approximately 2 cm proximal to the patellar insertion (Fig 4A, Video 1). This is necessary because the distal part of the tendon tends to blend together, making it challenging to separate the layers. The FiberTape (Arthrex) is looped around the separated superficial layer of the quadriceps graft, and then the Metzenbaum scissors are used to release the adhesion band that is attached to the deep layer (Fig 4B, Video 1).

### Step 5: Graft Harvesting

The graft is released directly from its attachment on the superior pole of the patella using a No. 15 scalpel blade (Fig 5A, Video 1). The graft is sutured using the whipstitch technique with FiberWire (Arthrex) (Fig 5B, Video 1). The 8-mm tendon harvester (Arthrex) is used to strip the graft. It is important to note that during the harvesting process, the knee should be extended to relax the quadriceps tension (Fig 6A, Video 1). Then the superficial quadriceps graft is harvested through a limited incision (Fig 6B, Video 1).

The minimally invasive harvesting technique for obtaining a superficial quadriceps autograft involves obtaining a graft that is 27 cm long (Fig 7, Video 1). The graft is then triple-folded to achieve a diameter of 10 mm and a length of 8.5 mm (Fig 8, Video 1). This type of graft is suitable for knee ligament reconstruction.

### Demonstration of Harvested Graft and Damage to the Quadriceps Tendon

Only the superficial layer of the quadriceps tendon is harvested for the graft. The cadaveric knee reveals the presence of the deep layer (Fig 9A, Video 1). It is sufficient to repair the harvested defect only at the distal insertion (Fig 9B, Video 1).

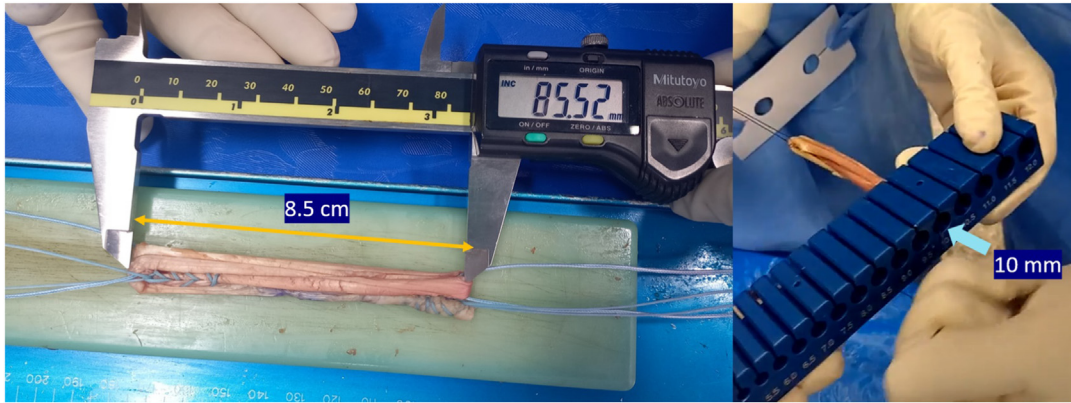
### Discussion

Historically, the harvest of the quadriceps tendon has necessitated larger incisions. This Technical Note describes a technique for minimally invasive and less morbid harvesting of superficial soft tissue quadriceps autografts. The technique involves obtaining a triple-fold graft with a diameter of 10 mm and a length of 8.5 mm, which is suitable for use in knee ligament reconstruction.

Graft selection is crucial in ACL reconstruction, with options including hamstring, BPTB, and quadriceps grafts, each having pros and cons.<sup>1-3</sup> The disadvantages of hamstring grafts include increased laxity, enlargement of the femoral tunnel aperture, hamstring weakness, potential saphenous nerve injury, and an increased risk of graft rupture due to inadequate removal of the accessory band.<sup>6-8,18</sup> BPTB grafts can result in anterior knee pain, patellar fracture, difficulties with kneeling, saphenous nerve injury, and increased morbidity such as patellar tendonitis at the harvest site.<sup>11-13</sup>

This technique offers several advantages, including low donor site morbidity, a minimally invasive incision, sacrifice of only the superficial layer of the quadriceps tendon, predictable graft size and length, and the absence of any need for special or specific instruments for graft harvesting. Furthermore, this technique, combined with the use of a foldable graft, provides a wider range of options for graft fixation techniques. However, this technique does have some disadvantages, including the surgeons' potential unfamiliarity with the graft harvest, the risk of hemorrhage at the donor site, and the lack of existing biomechanical properties or clinical outcomes for this specific type of graft. There is also no risk of complications associated with the patella and nerve injury, in comparison to the BPTB graft.<sup>11-13,19</sup>

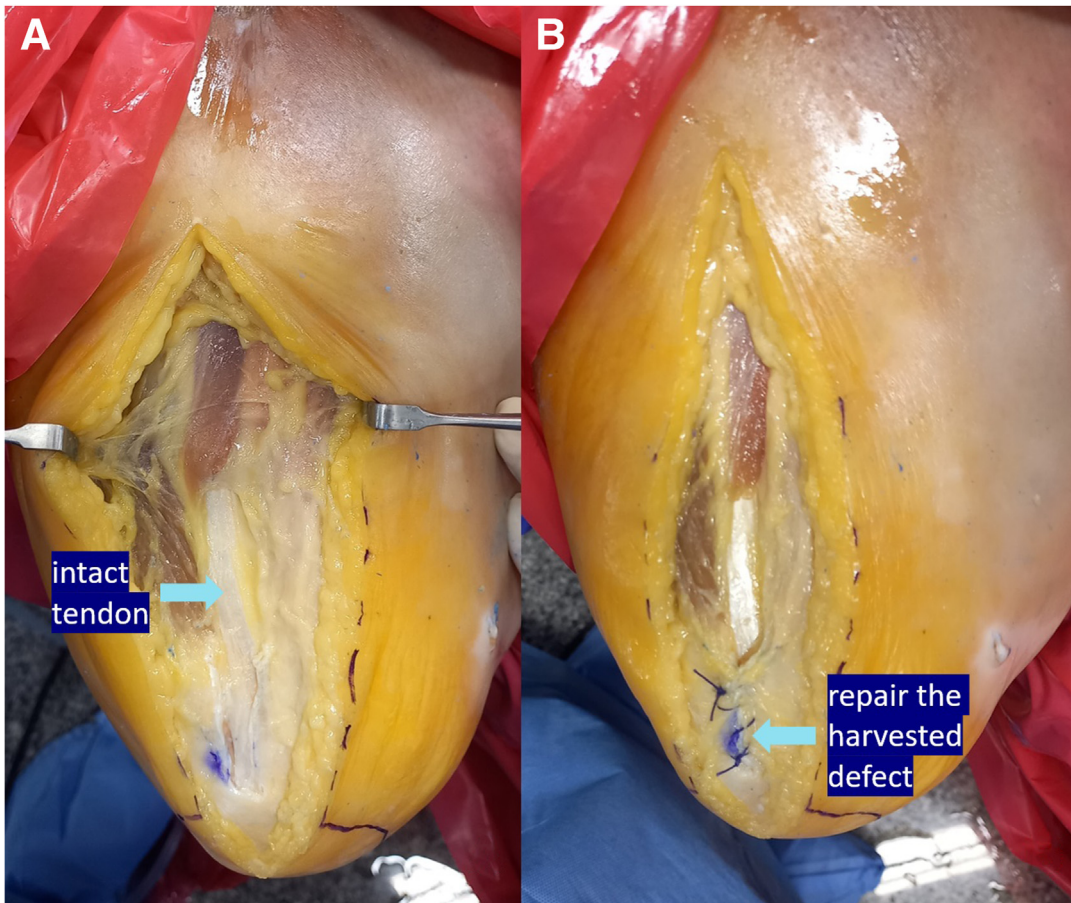
The key points and pearls of this technique are as follows: first, it is important to harvest the graft at the lateral one-third of the quadriceps tendon as this



**Fig 8.** To achieve the proper diameter for the ligament reconstruction, the superficial quadriceps autograft is triple-folded to achieve a diameter of 10 mm and a length of 8.5 mm.

location allows for obtaining the longest graft.<sup>20</sup> Second, strip the graft to a width of 8 mm, corresponding to the diameter of the tendon harvester. Third, when separating the superficial layer of the quadriceps tendon, it is crucial to do so 2 cm proximal to the insertion point of the tendon, as the layers of quadriceps tend to blend together at the insertion, making

separation difficult. Fourth, caution must be exercised to avoid injury to the deep layer and joint capsule. Fifth, the knee should be extended when using the tendon harvester to strip the graft, to relax the tension in the quadriceps muscle. Last, the use of Metzenbaum scissors is recommended to release any adhesion bands attached to the deep layer, ensuring that the scissors



**Fig 9.** Right soft cadaveric knee, supine position. After harvesting the superficial band of the quadriceps autograft, (A) the cadaveric knee reveals the presence of the deep layer. (B) It is sufficient to repair the harvested defect only at the distal insertion.

**Table 1.** Advantages/Disadvantages/Pearls of the Procedure

Advantages	<p>Low donor site morbidity  Minimally invasive incision  Sacrificed just the superficial layer  No special instruments required for graft harvesting  Predictable graft size and length  Foldable graft enhances graft fixation versatility  Risk-free from patellar-associated complications  Nerve injury risk-free</p>
Disadvantages	<p>Surgeons' unfamiliarity with the graft harvest  Hemorrhage risk at the donor site  Lack of biomechanical properties or clinical outcomes for this graft type</p>
Pearls	<p>Harvest the graft at the lateral one-third of the quadriceps tendon  Strip the graft to a width of 8 mm, corresponding to the diameter of the tendon harvester  Separate the superficial layer of the quadriceps tendon at 2 cm proximal to the insertion point  Caution to prevent deep layer and joint capsule injury  Extend the knee while using the tendon harvester to relax quadriceps muscle tension during graft stripping  Recommend using Metzenbaum scissors to release adhesion bands attached to the deep layer prior to harvesting</p>

reach the muscle part to prevent premature graft amputation. Advantages, disadvantages, and pearls of the procedure are further described in Table 1.

In conclusion, this presented technique is a reproducible method and a safe surgical technique to harvest the superficial soft tissue quadriceps autografts.

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