Technical Note

Graft Retensioning by Dialing of Suture Disk on Tibial-Side Fixation in Arthroscopic Anterior Cruciate Ligament Reconstruction: Pathak Pune Dialing Technique

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Abstract: Arthroscopic anterior cruciate ligament (ACL) reconstruction is a common procedure performed for symptomatic ACL tears, especially in athletes. The desired surgical end product with any surgical fixation device remains a taut ACL graft, which is crucial during postoperative rehabilitation to reduce the risk of knee instability and rerupture of the ACL graft. The purpose of this Technical Note and accompanying video is to describe a simple and cost-effective technique to easily retension the ACL graft after tibial fixation in ACL reconstruction using a suture disk device. The technique uses a simple suture disk device to provide strong tibial fixation, along with the unique ability to retension the ACL graft by dialing it in a clockwise direction.

The anterior cruciate ligament (ACL) is one of the primary stabilizers of the knee, and ACL tears are commonly associated with sports injuries.[1] The ACL is the main restraint against anterior tibial translation. Arthroscopic ACL reconstruction is the most commonly performed procedure for symptomatic ACL tears.[2] For a successful ACL reconstruction, a properly tensioned ACL graft that does not undergo elongation with initial postoperative knee motion and loading during rehabilitation is necessary.[3] Anatomic footprint restoration and optimum tensioning of the ACL graft are critical for healing and functional outcome.

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One of the reasons for graft failure is inadequate tensioning or a loose graft. Intraoperative residual laxity in the reconstructed graft can lead to postoperative instability, resulting in graft failure. Surgical reconstruction of the ACL with a taut graft construct is necessary to restore knee stability. Loss of tension in a graft can cause symptomatic anterior or rotatory instability and potential retear of the ACL graft.

A common form of graft fixation in ACL reconstruction on the femoral side is suspensory fixation in the form of a fixed- or variable-loop EndoButton (Smith & Nephew, Andover, MA), and a common form on the tibial side is interference screw or suspensory fixation. In India, a fixed-loop EndoButton on the femoral side with suspensory fixation on the tibial side is one of the commonly used combinations of fixation modalities. In these cases, the tibial suspensory fixation is achieved using a suture disk. The desired surgical end product of ACL reconstruction with any surgical fixation device remains a taut ACL graft; in addition, the ability to retension the tendon graft after fixation is a unique technical feature that cannot be obtained by all fixation devices. Variable-loop fixation can be used to retension the graft even after fixation, whereas fixation with a fixed-loop EndoButton with a suture disk shows a drawback in this regard; thus, our intent is to describe the Pathak Pune dialing technique to achieve

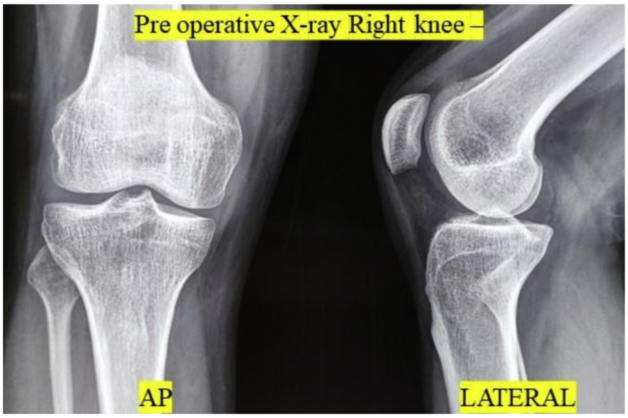

Fig 1. Preoperative radiographs of right knee: anteroposterior (AP) and lateral views.

retensioning after fixation by dialing of the suture disk in a fixed loop. A similar technique can be used in transosseous repair of the meniscal root and arthroscopic posterior cruciate ligament avulsion fracture fixation using a suture pullout technique on the tibial side.

The ability to retension the tendon graft after fixation is a unique technical feature not afforded by all fixation devices. Hence, the purpose of this Technical Note and Video 1 is to describe a simple and cost-effective technique to easily retension the ACL graft after tibial fixation in ACL reconstruction using a suture disk device. The technique uses a simple suture disk device to provide strong tibial fixation, along with the unique ability to retension the ACL graft by dialing it in a clockwise direction.

Surgical Technique

Preoperative Evaluation

The diagnosis of ACL injury is based on history, physical examination, and imaging. A traumatic contact injury or a noncontact pivoting injury during rapid acceleration or deceleration with a change in direction is the most common cause of ACL injury. Patients usually describe a history of a twisting injury to the knee that produces hyperextension, valgus, and abduction forces in the affected knee. Patients with an ACL tear will present with a swollen and painful knee with difficulty bearing weight on the affected extremity. The results of the Lachman and anterior drawer tests are often positive, indicating an ACL-deficient knee. Radiographs of the knee typically show normal findings (Fig 1). Swelling develops soon after the injury, and patients have difficulty in weight bearing. The diagnosis is confirmed using advanced imaging such as magnetic resonance imaging, which will show ligament disruption and other associated meniscal or osteochondral injuries (Fig 2).

Patient Setup

Stability is examined with the patient under anesthesia using the Lachman and pivot-shift tests. ACL reconstruction is performed using a transportal technique of femoral drilling. The implants used are the fixed-loop EndoButton CL Ultra device (15 mm; Smith & Nephew) and 2-hole conical suture disk washer (HIB Surgicals, Mumbai, India).

Position

Under spinal anesthesia, the patient is placed supine on the operating table in the standard arthroscopy position. A lateral post is placed just proximal to the knee at mid-thigh level. The lateral post acts as a stabilizer in the 90° position and aids in the valgus stress position. A foot bump is placed on the table to maintain a 90° knee flexion position. A tourniquet is applied just above midthigh level. In this position, the knee can be freely moved from a position of extension to hyperflexion with ease.

Arthroscopic Portal Placement

Knee arthroscopy is performed using standard anteromedial, anterolateral, and accessory anteromedial portals. Diagnostic arthroscopy is performed, ACL rupture is confirmed, and concurrent intra-articular pathologies are addressed. The femoral and tibial footprints are identified. A remnant-preserving technique is used.

ACL Graft Harvest

Semitendinosus graft is harvested through a small longitudinal incision made over the skin overlying the

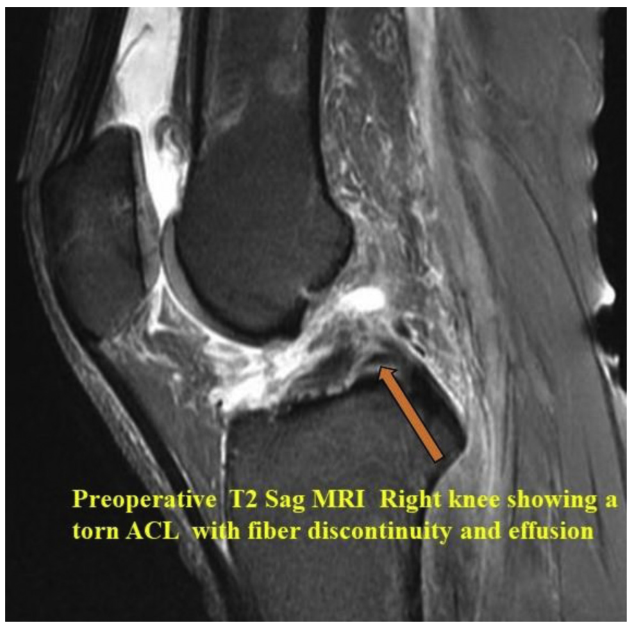

Fig 2. Preoperative sagittal (Sag) T2 section on magnetic resonance imaging (MRI) of right knee showing torn anterior cruciate ligament (ACL) with fiber discontinuity and effusion (arrow).

pes anserinus. Typically, the length of the semitendinosus varies from 26 to 28 cm. A 4-fold semitendinosus graft is prepared using No. 5 Ethibond (Ethicon [Johnson & Johnson], Chihuahua, Mexico). A minimum graft diameter of 8 or 9 mm is accepted. If the diameter is less than 8 mm, double-folded gracilis is added to the graft construct. The overall length of the graft varies from 6.5 to 7 cm.

Tunnel Drilling

Transportal femoral drilling is performed using a 3-mm guidewire through an accessory low medial portal in hyperflexion greater than 120°. A 4.5-mm femoral reamer (Acufex; Smith & Nephew) is passed over the drill wire and drilled throughout the femoral condyle. The femoral tunnel depth is measured (e.g. 40 mm).

The femoral-side anatomic footprint is identified using bony ridges. For a 40-mm femoral tunnel, 20 mm of fixed-loop EndoButton CL Ultra (with a 15-mm length) is chosen. A minimum of 8 to 10 mm of the far cortex of the femur is preserved to prevent femoral tunnel blowout.

The tibial tunnel is drilled using an ACL jig (Acufex; Smith & Nephew) with a 55° angle at 90° of knee flexion. It should be ensured that the length of the tunnel is more than 35 mm so that the graft will not come out of the tunnel. The anterior horn of the lateral meniscus and tibial eminence spine are used as references for drilling the tibial tunnel.

The tibial mouth of the tunnel is cleared of soft tissues. A wire loop is passed through the femoral and tibial tunnels. The EndoButton CL Ultra (15-mm) device with graft is passed with the help of the wire loop. Prior to the passage of the graft and loop, the lateral condylar width (adding 6 mm) is marked from the button toward the graft, indicating where the button should flip on the lateral cortex (Figs 3 and 4). A No. 2-0 Vicryl marker (Ethicon) is placed at 46 mm to assist smooth flipping of the EndoButton. The EndoButton CL Ultra (15-mm) device is flipped over the femoral cortex. Multiple knee-bending maneuvers are performed to remove slack in the sutures and graft while on the table. Tibial fixation is achieved using the 2-hole conical suture disk washer by tying multiple knots in No. 5 Ethibond at 30° of flexion.

ACL Graft Retensioning

After tibial fixation, graft tension is assessed with a probe. About 50% of the time, the graft is found to be slightly loose. To optimize graft tension, we use our technique of dialing of the 2-hole conical suture disk washer (Fig 5). Clockwise rotation of the suture disk is achieved with an artery forceps holding onto the 2 holes of the conical suture disk washer. Three to four rotations can easily achieve optimum retensioning of the graft (Fig 6). Intraoperatively, dialing is viewed arthroscopically through the anterolateral portal, and ACL graft tension is noted before (Fig 7), during (Fig 8), and after (Fig 9) dialing of the 2-hole conical suture disk washer. This is also confirmed by clockwise movement of the graft and distal movement of the No. 2-0 Vicryl marker tied on the ACL graft.

At the end of dialing and retensioning, we check for spontaneous "undialing" (which has not occurred in our experience). Graft tension is again checked using a probe (Fig 10). Distal movement of the marker confirms tensioning by 1 to 2 mm. Notch impingement is checked by positioning the knee in full extension. The entire procedure, from preoperative retensioning of the graft to intraoperative dialing of the 2-hole conical suture disk washer from outside and arthroscopic retensioning, is shown in Video 1.

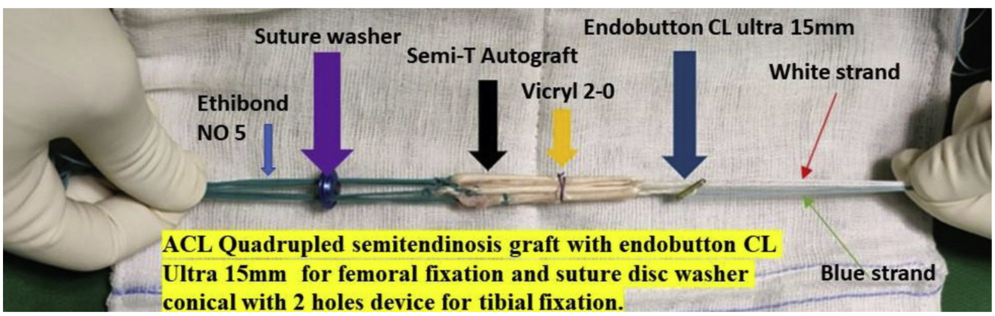

Fig 3. Anterior cruciate ligament quadrupled semitendinosus graft with EndoButton CL Ultra (15-mm) device for femoral fixation and 2-hole conical suture disk washer for tibial fixation. The pre-sutured 4-fold semitendinosus (Semi-T) autograft (black arrow) with the fixed-loop EndoButton CL Ultra 15-mm device (dark blue arrow) is used for proximal fixation, and the 2-hole conical suture disk washer (purple arrow) is used distally. The graft construct is advanced through the tibial tunnel by pulling the white passing suture's leading strand (red arrow), advanced into the femoral tunnel by pulling both the white strand (red arrow) and blue strand (green arrow), and flipped by pulling the blue strand. The No. 2-0 Vicryl thread (yellow arrow) tied on the graft serves as a marker to assist smooth flipping of the EndoButton.

Fig 4. Two-hole conical suture disk washer used for tibial-side fixation. The convex surface of the suture disk washer sits snugly on the tibial tunnel mouth.

Final Examination and Postoperative Care

The Lachman test is performed to examine knee stability. Graft tension is confirmed using a probe. The wounds are then irrigated and closed in the standard fashion. The knee is placed in a functional brace locked in extension. A long knee brace is worn for a total of 2 weeks postoperatively, followed by a hinged knee brace for another 4 weeks.

Postoperative Rehabilitation

Quadriceps-strengthening exercise is performed immediately after surgery. Partial weight bearing is allowed on the second postoperative day, with full weight bearing as tolerated. The long knee brace is removed, and range of motion is gradually increased, with a maximum of 90° of knee flexion advised over the next 24 to 48 hours postoperatively. Stationary bicycling, proprioception exercise, and jogging are allowed 3 months after surgery. Competitive sports, except for exercises that might involve strong contact with other individuals or exercises that might impose strong external forces on the patient's knee, are allowed 6 to 9 months after surgery.

Discussion

The success of arthroscopic ACL reconstruction depends on several factors, including graft tension during fixation,[4] type and source of the graft,[5] tunnel position,[6] knee flexion angle at the time of fixation,[7] method of graft fixation,[8] and initial graft tension at the time of fixation.[9] Of these variables, the amount of tension applied during graft fixation has been hypothesized to be an important determinant of successful ACL reconstruction.

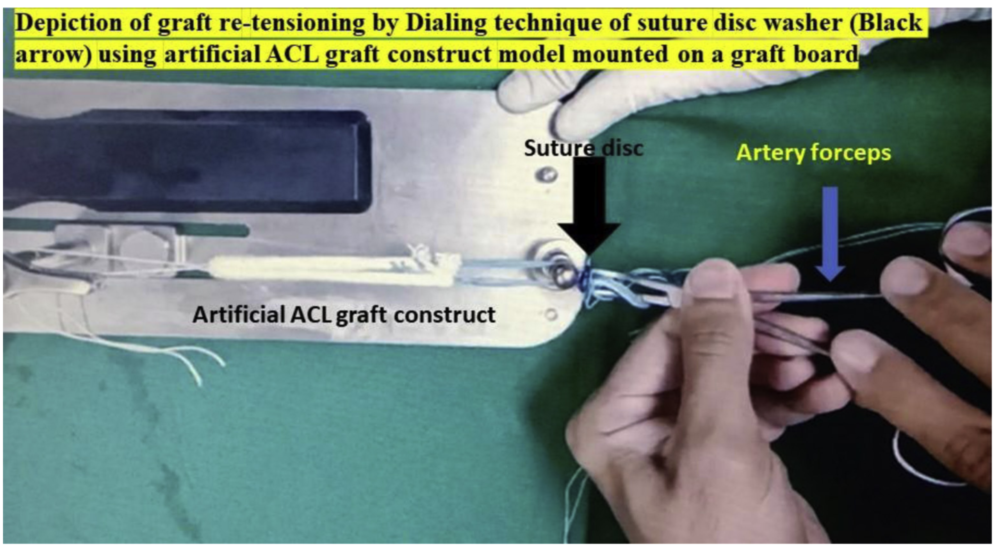

Fig 5. Graft retensioning by dialing technique with 2-hole conical suture disk washer (black arrow) using artificial anterior cruciate ligament (ACL) graft construct model mounted on graft board.

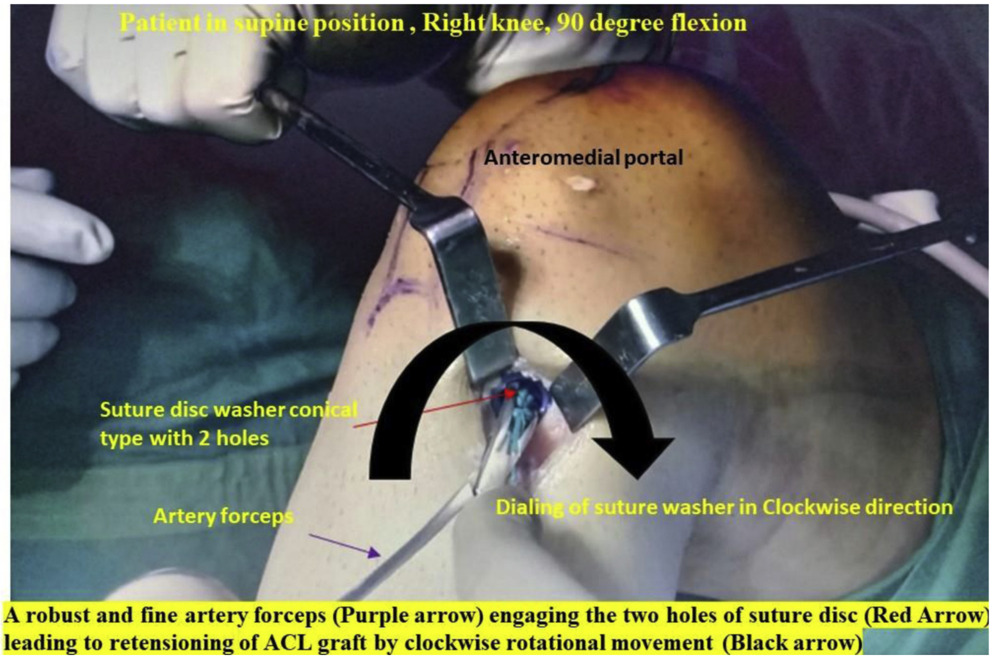

Fig 6. Patient in supine position with right knee in 90° of flexion. Robust and fine artery forceps are used to dial the 2-hole conical suture disk washer (red arrow). Both tips of artery forceps (purple arrow) are inserted into the 2 holes of the conical suture disk washer, and clockwise dialing (black arrow) is performed to retension the anterior cruciate ligament (ACL) graft.

The desired surgical end product of ACL reconstruction with any surgical fixation device remains a taut ACL graft.[10,11] A well-tensioned ACL tendon graft at the end of surgery is essential because it improves knee stability and patients' clinical and functional outcomes.[12,13] An unstable knee often leads to further chondral, meniscal, or ligamentous injuries.[14] Loss of tension can occur even with maximum manual tension on the tibial side. Noyes et al.[3] examined ACL graft—conditioning protocols to decrease postoperative

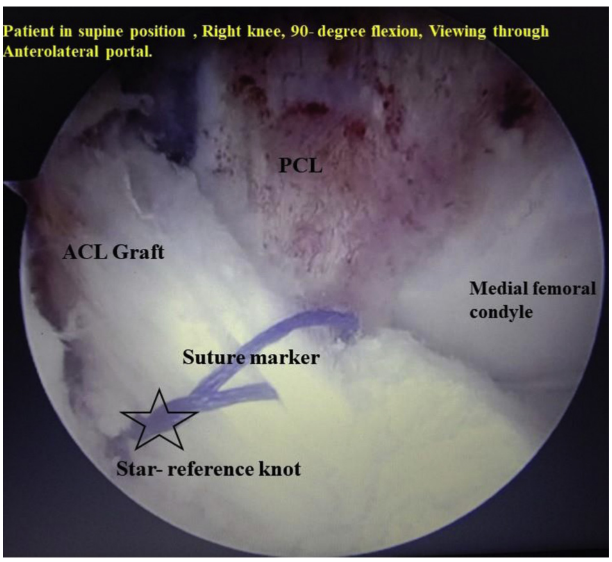

Fig 7. Patient in supine position with right knee in 90° of flexion. Arthroscopic visualization of the anterior cruciate ligament (ACL) graft is performed through the anterolateral portal, before dialing. The purple thread on the graft and the star-reference knot serve as markers of tensioning (PCL, posterior cruciate ligament.)

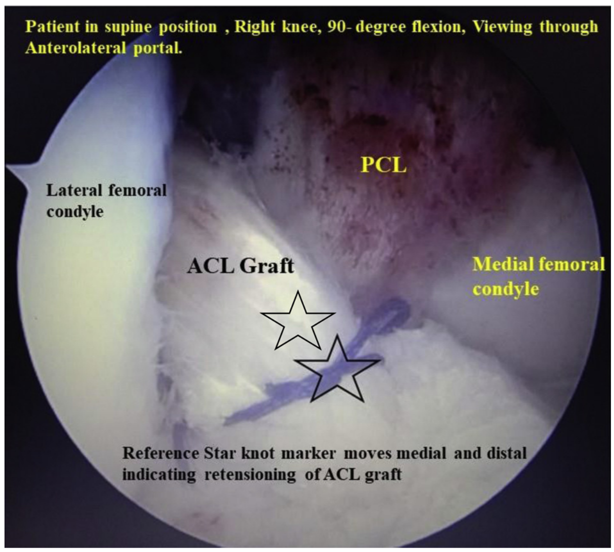

Fig 8. Patient in supine position with right knee in 90° of flexion. Arthroscopic visualization of anterior cruciate ligament (ACL) graft is performed through the anterolateral portal, which confirms clockwise rotation and tensioning of the ACL graft during dialing. The purple thread on the graft serves as a marker of tensioning. The stars indicate the clockwise direction of retensioning, which shows medial movement, indicating dialing of the 2-hole conical suture disk washer. In addition, distal movement of the graft confirms retensioning by 1 to 2 mm. (PCL, posterior cruciate ligament.)

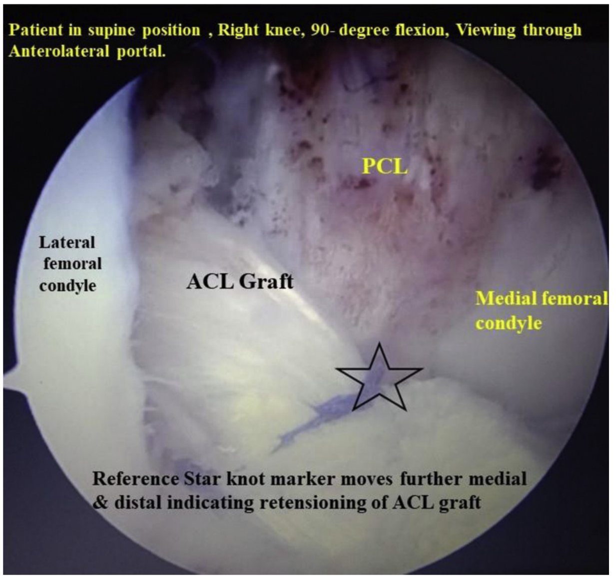

Fig 9. Patient in supine position with right knee in 90° of flexion. Arthroscopic visualization of the final position of the anterior cruciate ligament (ACL) graft is performed through the anterolateral portal after dialing, which is confirmed by clockwise (star) and distal movement of the No. 2-0 Vicryl marker (purple thread) tied on the ACL graft. (PCL, posterior cruciate ligament.)

graft elongation after ACL reconstruction in a robotic simulator study using cadaveric ACL graft. They concluded that a secondary ACL graft—conditioning protocol of 40 flexion-extension cycles under 90 N of graft loading was required for a well-conditioned graft, preventing further elongation and restoring normal anterior-posterior and pivot-shift translations.

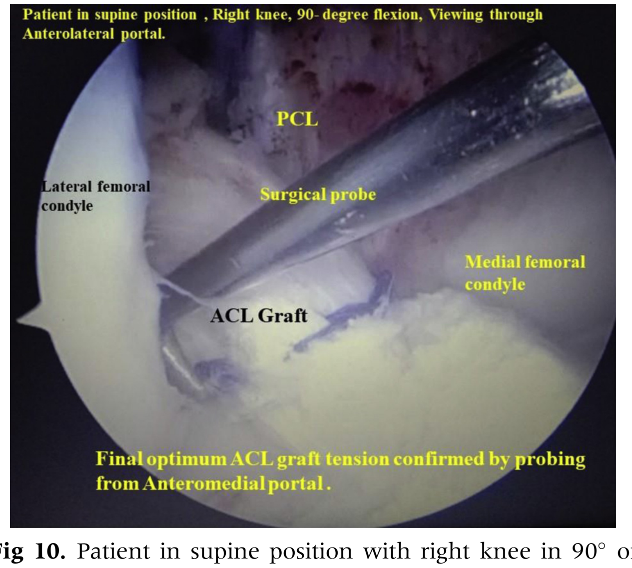

Fig 10. Patient in supine position with right knee in 90° of flexion. The final optimum anterior cruciate ligament graft tension is reconfirmed by manual probing viewed through the anterolateral portal. (PCL, posterior cruciate ligament.)

There is consensus within the literature that unlike fixed-loop devices, adjustable-loop fixation devices bring with them concerns of loop slippage and elongation with cyclic loading of the knee, especially during postoperative rehabilitation.[15] Gamboa et al.[11] performed a graft retensioning technique using an adjustable-loop fixation device in arthroscopic ACL reconstruction. They concluded that retensioning of the graft after tibial fixation may eliminate the need for posterior drawer testing of the knee because the resulting laxity will be removed with retensioning. Morrison et al.[4] recently performed a study of device-assisted tensioning compared with manual tensioning in ACL reconstruction and concluded that current practice is divided evenly between manual tensioning and device-assisted tensioning; however, they suggested that device-assisted tensioning may be associated with lower rates of graft failure.

Pilia et al.[16] studied pre-tensioning of soft-tissue grafts in ACL reconstruction. They considered graft tensioning a critical surgeon-controlled factor that affects ACL reconstruction outcomes. They concluded that combining pre-tensioning and preconditioning gives significantly more graft tension.

Pontoh et al.[17] conducted a randomized controlled trial by modifying exorotation of graft tension for tibial fixation in ACL reconstruction and concluded that this technique significantly reduced tibial internal rotation, as well as prevented cartilage breakdown and improved functional outcomes, in patients with total ACL rupture. Nishizawa et al.[18] compared intra- and extra-articular tension of the graft during fixation in ACL reconstruction in a cadaveric study. They found that the amount of graft tension measured on an extra-articular device was significantly lower than the intra-articular tension on the graft, which meant that cyclic loading and pre-tensioning did not eliminate the difference in graft tension between inside and outside the joint at the time of fixation during ACL reconstruction.

With our implant of choice for ACL reconstruction—a fixed-loop and suspensory fixation device—we commonly find residual graft laxity on

Table 1. Advantages and Disadvantages of ACL Suture Disk Fixation Technique

Advantages
The technique is simple and can be easily reproduced by surgeons worldwide.
The technique is cost-effective.
Dialing under arthroscopic vision gives an idea about the exact amount of retensioning to be performed, in a controlled manner.
Disadvantages
Accidental undialing of the suture disk postoperatively may lead to loosening of the ACL graft. (However, we have never faced such a situation using the described technique.)

ACL, anterior cruciate ligament.

Table 2. Pearls and Pitfalls of ACL Tibial Suture Disk Fixation Technique

Pearls
The ability to retension the graft after definitive femoral fixed-loop fixation and tibial suture disk fixation gives more stability; the technique is unique given the fact that, even after fixation is performed on both sides, further retensioning is possible.
The suture disk used is conical with 2 holes, and because the convex side is placed on the proximal third of tibia, it snugly fits in the tibial tunnel mouth, thereby providing stable fixation.
Pitfalls
Choosing the correct length of graft is most crucial because the graft should not come out of the tibial tunnel mouth; otherwise, interference screw fixation must be used.
Excessive over-dialing may lead to unnecessary tensioning of the graft, which should be avoided.

ACL, anterior cruciate ligament.

the table; hence, we devised the described technique. The principal advantage of the retensioning technique using the suture disk device in ACL reconstruction is the ability to retension the graft after tibial fixation. Advantages and disadvantages of the dialing technique are described in Table 1, and pearls and pitfalls are explained in Table 2. A taut ACL construct is crucial during postoperative rehabilitation to reduce the risk of knee instability and prevent rerupture of the ACL graft. The graft retensioning technique described in this article is a simple and cost-effective approach to reduce graft laxity and thereby increase graft tautness. In addition, retensioning of the graft after tibial fixation may avoid the need for posterior drawer testing of the knee because the resulting laxity will be removed with retensioning. The risk as well as limitation of our technique is that excessive over-dialing may lead to unnecessary tensioning of the graft, which should be avoided, and accidental undialing postoperatively may lead to loosening of the ACL graft. Choosing the precise length of the graft is most crucial because if the graft comes out of the tibial tunnel mouth, then interference screw fixation has to be used and the suture disk technique cannot be performed.

On the basis of our observations using the Pathak Pune technique, we conclude that dialing of the suture disk is a simple and very cost-effective way to retension the ACL graft after final fixation on the femoral and tibial sides. It can be effectively used in arthroscopic ACL reconstruction and in transosseous meniscal root repair and arthroscopic posterior cruciate ligament avulsion fracture fixation using a suture pullout technique on the tibial side.

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