

A Minimally Invasive and Simple Technique of Superficial Quadriceps Tendon Graft Harvesting

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Abstract: Quadriceps tendon (QT) graft is a versatile graft for anterior and posterior cruciate ligament reconstruction. Advantages of quadriceps tendon autograft are the superior quality of graft, customization of graft size, reduced anterior knee pain, reduced risk of neurovascular injury, reduced incidence of arthrofibrosis compared to BPTB graft, preservation of ACL agonists, i.e., hamstrings, implantation of thicker graft and better patella mobility. Considering its advantages over other available autografts, its popularity is now increasing among surgeons. Conventionally, quadriceps tendon graft is harvested by an open technique, which produces an ugly scar and delays rehabilitation. In this article, we describe a minimally invasive technique of quadriceps tendon graft harvesting with a 2-2.5-cm vertical skin incision. Our technique does not require any specialized instrumentation, unlike other reported minimally invasive QT graft harvesting techniques, as we harvest the graft with a close tendon stripper.

Introduction

Cruciate ligament injury is the most common ligament injury in the knee. Reconstruction of cruciates has shown promising and reproducible results.¹ Reconstruction of the anterior cruciate ligament (ACL) was first described in 1917 by Hey-Groves using iliotibial band autograft, but the ideal graft for reconstruction of cruciates is still a matter of debate.^{2,3} An ideal graft should have biomechanical and structural similarities with native ligament, should allow secure fixation with bony tunnel and rapid biological incorporation, and should have minimal donor site morbidity.² Although allograft and even synthetic graft material have been tried, they could not attract user interest due to their several limitations.³ As a result, to date, autograft is the graft of choice for ligament reconstruction. Bone-patellar-tendon-bone (BPTB)

graft, once considered the gold standard for ACL reconstruction, has lost its popularity and is now reserved for only revision and special cases because of several disadvantages like an ugly scar, anterior knee pain, graft-tunnel length mismatch, iatrogenic patella fracture, or patellar tendon rupture, and others.^{4,5} For the last few decades hamstring tendon autograft has become the graft of choice, but it also has some limitations, like unpredictable graft thickness, premature graft amputation, terminal knee flexion weakness, injury to the infrapatellar branch of the saphenous nerve, increased incidence of infection, among others.⁶

Quadriceps tendon (QT) autograft is a viable alternative in this scenario (Table 1). In 2010, a review of graft choice revealed that only 2.5% of anatomic ACL reconstruction was done with quadriceps tendon.⁷ But recent data by Middleton⁸ show that the use of QT autograft represented 11% of all anatomic ACL reconstruction. This denotes that QT autograft is gaining popularity in recent times for both primary and revision cruciate reconstruction.⁹ Anatomical description of quadriceps tendon mentions a trilamellar pattern with a major contribution of the superficial layer of the rectus femoris, the deepest layer of the vastus intermedius, and the distal 6 cm of the tendon middle layer is formed by the union of vastus medialis and vastus lateralis. Harris et al. reported that the average width of the quadriceps tendon is 27 mm, and the average thickness of 8 mm.¹⁰ With experience, surgeons can harvest quadriceps grafts of

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Table 1. Advantages and Disadvantages of the Quadriceps Tendon Graft Procedure**Advantages of Quadriceps Tendon Graft**

1. Superior quality of graft
2. Decreased risk of neurovascular injury
3. No flexion weakness
4. No or minimal anterior knee pain
5. Customization of graft size
6. Reduced incidence of arthrofibrosis
7. Better patella mobility

Disadvantages of Quadriceps Tendon Graft

1. If the thickness of quadriceps tendon at 3 cm proximal to upper pole of patella in mid sagittal section in MRI is < 7 mm, QT graft is not preferred
2. Risk of penetrating supra patellar pouch complicating subsequent arthroscopy specially when full thickness graft is harvested
3. This procedure is to be avoided in patients in whom BPTB graft has been harvested previously

7-8 cm in length, 6-7 mm thick, and 9-10 mm width consistently without violation of suprapatellar pouch.⁶ Harris et al. demonstrated that the



Fig 1. Picture clearly shows that vastus medialis is more muscular, and vastus lateralis is less so. We harvest superficial quadriceps graft from the lateral part of quadriceps tendon, as it is more tendinous in that area. L, vastus lateralis; M = vastus medialis; QT, quadriceps tendon.

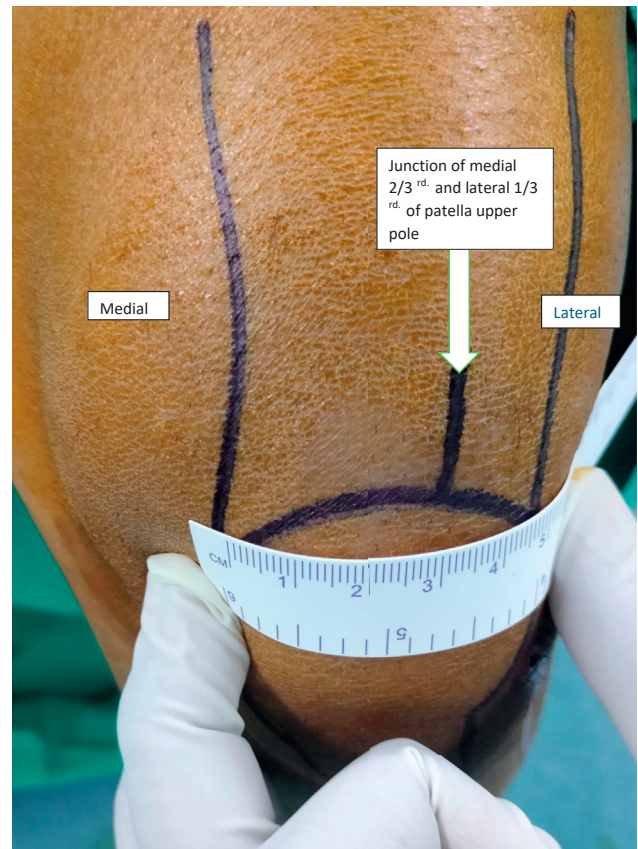


Fig 2. A 2.5-cm vertical skin marking is made starting from the upper pole of patella at the junction of middle and lateral third and extends upward.

quadriceps tendon graft contains 20% higher collagen, higher fibril-interstitium ratio, and higher fibroblast density compared to the same size BPTB graft.¹⁰ There are many advantages of QT autografts like versatility, customization of graft size, reduced anterior knee pain, reduced risk of neurovascular injury, reduced incidence of arthrofibrosis compared to BPTB graft, and preservation of ACL agonist (i.e., hamstrings, implantation of thicker graft and better patella mobility).¹⁰

Shani et al. reported that the 10 mm quadriceps tendon strip has a higher cross-sectional area (91.2 mm^2 vs 48.4 mm^2), higher ultimate load to failure (2185.9 N vs 1580.6 N), and higher stiffness (466.2 N/mm vs 278.0 N/mm) compared to the patellar tendon.¹¹ In a systematic review by Slone et al., 14 studies were reviewed, which included 1,154 ACL reconstruction with QT autograft and concluded that stability outcome, functional outcome, overall patient satisfaction, range of motion, and complications were similar between QT and other tendon autografts, but donor site morbidity was lower in patients who underwent ACL reconstruction with



Fig 3. A 2.5-cm skin incision over above-mentioned skin marking.

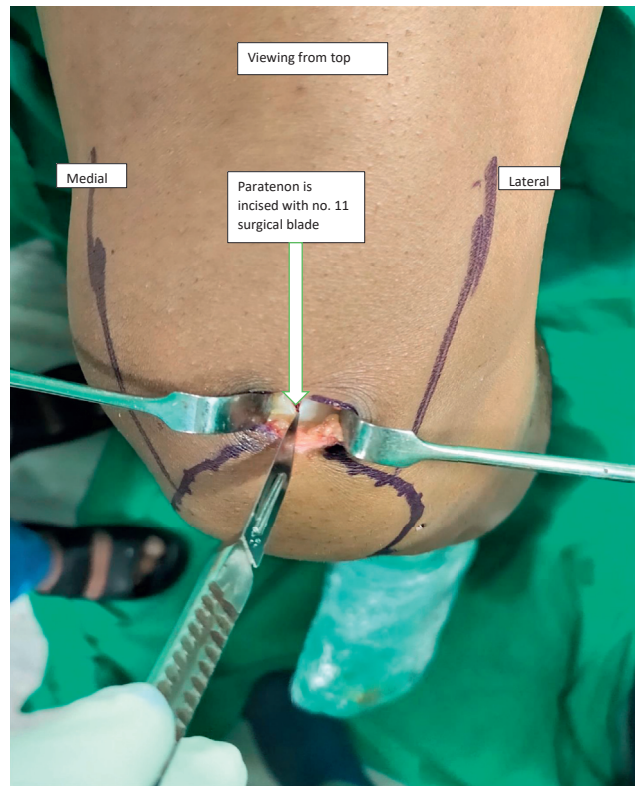


Fig 5. Paratenon is incised with no. 11 surgical blade.

QT autograft.¹² Conventionally, QT autograft is harvested with a long incision, which produces an ugly scar.¹³ Here, we introduce a minimally invasive technique of superficial quadriceps tendon harvesting with the help of a close tendon stripper without using any specialized instrument.

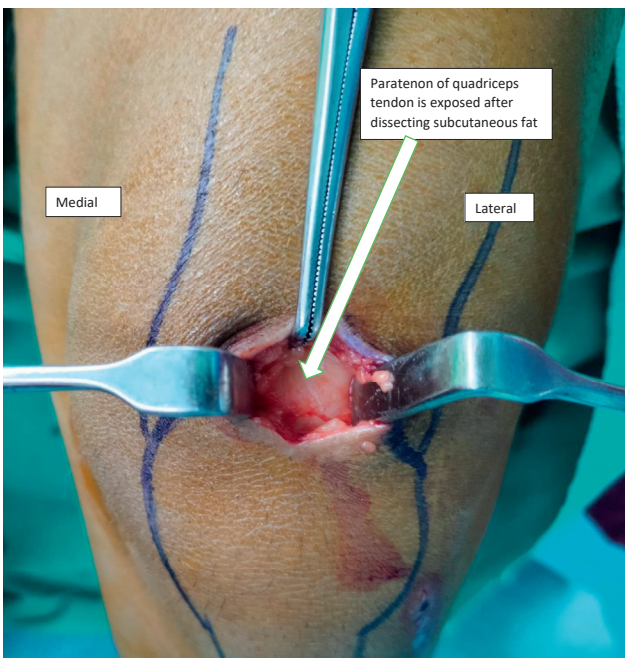


Fig 4. Paratenon is exposed after dissecting subcutaneous fat.

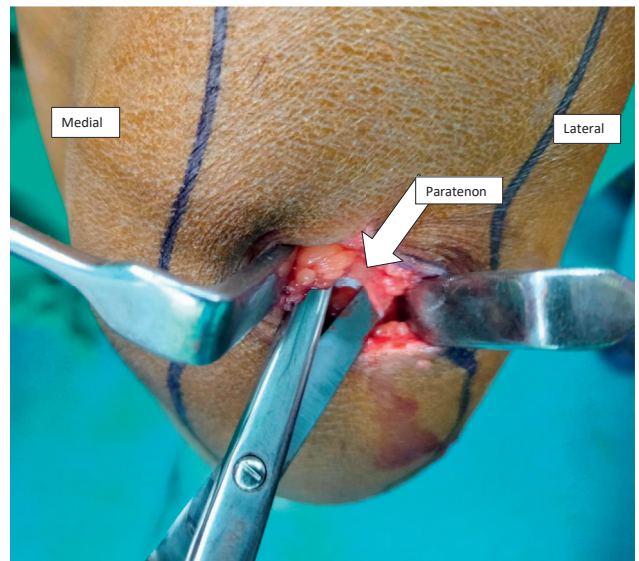


Fig 6. Paratenon is dissected with Mayo dissecting scissor.

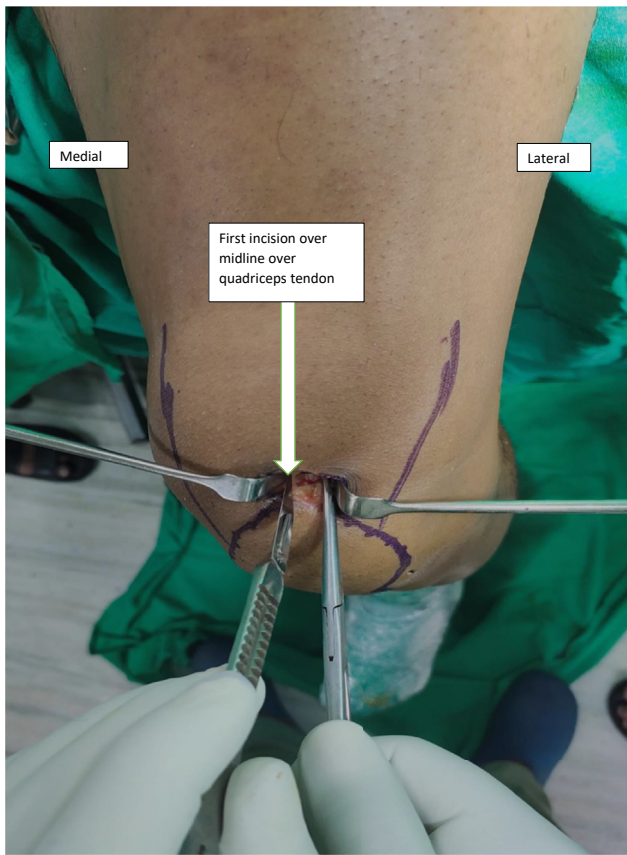


Fig 7. First midline vertical incision over quadriceps tendon

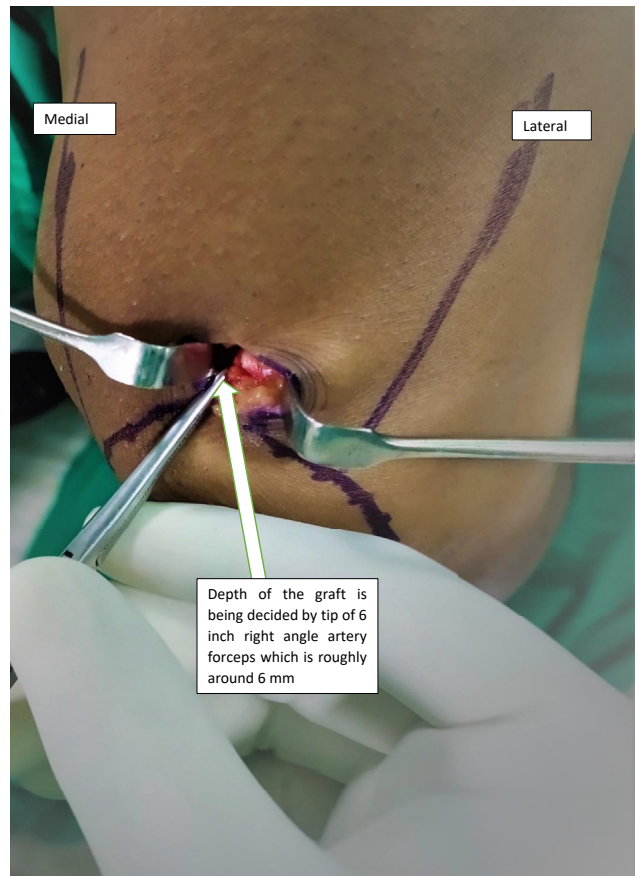


Fig 9. Thickness of graft to be harvested is determined with tip of 6-inch right angle artery forceps (which is roughly 6 mm).

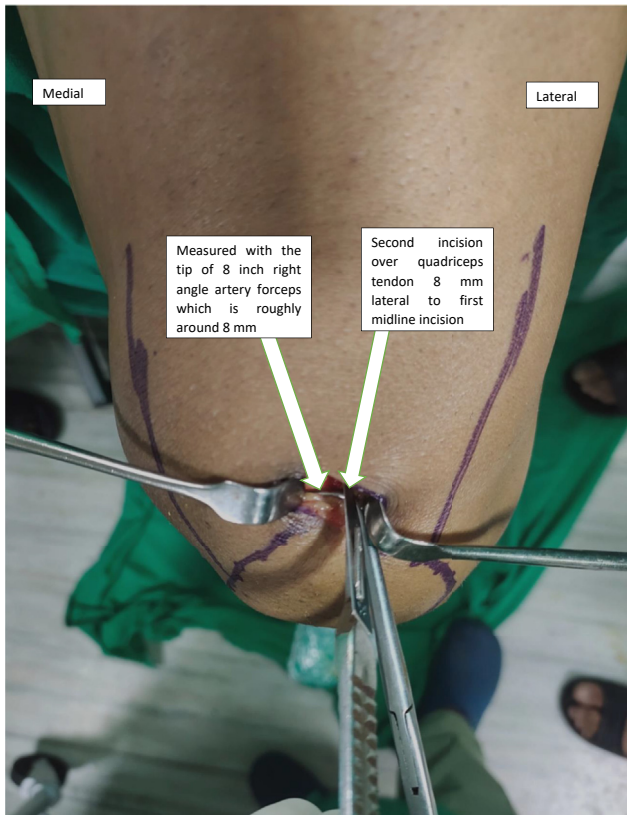


Fig 8. Second vertical incision over quadriceps tendon 8 mm lateral to first vertical incision.

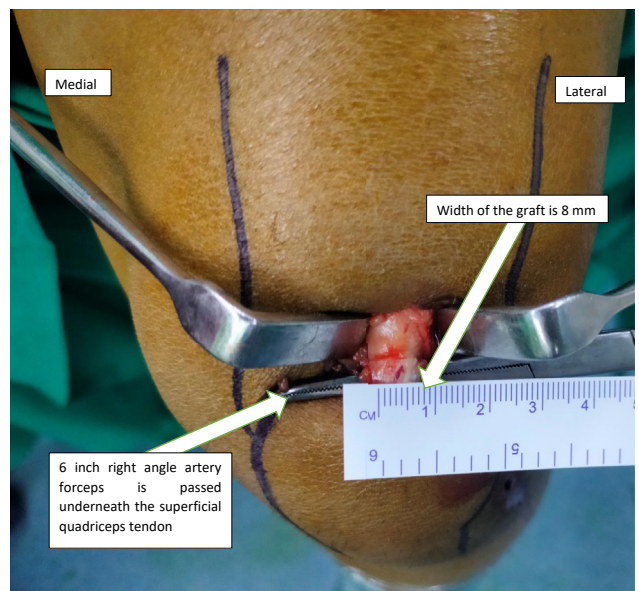


Fig 10. 6-inch right angle artery forceps is passed underneath the superficial quadriceps tendon.

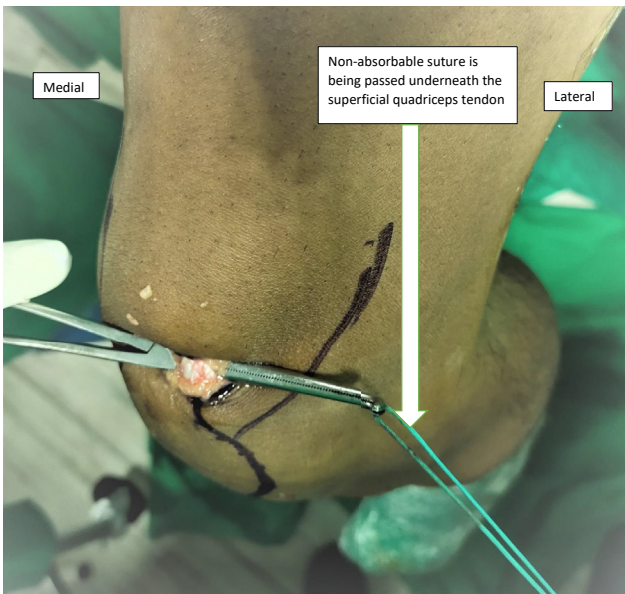


Fig 11. Passing of nonabsorbable suture underneath the superficial quadriceps tendon.

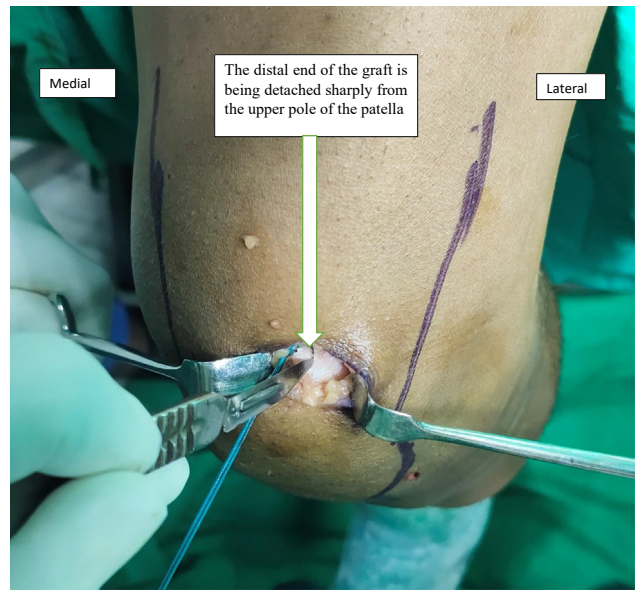


Fig 13. Distal end of the graft is sharply detached from proximal pole of patella.

Surgical Technique

We routinely evaluate the quadriceps tendon using magnetic resonance imaging of the knee to look for thickness of the quadriceps tendon, which is measured 3 cm above the upper pole of the patella in the midsagittal section. We proceed with quadriceps graft harvesting if the thickness at the above-mentioned point is 7 mm or more. Surgery is done under spinal anesthesia unless it is contraindicated; otherwise, general anesthesia is preferred. A pneumatic tourniquet is applied as high as possible in the

upper thigh, and during inflation, the knee is kept maximally flexed to obtain maximum quadriceps length. The leg is put in a hanging position with the knee flexed at 90°. We harvest superficial quadriceps graft from the lateral part of the quadriceps tendon, as it is more tendinous in that area (Fig 1). A 2-2.5-cm vertical skin marking is made, starting from the upper pole of the patella at the junction of the middle and lateral third and extending upward (Fig 2). The skin incision is made with a number 10 surgical blade (Fig 3). Subcutaneous fat is dissected, and the paratenon is exposed (Fig 4). Paratenon is incised with no.

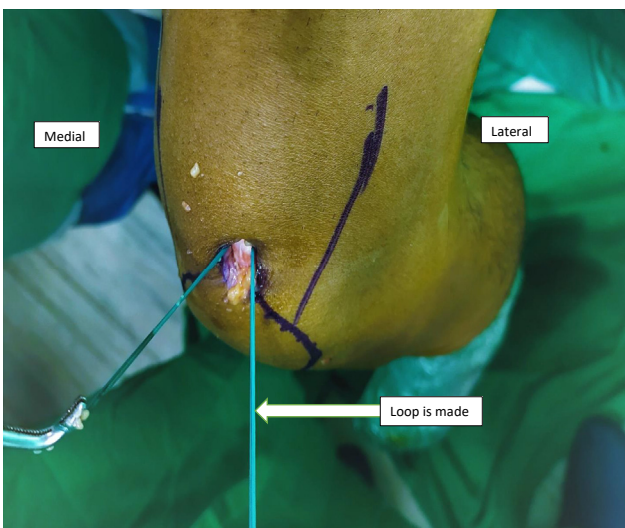


Fig. 12. Superficial quadriceps graft is looped with nonabsorbable suture.

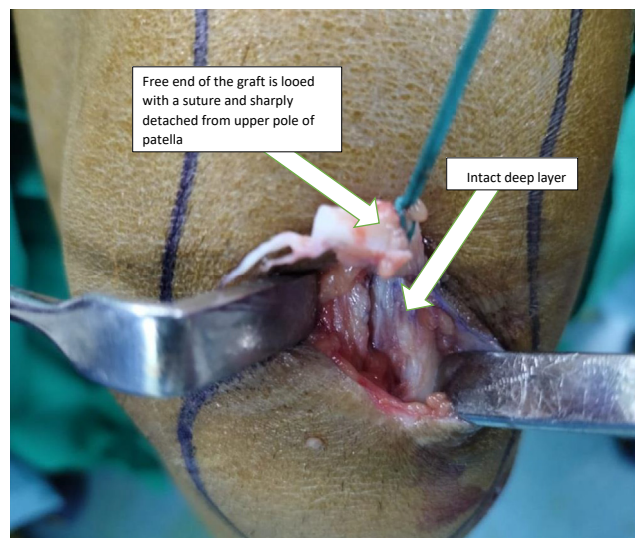


Fig 14. Presence of intact deep layer of quadriceps tendon is ensured

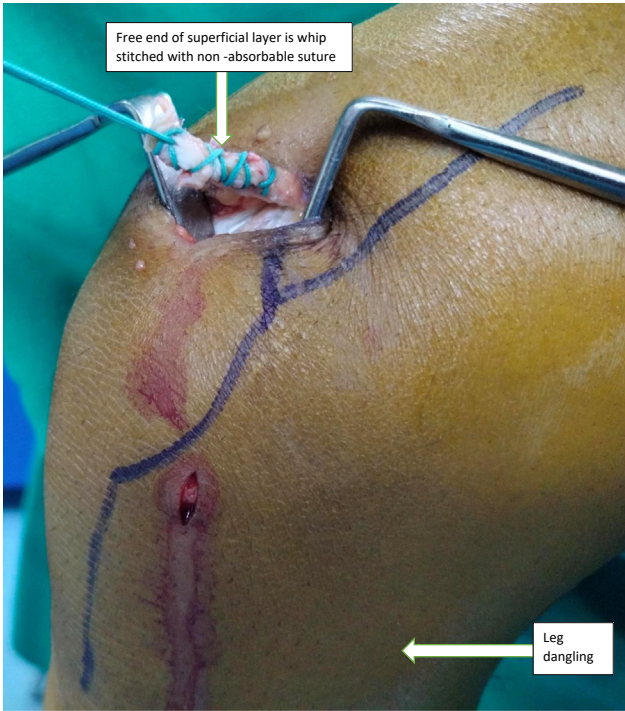


Fig 15. Free distal end of the graft is secured with whipstitch with non-absorbable suture.

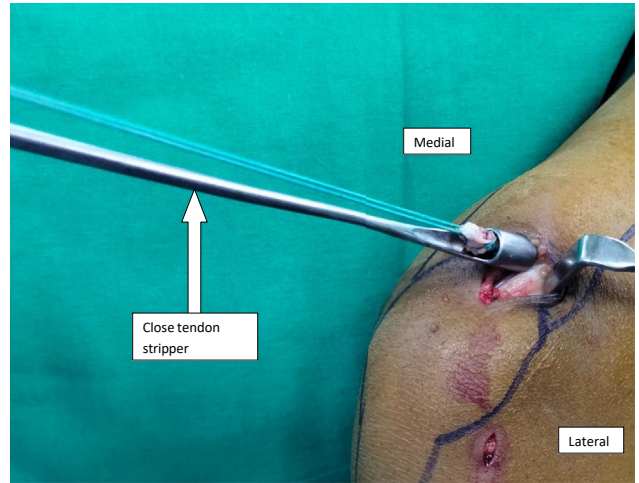


Fig 17. Close tendon stripper is being introduced.



Fig 16. 2-3 cm of superficial tendon is elevated by dissecting with a Mayo dissecting scissor.

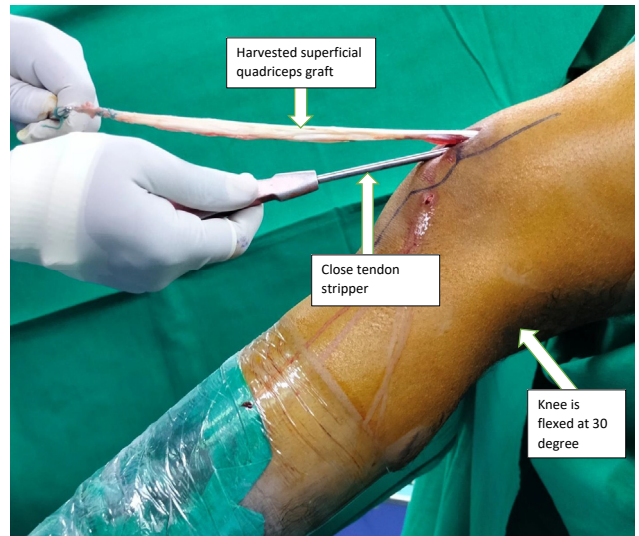


Fig 18. Closed tendon stripper is pushed gently while extending the knee to about 30° flexion to relax the quadriceps muscle. Superficial quadriceps graft is harvested.

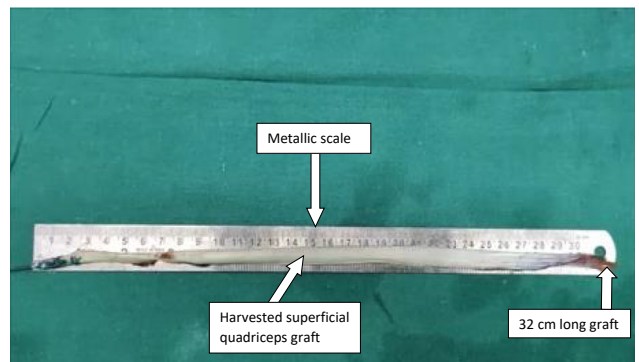


Fig 19. Harvested superficial quadriceps tendon.

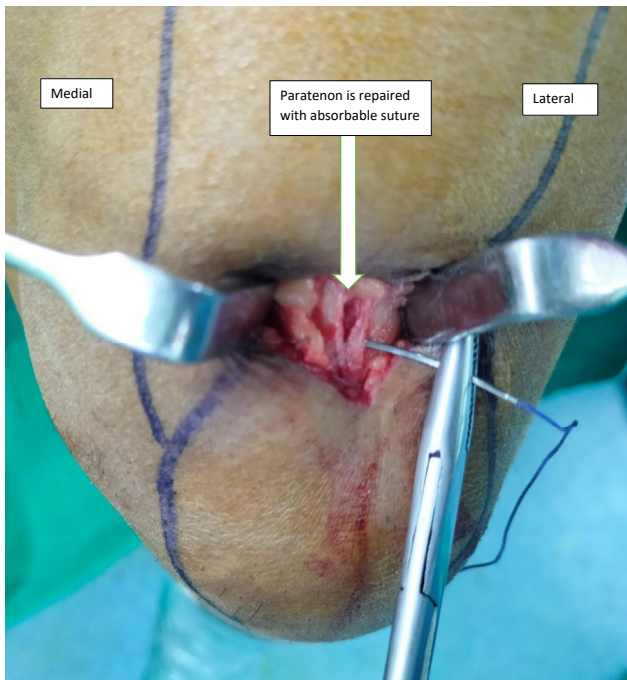


Fig 20. Paratenon is closed with absorbable suture.



Fig 21. Skin incision after closure with nonabsorbable suture.

11 surgical blade (Fig 5) and is dissected and retracted with the Langenbeck retractor until the quadriceps tendon is exposed (Fig 6). Two vertical incisions are made over the quadriceps tendon with number 11 surgical blade—one at midline (Fig 7) and another at 6-8 mm lateral to the midline (Fig 8). Width of the graft is measured with the tip of 8-inch, right-angle artery forceps, which is roughly 8 mm. The thickness of the graft to be harvested is determined with a

6-mm probe or tip of 6-inch right angle artery forceps (which is also 6 mm) (Fig 9). A right-angle artery forceps is passed through the graft at determined depth (Fig 10). The end of the graft is looped with a suture (Fig 11 and Fig 12), and the distal end of the graft is detached sharply from the upper pole of the patella (Fig 13). Intactness of the deep layer of quadriceps tendon is confirmed (Fig 14). The free distal end is secured with whipstitch and nonabsorbable suture (Fig 15); 2-3 cm of superficial tendon is elevated (Fig 16). Here, in this step, we dissect the superficial to the deep layer of the quadriceps tendon. A closed tendon stripper is introduced (Fig 17) and pushed gently while extending the knee to about 30° flexion to relax the quadriceps muscle (Fig 18). The superficial graft is harvested and carefully transferred to the surgical trolley, and graft length is measured (Fig 19). Attached muscle fibers are scrapped out with the help of the end of the metallic scale and prepared accordingly. Paratenon is closed with an absorbable suture (Fig 20). Subcutaneous tissue and skin are closed (Fig 21 and Video 1).

Discussion

Quadriceps tendon autograft is now increasingly used for cruciate ligament reconstruction. Because of the highly invasive nature of the QT graft harvesting technique, many surgeons do not prefer it as a graft of choice. In 2014, Christian Fink¹⁴ described a minimally invasive technique of QT graft harvesting that requires specialized instruments like a double knife, tendon separator, and special tendon cutter (Karl Storz). But our technique does not require any specialized equipment, and the graft can be harvested using a close tendon stripper. A close tendon stripper prevents premature amputation of graft and avoids the penetrating deeper layer or suprapatellar pouch (Fig 22, A-C) (Table 2). The graft is harvested from the lateral part of the tendon keeping in mind the fact that vastus medialis is more muscular, whereas vastus lateralis is more tendinous. As the superficial layer of the tendon is harvested, it does not lead to quadriceps contracture, and prompt rehabilitation can be started, unlike BPTB graft, where sometimes rehabilitation needs to be delayed for several weeks (Table 3). Graft failure is a cause of laxity after ACL reconstruction. There is concern with fixation method during the reconstruction. Though there are publications mentioning tunnel widening after ACL reconstruction with hamstring autograft, no study reports tunnel widening with quadriceps soft tissue graft.¹⁵

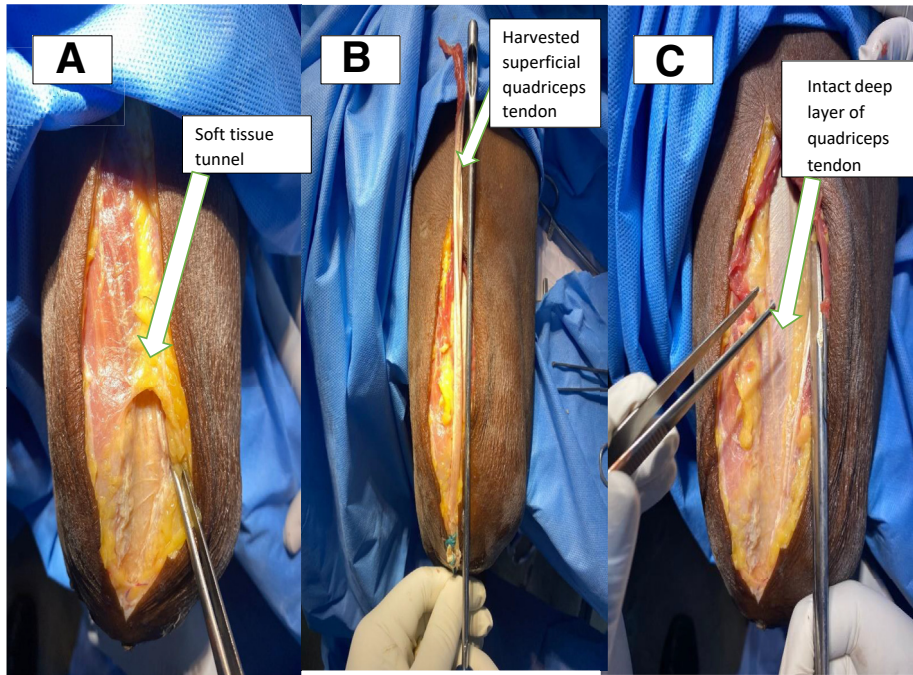


Fig 22. (A, B, C) Pictures from cadaver after harvesting superficial quadriceps tendon by our technique. We opened up the soft tissue tunnel to see whether there is any damage to deep quadriceps. Pictures clearly demonstrate that our technique does not cause any damage to deep quadriceps.

Table 2. Surgical Tips

Surgical Tricks

1. Position: Initially leg is dangling with knee flexed at 90°, then the knee is gradually extended up to 30° flexion during graft harvesting.
2. Skin incision: 2- 2.5 cm, starting from upper pole of patella at the junction of middle third and lateral third and extending upward
3. Incision on quadriceps tendon at midline and 6 mm lateral to it
4. Carefully detach distal end at tendon from upper pole of patella.
5. Always whipstitch the distal end because considerable force need to be applied with tendon stripper during graft harvesting.
6. Repair the paratenon with absorbable suture.

Table 3. Advantage and Disadvantages of our Technique

ADVANTAGES OF OUR TECHNIQUE

1. Minimally invasive technique
2. Simple, does not require any specialized instrumentation
3. Early rehabilitation

DISADVANTAGES OF OUR TECHNIQUE

1. As we use an ordinary close tendon stripper, reasonable force has to be applied by the surgeon to harvest the graft.
2. Although we have not come across it, theoretically, there is risk of quadriceps contracture.
3. Occasionally, there is hematoma formation at musculotendinous junction of quadriceps.

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