Technical Note

Anterior Cruciate Ligament Reconstruction Using Fixed Loop All-Inside (FLAI) Technique

Hesham Mohamed Gawish, M.D., Mahmoud Hammam Hashish, M.Sc., and Mohamed Abd Elmonsef Elghaish, M.Sc.

Abstract: The aim of this surgical technical note is to provide a more secure option to prevent possible graft loosening with all-inside anterior cruciate ligament (ACL) reconstruction. A triple strategy is used. First, a fixed loop cortical device is used on the femoral side. Second, an internal brace augmentation for ACL graft is employed to prevent graft loosening during early postoperative period. Lastly, tying off the sutures of tibial adjustable loop after retensioning to secure its locking mechanism from slippage.

The mechanical properties of the fixation device used to secure the anterior cruciate ligament (ACL) graft before integration play a pivotal role in the outcome of ACL reconstructive surgery. Graft fixation implants must provide appropriate fixation to ensure that graft tension is maintained until graft is incorporated to native bone. The hamstring grafts require about 8 to 12 months for incorporation. During this time, the graft is totally dependent on tibial and femoral fixation devices to maintain normal ACL graft tension. An increase in the length of the graft-fixation device construct during the early postoperative period can lead to micromotion at the graft-bone interface, loss of graft tension, tunnel widening, and clinical failure.[1-3]

The all-inside ACL reconstruction technique was first described in 1995 and has been gaining in popularity ever since. Lubowitz et al.[4] described a second-generation all-inside ACL reconstruction technique, in which a quadrupled graft was tensioned and linked to adjustable-loop cortical suspensory devices on both the femoral and tibial ends.[5] Adjustable-loop cortical suspensory fixation devices are reported to loosen, particularly when they are not tied off after retightening.[1,4]

Kocabey et al. proposed an alternative technique for all-inside ACL reconstruction to prevent possible graft loosening using fixed femoral loop and tying the adjustable tibial cortical fixation sutures.[6] In this article, a fixed loop was used on the femoral side, and an adjustable loop on the tibial side. An internal brace can be added to augment the graft during the early postoperative period. After fixing the graft on both sides, the knee was then cycled 50 times, and then the tibial adjustable loop was retensioned. At the end the tibial fixation device, sutures were fastened along with internal brace sutures (Video 1).

Surgical Technique

Patient Setup

The procedure is usually performed under general anesthesia for easier graft harvesting. The patient is placed in a supine position with leg extended over the table. Examination under anesthesia is performed first to grade the pivot shift and to exclude any other ligamentous injuries. Standard anterolateral and anteromedial arthroscopic portals are used. A diagnostic arthroscopy is then performed, and any intra-articular

From the Department of Orthopedic Surgery and Traumatology, Kafr el-sheik University, Egypt (H.M.G.); Department of Orthopedic Surgery and Traumatology, Ibrahim Obeid Specialized Hospital, Alexandria, Egypt (M.H.H.); and Department of Orthopedics, Hatta Hospital, Dubai Academic Health Corporation, Dubai, United Arab Emirates (M.A.E.E.).

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received April 8, 2023; accepted June 22, 2023.

Address correspondence to Hesham Mohamed Gawish, M.D., Department of Orthopedic Surgery and Traumatology, Kafr el-sheik University, 205 Smouha Gold tower, El Nasr St, Smouha, Alexandria, 21648, Egypt. E-mail: hichamgawish@gmail.com

2212-6287/23537
https://doi.org/10.1016/j.eats.2023.06.017

Fig 1. Use of an open stripper to harvest semitendinosus graft from patient's right leg.

pathology present is treated first. The femoral footprint is identified and prepared with preservation of the ACL remnant. The tibial ACL stump is partially excised to prevent graft dislodgement during graft passage from inside of the knee.

Graft Harvest and Preparation

For this technique, only the semitendinosus is harvested using an open-ended tendon stripper (Pigtail Hamstring Tendon Stripper; Arthrex). The graft is then debrided from any muscular tissue attached. The graft is socked with 1 g of vancomycin powder before and after its preparation (Fig 1).

The graft is then prepared in a loop fashion, as described for original All-Inside ACL reconstruction technique by Lubowitz et al.[4] However, the semitendinosus is looped between a fixed femoral button (Auxilock GFS Mini, Auxein Medical, Haryana, India) and an adjustable tibial button (Auxilock GFS Ultimate Mini, Auxein Medical). The graft is quadrupled over itself and tubularized with no. 2-0 Ethibond sutures (Ethicon, Somerville, NJ) (Fig 2).

The graft length should not exceed 65 mm to avoid graft slackness after passage of the graft from inside the knee. Regarding the femoral fixed loop length, it is advisable to use a 20-mm loop if the femoral tunnel is larger than 32 mm; however, if the femoral tunnel length is less than 32 mm, it is better to use 15-mm loop to allow more graft tissue inside the femoral socket. If the tunnel is more than 35 mm and a 15-mm loop is used, then the graft should be 70 mm long because more graft will be loaded inside femoral socket, making less graft available for tibial socket (Fig 3).

The construct is whipstitched from both sides to allow 15-20 mm of the graft within sockets (Fig 4). The graft is then measured to determine the diameter of femoral and tibial sockets (Fig 5).

Tape Augmentation

A high-strength tape suture can be used to augment the graft and avoid its loosening. Unlike the original internal bracing technique, the tape cannot be shuttled inside the femoral button. Instead, the tape can be loaded with the graft inside the loop of femoral button. The strands of the tape suture are then crossed and wrapped around the graft bundles, creating a self-reinforcing suture noose when tied. The tape ends are then shuttled at the end of surgery through the tibial button and fastened separately as described in Waly et al.[7] (Figs 6 and 7).

ACL Femoral Socket

It is very important to precisely identify the anatomic ACL footprint. The femoral tunnel should be drilled according to anatomical landmarks through the anteromedial portal at 110°−120° of flexion. With the scope in the accessory anteromedial portal, a guide pin is inserted from anteromedial portal in the center of ACL footprint.

A 4.5-mm cannulated reamer is then inserted over the guide pin to drill the path for the femoral button. This graduated reamer is also used to measure the femoral tunnel. It is very important that the cannulated reamer diameter is larger than the diameter of the metal button to allow its passage outside femoral tunnel without getting stacked inside (Fig 8).

A low-profile reamer of the same graft size is then used to drill femoral socket through the portal to avoid damage to the femoral condyle and the posterior cruciate ligament (Fig 9). It is very important to exactly estimate the length of button, length of loop, and length of femoral tunnel. The femoral socket is usually drilled 6-10 mm longer to enable the "flip" movement of the button, resulting in a cavity above the graft after it is tensioned. The depth of drilling of the femoral socket is calculated through this equation:

$$\text{Socket depth } (S) = (\text{femoral tunnel length } (T) - \text{loop length}(L)) + 3/4 \text{ button length } (B)$$

$$S = (T - L) + 3/4\,B$$

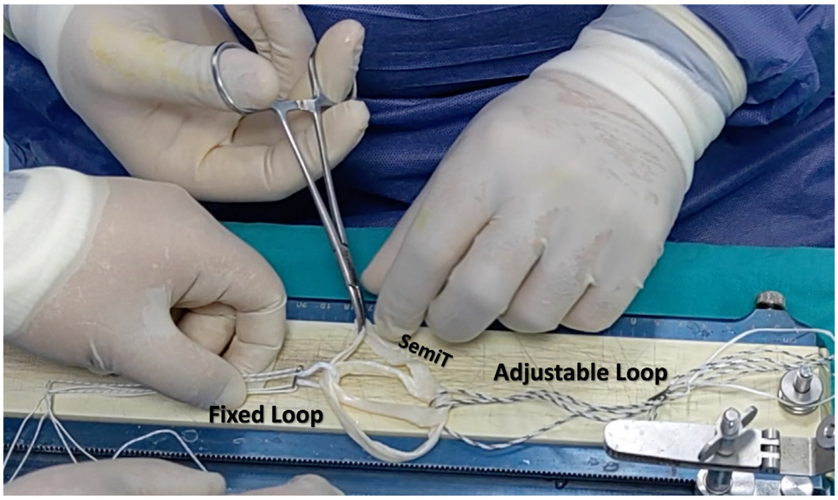

Fig 2. The semitendinosus graft of the right leg is looped between a fixed femoral button and adjustable tibial button.

So, if the femoral tunnel is 38 mm, loop length is 20 mm, and button length is 10 mm, so socket depth will be 25 mm (Figs 10-12). A shuttle suture is then pulled from femoral tunnel (Video 1).

ACL Tibial Socket

With the arthroscope in the anterolateral portal, the FlipCutter ACL tibial C-guide (Arthrex) is locked on the FlipCutter guide ring at an angle of ∼55° to 60°. A retrograde drill (FlipCutter; Arthrex) is used to create the socket. The FlipCutter guide pin is drilled through the graduated-tip guide pin sleeve with a stepped 7-mm-long narrow tip. This tip should be tapped inside the tibial metaphyseal cortex. The FlipCutter is advanced with forward drilling into the knee. The FlipCutter handle is loosened, and a handle switch flips the guide pin tip into the retrograde drilling position. With continued forward drilling but with retrograde force, the tibial socket is drilled in a retrograde manner to create a 30-mm socket. The FlipCutter is pushed back into the knee, flipped back into the guide pin mode, and then removed. The cannulated guide pin sleeve is not removed. Cortical preservation is required for cortical suspensory fixation (Fig 13).

After the FlipCutter is removed, the sleeve is left in place, facilitating simple and reproducible passage of the graft-passing sutures for later graft passage.

Suture Shuttling

Femoral and tibial graft-passing sutures are retrieved. A technical pearl is to retrieve the femoral and tibial graft-passing sutures from the AM arthroscopic portal at the same time to avoid suture tangling or soft-tissue interposition (Fig 14).

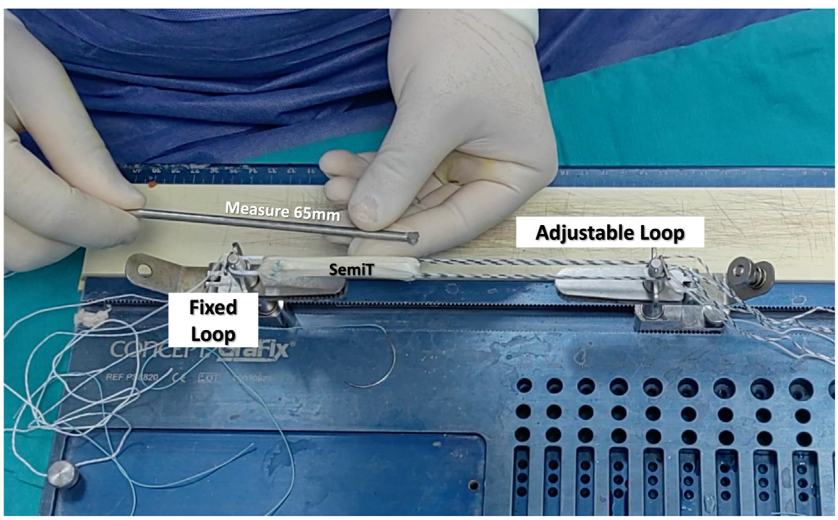

Fig 3. The graft is measured about 65 mm to avoid any graft slackness during all-inside ACL reconstruction.

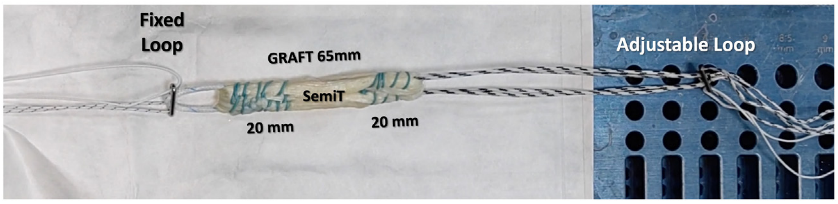

Fig 4. The graft is whipstitched about 20 mm from each side.

Graft Passage Into the Femoral Socket

The femoral fixed loop sutures are retrieved first from anteromedial portal. The femoral button is pulled up until the graft is seen entering the femoral socket. The pulling suture and flipping suture of the fixed button are toggled back-and-forth to ensure cortical button flipping. (Figs 15 and 16)

The tibial adjustable loop and internal brace sutures are then retrieved through the tibial socket to the outside. Once the tibial button and the internal brace sutures are outside the tibial cortex, the internal brace strands are then shuttled through the tibial adjustable loop peripheral holes (Fig 17), according to Waly et al.[7]

The graft is then pulled through the tibial socket after tensioning the tibial adjustable loop. Care should be taken to avoid any soft-tissue interposition between the tibial cortex and the tibial button. The knee is cycled through its range of motion about 50 times, and additional tension may be applied by pulling tibial adjustable-loop sutures for fine tuning of the graft tension with the knee in 15 to 20° of knee flexion, allowing at least 1.5-2 cm of the graft inside each socket. An overly long graft will bottom out on the socket floor and is, therefore, not acceptable (Fig 18 and 19).

The tibial adjustable loop sutures are then fastened over the button to close the loop and prevent locking mechanism slippage (Fig 20). This is followed by suture tape tensioning in full extension and neutral rotation to prevent any overconstraining of the knee and to avoid capturing knee in flexion.

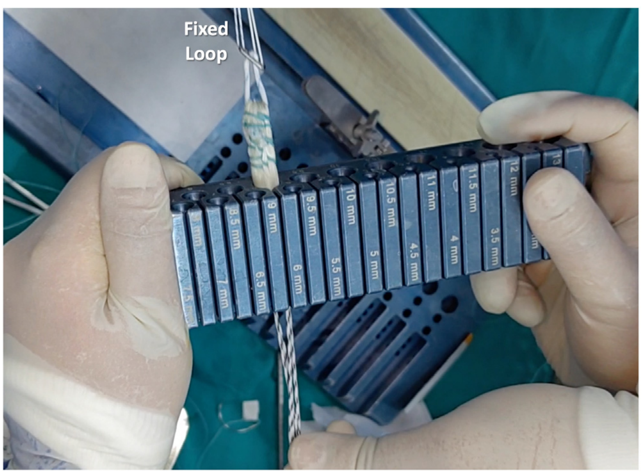

Fig 5. The graft diameter is measured to determine size of femoral and tibial sockets.

Closure

The arthroscopic portals along with the hamstring harvest incision are closed with no. 3-0 PROLENE sutures.

Rehabilitation

Rehabilitation is the same as standard ACL rehabilitation using any other technique. Full weight-bearing and progressive range of motion exercises are encouraged. Early rehabilitation is focused on obtaining full extension and quadriceps activity. Closed-chain strengthening is emphasized. A gradual return to sports activities is allowed as rehabilitation progresses.

Discussion

There are two main types of cortical suspensory fixation devices for ACL graft: the fixed loop and the adjustable loop. With the fixed-loop cortical suspensory devices, the graft is suspended over a continuous high-strength suture loop linked to a button, which is flipped and then fixed over the femoral cortex. These devices provide excellent graft fixation in terms of least graft slippage postoperatively. However, the requirement of drilling the femoral socket to a particular calculated tunnel depth to allow flipping of the button raises concerns in terms of bone preservation, tunnel widening, and inadequate graft length in some anatomical short tunnels.[3]

In contrast, an adjustable-loop cortical suspensory fixation device has a button linked to the graft through the adjustable loop, and the loop is tightened progressively to pull the graft to the end of the femoral socket, which eliminates the undue tunnel drilling required for button flipping. Adjustable-loop devices allow the surgeon to choose any tunnel lengths intraoperatively and to maximize the amount of graft within the tunnel by not drilling undue socket space. Moreover, these devices allow retension of the graft after knee cycling and tibial fixation.[3,8]

The all-inside ACL reconstruction technique was then described by Lubowitz et al.,[4] taking the privileges of

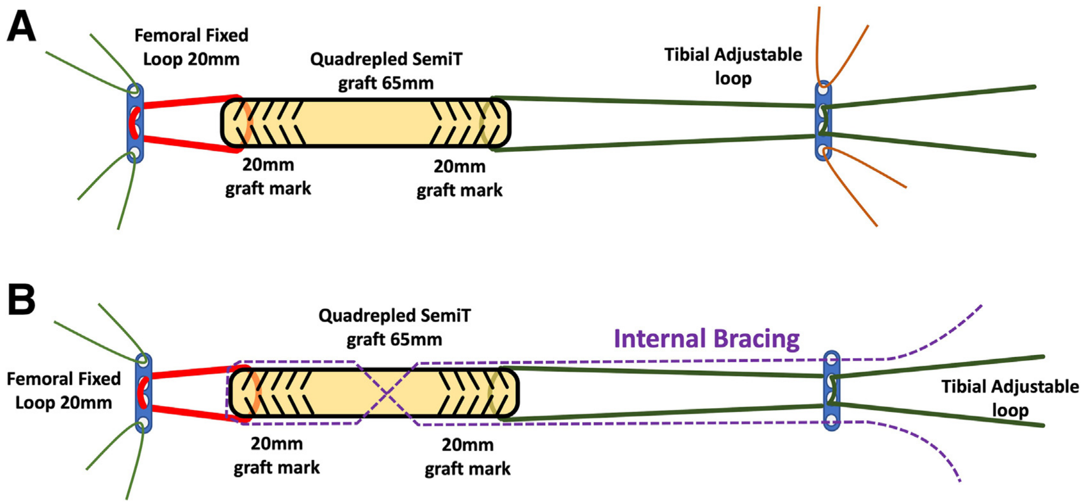

Fig 6. (A) An illustration showing the graft encircled between fixed femoral loop (red) and adjustable tibial loop (green). (B) Augmentation of the construct with internal brace (dashed violet line). The tape is loaded inside femoral closed loop with the graft. The tape is then wrapped and crossed inside the graft. The 2 free ends of the tape are loaded later over peripheral tibial buttonholes.

these adjustable loops to create closed-socket tunnels with double (femoral and tibial) suspensory fixation using small skin incisions. In addition, a single semitendinosus graft is sufficient in most cases. Preserving the gracilis tendon helps maintain knee flexion strength. However, there are rising concerns recently regarding the adjustable loop devices that may elongate over time more than the fixed-loop devices. The one-way locking mechanism of these loops may loosen with continuous cyclic loading, leading to increased graft slippage and clinical laxity postoperatively specially during the golden period of graft incorporation.[1,9]

Houck et al. performed a systematic review and meta-analysis of biomechanical studies comparing fixed with adjustable loops. They found that the fixed-loop device showed the least cyclic displacement, which may be a more clinically applicable measure of device superiority. Moreover, suture failure occurred among a significantly higher proportion of adjustable-loop devices than fixed-loop devices. This meta-analysis suggested that all the adjustable-loop devices lengthen under cyclic loading, which may result in graft fixation lengthening during the early postoperative period and may be clinically significant if more than 3 mm increase in anterior tibial translation. Cyclic loading may be a more clinically applicable test than ultimate load to failure because cyclic displacement significantly affects the graft's capability to heal efficiently, and if the graft displaces but still heals, patients may complain of instability when going back to normal activity levels even without having graft ruptures. Therefore, fixed loops for femoral fixation are considered biomechanically the best option with least displacement.[8]

Petre et al. suggested that sutures of the adjustable loops are sliding through the locking mechanism, thus, allowing the loops to lengthen. Furthermore, these devices may need to be retensioned after cycling the knee. Moreover, they recommended that the fixed-

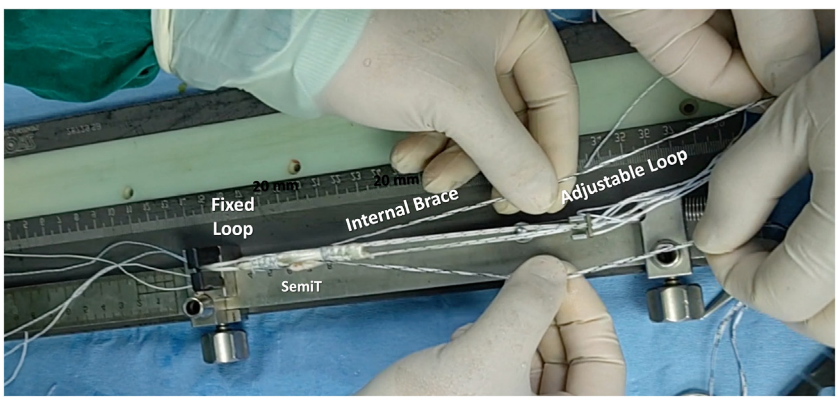

Fig 7. Augmentation of the construct with internal brace. The tape is loaded inside femoral closed loop (right sided loop) with the graft. The tape is then wrapped and crossed inside the graft. The 2 free ends of the tape are loaded later over peripheral tibial buttonholes (left sided loop).

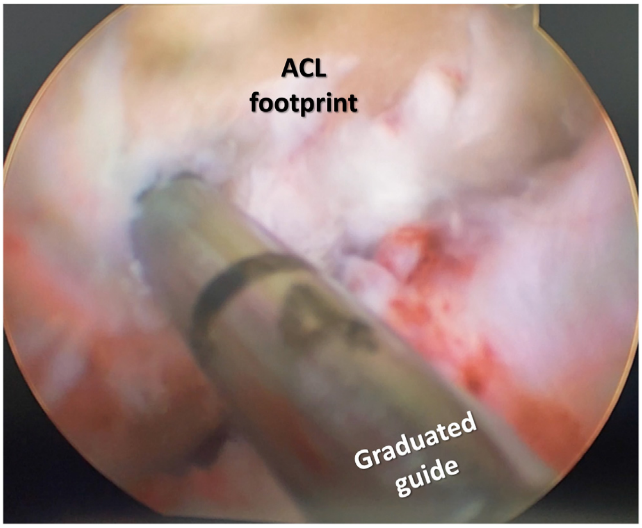

Fig 8. An arthroscopic view of the right knee from accessory anteromedial portal showing a graduated guide pin introduced through anteromedial portal in the footprint of the ACL on medial wall of lateral femoral condyle.

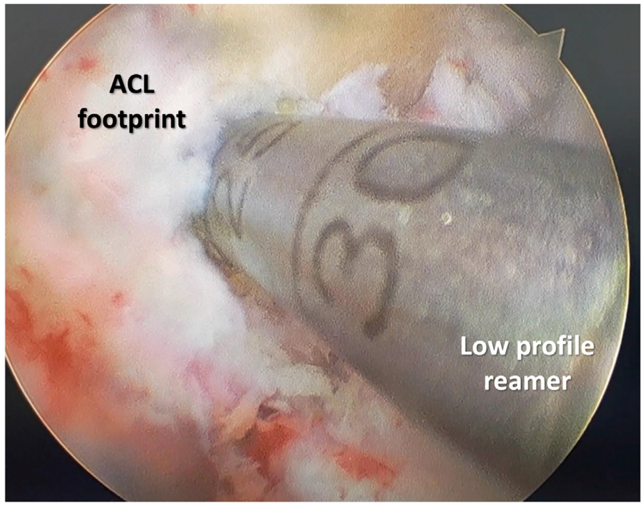

Fig 10. An arthroscopic view of the right knee from accessory anteromedial portal showing a femoral socket depth reaming to 25 mm.

loop device may be superior because it allows less cyclic and initial displacement, thus providing better graft fixation in terms of limiting graft slippage and providing sufficient graft strength.[10]

Choi et al. demonstrated that fixed loops used for femoral fixation yielded significantly greater stability on the pivot-shift test than the adjustable-loop device after ACLR with a hamstring grafts.[11]

Barrow et al. performed a biomechanical study to evaluate lengthening of adjustable loops. They found that adjustable loop systems lengthen under cyclic loads because the free suture ends are pulled into the adjustable loop. This may allow for graft-fixation device lengthening during the acute postoperative period and subsequently leads to delayed graft healing and knee instability. The TightRope and ToggleLoc lengthened greater than the 3-mm threshold for failure during cyclic loading. The TightRope RT showed the greatest elongation over the cyclic loading test. The displacement of the adjustable-length devices can be limited with knot tying but not sufficiently to prevent failure. Not accounting for graft elongation or tibial fixation, the graft must incorporate before ∼2,000 cycles to avoid clinical failure for both the TightRope and the ToggleLoc. The Arthrex TightRope reached clinical failure of 3 mm of lengthening after few cycles (1349 ± 316 cycles), and the Smith & Nephew EndoButton did not reach clinical failure during cyclic load testing. This means that weight bearing and knee loading should be delayed for adjustable-loop systems. The method of

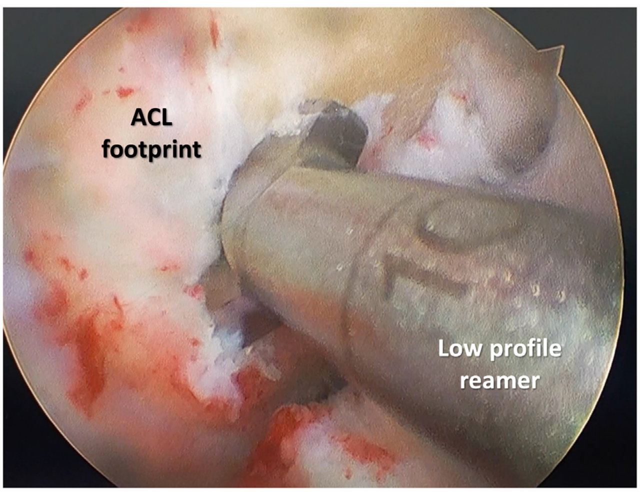

Fig 9. An arthroscopic view of the right knee from accessory anteromedial portal showing a low-profile reamer introduced through anteromedial portal to drill femoral socket.

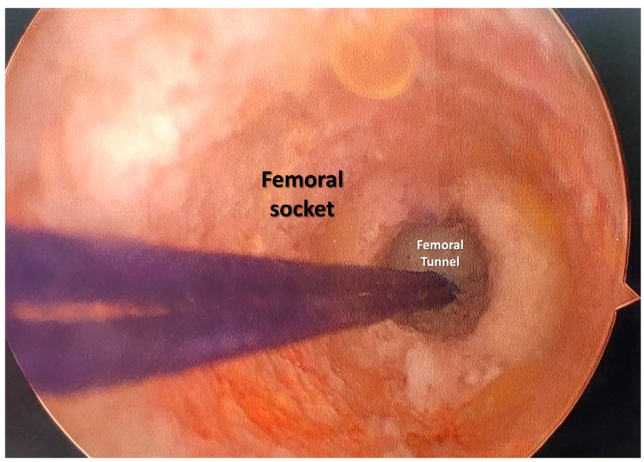

Fig 11. An arthroscopic view of the right knee from anteromedial portal inside femoral tunnel showing socket depth with intact femoral cortex.

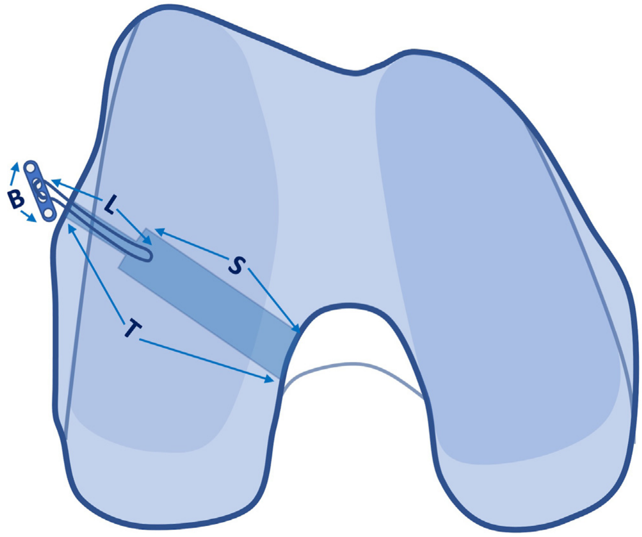

Fig 12. An illustration of distal femur of the right knee showing socket depth (S), femoral tunnel length (T), fixed loop length (L), and button diameter (B).

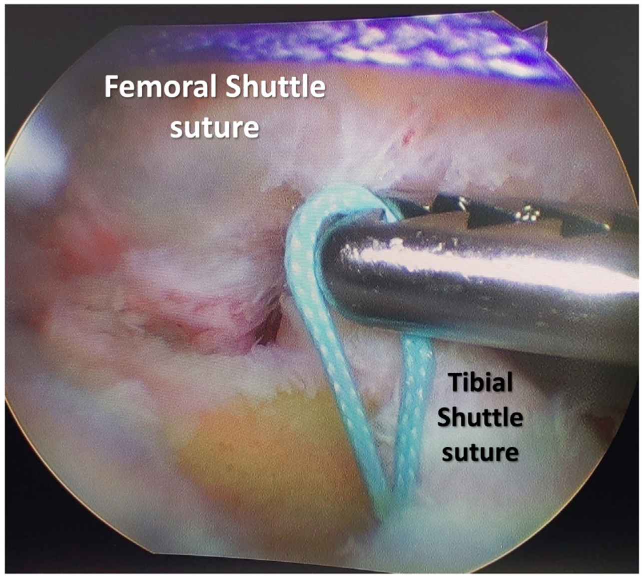

Fig 14. An arthroscopic view of the right knee from the anterolateral portal showing tibial and femoral shuttle sutures of different colors.

construct failure for all TightRope and ToggleLoc devices during both modes of testing was suture breakage near its contact at the button device. The mode of failure for all fixed-loop devices was mid-substance suture loop breakage, which is very rare to happen.[1]

Noonan et al. evaluate the effects of retensioning and knot tying of adjustable loops after ACL reconstruction. They found that elongation of adjustable loops was eliminated by retensioning and knot tying. The elongation was reduced by 60%-88% if retensioning and knot tying were performed after the initial cycling, which also enhanced ultimate load. This technique may help to further reduce concerns of loop slippage and displacement with cyclic loading during postoperative rehabilitation.[12]

Johnson et al. biomechanically compared the current fixed-loop and adjustable-loop cortical suspension devices for femoral fixation under high loads. They observed significant differences between fixed-loop and adjustable-loop cortical suspensory fixation devices. They recommended avoiding early rehabilitation protocols that may subject the graft construct to higher loads.[13]

Singh et al. in their systematic review found that all adjustable loops showed elongation occurred more than 3 mm under loading protocols, whereas the clinical studies have not shown any significant differences

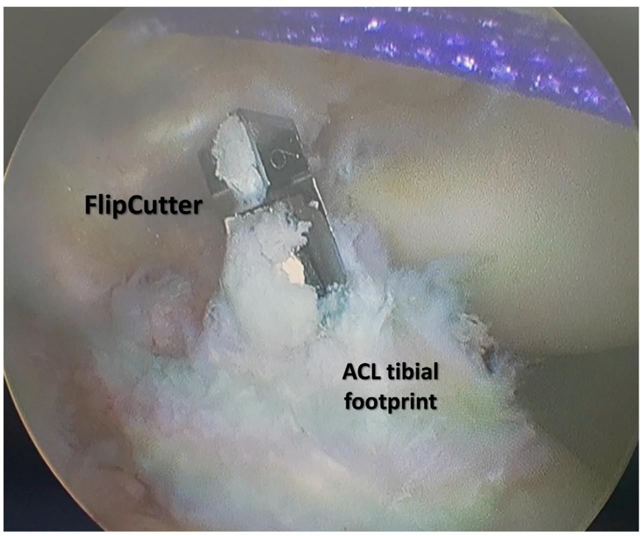

Fig 13. An arthroscopic view of the right knee from anterolateral portal showing a FlipCutter introduced to create tibial tunnel.

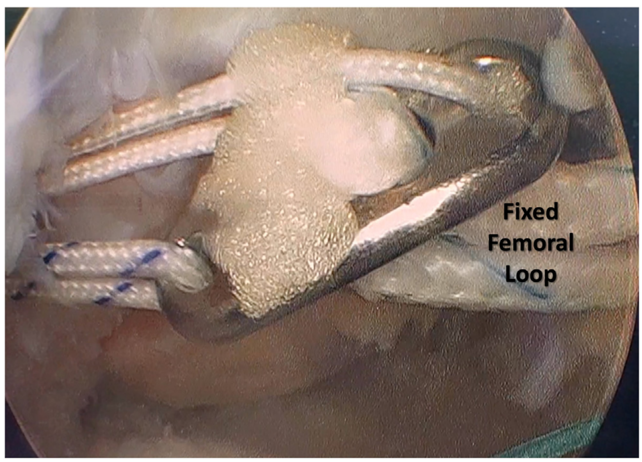

Fig 15. An arthroscopic view of the right knee from the anterolateral portal showing retrieval of femoral button from anteromedial portal.

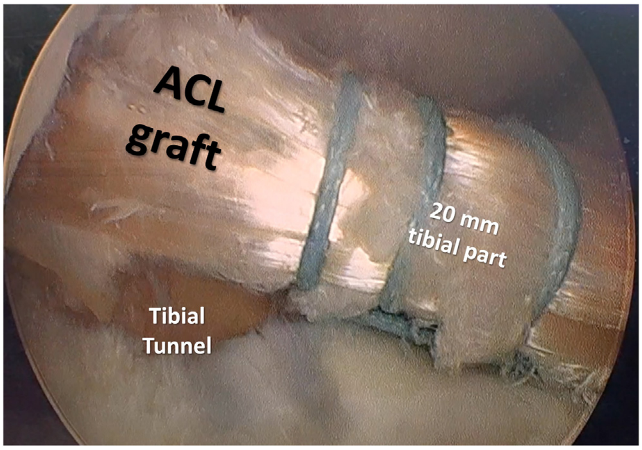

Fig 16. An arthroscopic view of the right knee from the anterolateral portal showing the ACL graft is retrieved through the anteromedial portal into the femoral socket with the tibial part of graft (20 mm at edge of tunnel) still not retrieved.

between the patients with fixed loop and the patients with adjustable loop devices.[14]

Chapman et al. in 2023 biomechanically compared all adjustable loops and found that the Arthrex TightRope displayed the greatest permanent deformation and the greatest cumulative peak displacement. Moreover, it had the least stiffness among five tested loops. This study provoked the concern about using this loop for all-inside ACLR.[15]

Kano et al. evaluated the mechanical damage to the graft with suspensory fixation devices. They found that

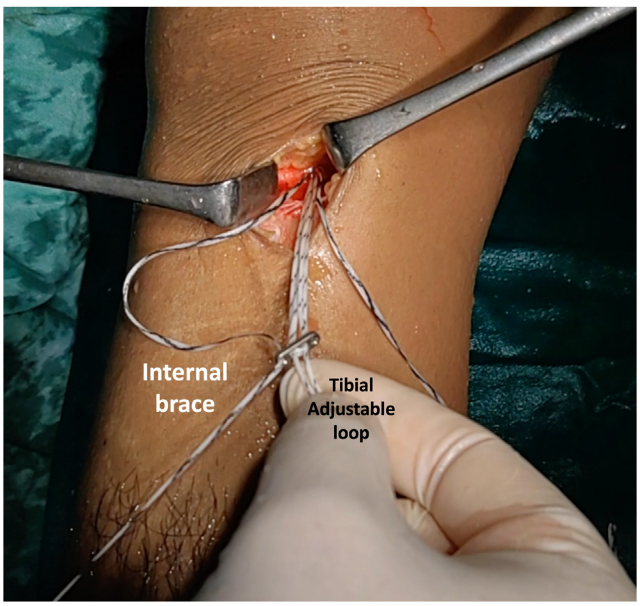

Fig 17. Once the tibial button and the internal brace sutures are outside the tibial cortex, the internal brace strands are then shuttled through the tibial adjustable-loop peripheral holes.

Fig 18. Tensioning of tibial adjustable loop over upper tibial metaphysis of the right knee.

fixed loops demonstrated the least cyclic displacement. Moreover, some types of adjustable loops (namely, Arthrex TightRope) exhibited the greatest graft tissue damage at the suspensory site. The thinner the adjustable loop mechanism, the more graft damage there is by frictional stresses during loop adjustment or by repetitive tensioning stresses.[16]

To solve the problem of adjustable loop loosening with all-inside ACL reconstruction, Kocabey et al. proposed an alternative option with use of a femoral fixed loop and tying off the sutures of the adjustable tibial loop after retensioning and knee cycling.[6]

In this technique, three main strategies were used to overcome the aforementioned problems of lengthening of the graft and lengthening of the devices. The first strategy is the use of a fixed loop for femoral fixation. The length and size of the graft should, therefore, be

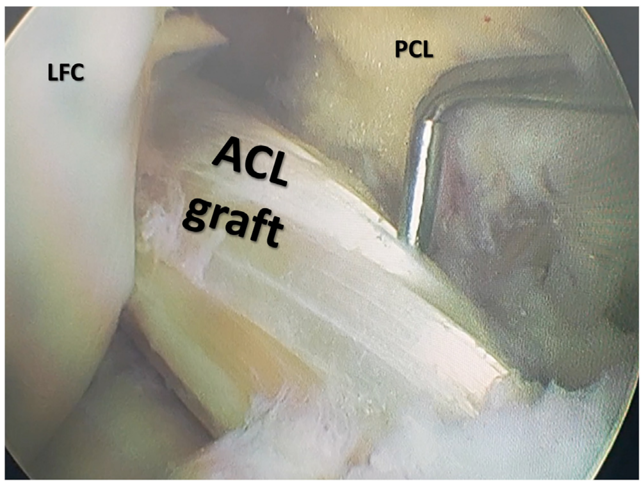

Fig 19. An arthroscopic view of the right knee from anterolateral portal showing well tensioned ACL graft without slackness. ACL, anterior cruciate ligament; LFC, lateral femoral condyle; PCL, posterior cruciate ligament.

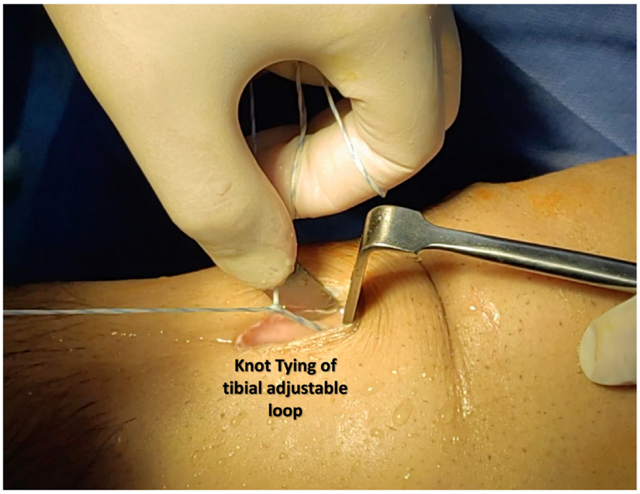

Fig 20. Knot tying of tibial adjustable-loop sutures to close the loop and avoid slackness of its locking mechanism upon loading.

meticulously adjusted intraoperatively. The second strategy is securing the locking mechanism of the tibial adjustable loop by suture tying off over the tibial button after adequate tensioning of the graft and cycling of the knee. The third strategy is internal bracing with tape augmentation of the graft to minimize graft lengthening during early postoperative period. The pearls and pitfalls of the technique are discussed in Table 1, and advantages and disadvantages of the technique are discussed in Table 2. Applying these three strategies, the graft can reach zero laxity from day 0 and along the whole early postoperative period until graft incorporation within the tunnel. This technique may offer a safe early rehabilitation protocol without higher risk of graft lengthening.

Table 1. Pearls and Pitfalls of the FLAI Technique

Pearls	Pitfalls
The total length of tibial and femoral tunnels and intra-articular distance should be longer than the quadrupled graft to avoid "bottoming out" of the graft.	Any mistake during sizing of the graft would lead to slackness of the graft.
Socket depth must be meticulously measured and reamed	Any mistake during femoral socket sizing may lead to nonflipping of the button or femoral cortex blowout.
If tunnel is shorter than 32 mm, it is better to use 15-mm fixed loop. If the femoral tunnel is longer than 32, it is better to use 20-mm fixed loop	The requirement of overdrilling the femoral socket to allow flipping of the button raises the concerns in terms of bone preservation, tunnel widening, and inadequate graft length in some anatomical short tunnels
The graft should not exceed 60-65 mm to avoid graft slackness	In cases of shorter tunnels, the amount of the graft may be less than 15 mm in contact with host bone for graft incorporation.

FLAI, fixed loop all-inside.

Table 2. Advantages and Disadvantages of FLAI Technique

Advantages	Disadvantages
Fixed loop femoral fixation with least displacement on cyclic loading	Tensioning of the graft can only be adjusted from the tibial side.
Securing the locking mechanism of tibial adjustable loop after appropriate tensioning is achieved may lock the reported loosening of the adjustable loop.	High risk of error in adjusting the tunnel and graft length
Tape augmentation may protect the graft during early rehabilitation by unloading the construct till graft incorporation.	More bone reaming is necessary in the femoral tunnel to allow button flipping.
It is a safer all-inside ACL reconstruction with the whole merits of all-inside technique reported.	
Only semitendinosus is harvested leaving the gracilis intact for better knee function in athletes	

ACL, anterior cruciate ligament; FLAI, fixed loop all-inside.

References

1. Barrow AE, Pilia M, Guda T, Kadrmas WR, Burns TC. Femoral suspension devices for anterior cruciate ligament reconstruction: do adjustable loops lengthen? *Am J Sports Med* 2014;42:343-349.
2. Nye DD, Mitchell WR, Liu W, Ostrander RV. Biomechanical comparison of fixed-loop and adjustable-loop cortical suspensory devices for metaphyseal femoral-sided soft tissue graft fixation in anatomic anterior cruciate ligament reconstruction using a porcine model. *Arthroscopy* 2017;33:1225-1232.
3. Boyle MJ, Vovos TJ, Walker CG, Stabile KJ, Roth JM, Garrett WE Jr. Does adjustable-loop femoral cortical suspension loosen after anterior cruciate ligament reconstruction? A retrospective comparative study. *Knee* 2015;22:304-308.
4. Browning WM 3d, Kluczynski MA, Curatolo C, Marzo JM. Suspensory versus aperture fixation of a quadrupled hamstring tendon autograft in anterior cruciate ligament reconstruction: A meta-analysis. *Am J Sports Med* 2017;45:2418-2427.
5. Lubowitz JH, Ahmad CS, Anderson K. All-inside anterior cruciate ligament graft-link technique: second-generation, no-incision anterior cruciate ligament reconstruction. *Arthroscopy* 2011;27:717-727.
6. Kocabey Y, Yalçın S, Erdil M, Polat G. An alternative femoral fixation in all-inside anterior cruciate ligament reconstruction: A solution for preventing possible graft loosening. *Arthrosc Tech* 2019;8:e861-e865.

7. Waly AH, ElShafie HI, Morsy MG, et al. All-inside anterior cruciate ligament reconstruction with suture tape augmentation: Button tie-over technique (BTOT). *Arthrosc Tech* 2021;10:e2559-e2570.
8. Houck DA, Kraeutler MJ, McCarty EC, Bravman JT. Fixed- versus adjustable-loop femoral cortical suspension devices for anterior cruciate ligament reconstruction: A systematic review and meta-analysis of biomechanical studies. *Orthop J Sports Med* 2018;6, 2325967118801762.
9. Eguchi A, Ochi M, Adachi N, Deie M, Nakamae A, Usman MA. Mechanical properties of suspensory fixation devices for anterior cruciate ligament reconstruction: Comparison of the fixed-length loop device versus the adjustable-length loop device. *Knee* 2014;21:743-748.
10. Petre BM, Smith SD, Jansson KS, et al. Femoral cortical suspension devices for soft tissue anterior cruciate ligament reconstruction: A comparative biomechanical study. *Am J Sports Med* 2013;41:416-422.
11. Choi NH, Yang BS, Victoroff BN. Clinical and radiological outcomes after hamstring anterior cruciate ligament reconstructions: comparison between fixed-loop and adjustable-loop cortical suspension devices. *Am J Sports Med* 2017;45:826-831.
12. Noonan BC, Dines JS, Allen AA, Altchek DW, Bedi A. Biomechanical evaluation of an adjustable loop suspensory anterior cruciate ligament reconstruction fixation device: The value of retensioning and knot tying. *Arthroscopy* 2016;32:2050-2059.
13. Johnson JS, Smith SD, LaPrade CM, Turnbull TL, LaPrade RF, Wijdicks CA. A biomechanical comparison of femoral cortical suspension devices for soft tissue anterior cruciate ligament reconstruction under high loads. *Am J Sports Med* 2015;43:154-160.
14. Singh S, Shaunak S, Shaw SCK, Anderson JL, Mandalia V. Adjustable loop femoral cortical suspension devices for anterior cruciate ligament reconstruction: A systematic review. *Indian J Orthop* 2020;54:426-443.
15. Chapman G, Hannah J, Vij N, Liu JN, Morrison MJ, Amin N. Biomechanical comparison of adjustable-loop femoral cortical suspension devices for soft tissue ACL reconstruction. *Orthop J Sports Med* 2023;11, 23259671221146788.
16. Kano T, Ishikawa M, Ogawa Y, et al. Comparison of the mechanical properties and mechanical damages to tendon tissue in three suspensory fixation techniques. *Asia Pac J Sports Med Arthrosc Rehabil Technol* 2022;30:1-8.