Technical Note

Anterior Cruciate Ligament Femoral Socket Preparation Using a Cannulated, Calibrated Drill With Adjustable Stop and Slotted Cannula

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Abstract: Anteromedial portal–guided femoral tunnel preparation during anterior cruciate ligament reconstruction can be difficult owing to poor visualization. This may cause iatrogenic damage to the medial femoral condyle cartilage and the posterior cruciate ligament fibers or overdrilling through the lateral femoral cortex, creating difficulties in the use of femoral suspensory devices during anterior cruciate ligament reconstruction. We describe an accurate and safe technique for femoral graft socket preparation using a cannulated, calibrated drill with an adjustable stop and slotted cannula. This easy and reproducible technique uses simple additional instruments and effectively addresses concerns related to femoral graft socket preparation, without requiring additional surgical time.

Primary anterior cruciate ligament (ACL) reconstruction using autograft or allograft is one of the most common soft-tissue knee operations performed by orthopaedic surgeons worldwide.[1] Suspensory femoral fixation is a common technique used for ACL reconstruction. Good functional outcomes after anatomic primary ACL reconstruction are dependent on precise bony tunnel placement and accurate graft socket preparation. The femoral tunnel is commonly prepared using the anteromedial portal (AMP) drilling technique. The AMP drilling technique has the potential for scuffing the medial femoral condyle cartilage (MFCC) and damaging the posterior cruciate ligament (PCL) fibers and is fraught with poor visualization due to knee hyperflexion (>120°)[2] (Fig 1). Production of bone debris during sequential drilling further reduces visualization. This risks drilling through the lateral femoral cortex, resulting in failure of button deployment for suspensory femoral fixation. These potential risks can be circumvented by use of a cannulated, calibrated drill with an adjustable stop and slotted cannula.

The cannulated, calibrated drill with an adjustable stop and slotted cannula (Fig 2) is an instrument system designed to mitigate the potential risks involved in femoral bony tunnel and graft socket drilling in ACL reconstruction. In this article, we describe the technique for ACL reconstruction using this device.

Surgical Technique

Cannulated, Calibrated Drill With Adjustable Stop and Slotted Cannula

The drilling system is an easy-to-use system for femoral graft socket preparation (Fig 2). In addition to a 2.4-mm × 12-inch drill-tip guidewire (Beath pin), 4.5-mm cannulated endoscopic drill, and TRUKOR depth gauge from the Complete Solutions for Knee Arthroscopy set (Smith & Nephew, Andover, MA), this drilling system consists of the instruments described in Table 1.

Patient Setup

The standard arthroscopy setup is prepared for treatment in the supine position, with a lateral post just proximal to the knee, at the level of the padded tourniquet, to prevent external rotation of hip; a foot roll is positioned to maintain 90° of knee flexion (Fig 3).

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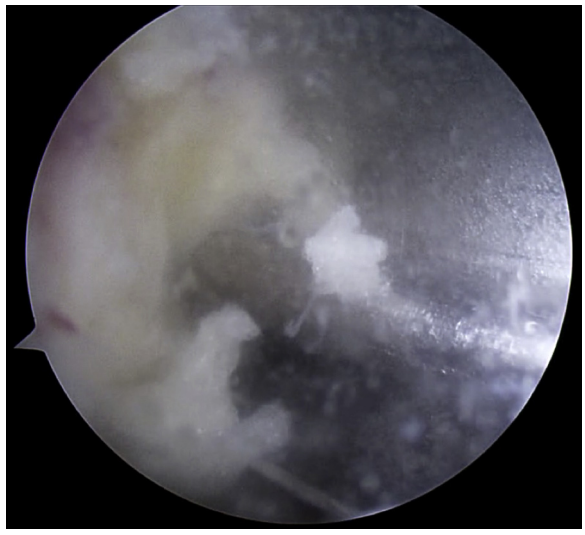

Fig 1. Arthroscopic view of the knee joint from the anterolateral knee arthroscopy portal during active drilling of the femoral tunnel through the anteromedial portal, showing bone debris that impedes the view of the markings on the drill. Clear visualization of these markings is essential to perform accurate preparation of the femoral graft socket and avoid inadvertent drilling of the lateral femoral cortex.

Incision, Exploration, and Graft Preparation

The high anterolateral portal is created at the level of the inferior border of the patella and approximately 4 mm lateral to the lateral border of the patellar tendon. The AMP is created adjacent to the medial edge of the patellar tendon and the inferior border of the patella. A full diagnostic arthroscopy is performed, and associated meniscal tears and cartilage lesions are treated. After

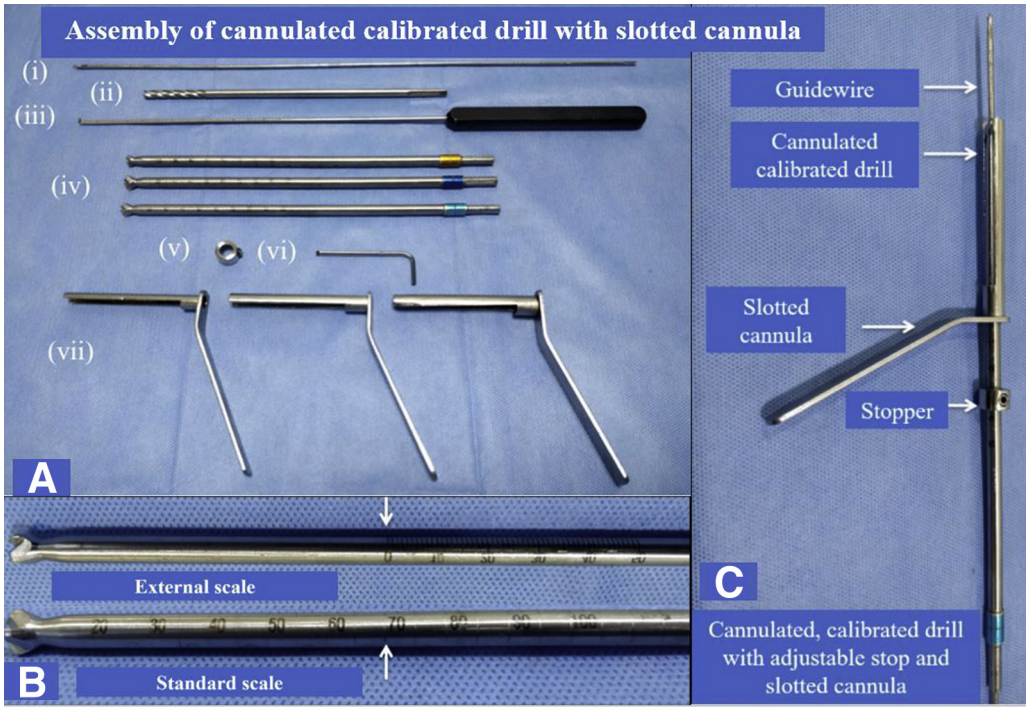

Fig 2. Instruments for femoral graft socket preparation in anterior cruciate ligament reconstruction using a cannulated, calibrated drill with an adjustable stop and slotted cannula. (A) Different instruments shown separately: 2.4-mm × 12-inch drill-tip guidewire (Beath pin) (I); 4.5-mm cannulated endoscopic drill (ii); TRUKOR depth gauge (iii); cannulated, calibrated drills of different sizes (iv); external stopper (v); Allen key (vi); and slotted cannula with distal slit (vii). Instruments i, ii, and iii are from the Complete Solutions for Knee Arthroscopy set (Smith & Nephew); instruments iv through vii are made by Australian Orthopaedic India (Pune, India). (B) Different scales on cannulated, calibrated drill (arrow demarcates the femoral aimer). (C) Composite assembly of cannulated, calibrated drill with variable external stop protected by slotted cannula of corresponding size.

Table 1. Special Instruments

Instrument	Description
Cannulated, calibrated drill with adjustable stop (Australian Orthopaedic India)	The cannulated drill has 2 calibrated scales and an adjustable external stopper. The 2 calibrated scales are the standard and external scales. The standard calibrated scale begins from the tip of the drill and has progressive calibrations 1 mm apart, making a scale of 0-150 mm. The external calibrated scale begins from the 70-mm (7-cm) mark on the standard scale and has similar progressive calibrations 1 mm apart, making a scale of 0-70 mm. Both the standard and external scales are used during ACL femoral tunnel and graft socket preparation to precisely measure the desired length of the femoral graft socket. The drills are available in sizes ranging from 5 to 12 mm in diameter in 1-mm increments. The drill is mounted with an adjustable stopper, which is fixed at the desired measurement on the external scale, corresponding to the calculated length of the femoral graft socket. This prevents overdrilling of the lateral femoral cortex.
Slotted cannula (Australian Orthopaedic India)	The slotted cannula is a hollow cylindrical sleeve with a fixed length of 70 mm. The cannulas are available in variable diameters corresponding to the different available cannulated, calibrated drill sizes (5-12 mm). The diameter of the cannula is 2 mm wider than the corresponding drill size to accommodate the cannulated, calibrated drill. The distal end of the cannula has a C-shaped slit of 4 cm in length. This helps to monitor the depth of femoral graft socket drilling using the standard scale on the cannulated, calibrated drill. The slotted cannula is fitted with an ergonomic handle at the proximal end to securely hold it in place.

ACL, anterior cruciate ligament.

arthroscopic confirmation of an ACL tear, the hamstring tendons are harvested and prepared. The remnant soft tissues are cleared from the trochlear notch, and the femoral footprint is demarcated.

Tunnel Preparation

The femoral tunnel is prepared by the inside-out technique using the following steps (Fig 4, Video 1):

1. With the knee in 90° of flexion, an offset aimer is used to place the 2.4-mm × 12-inch drill-tip guidewire (Beath pin) at the anatomic ACL footprint on the medial cortex of the lateral femoral condyle.
2. The knee is flexed further to 120° of flexion, maintaining the position of the guidewire. The guidewire is drilled beyond the lateral femoral cortex.
3. With knee flexion maintained at 120°, the guidewire is left in the anatomic location. The slotted cannula for the 4.5-mm drill is passed over the guidewire through the AMP to rest on the medial cortex of the lateral femoral condyle. The tunnel is drilled from the near cortex to the far cortex of the lateral femoral condyle with the 4.5-mm cannulated endoscopic drill.
4. The length of the femoral tunnel is determined with the TRUKOR depth gauge. The desired length of the graft socket is calculated by subtracting 5 mm from the measured tunnel length.
5. The appropriately sized cannulated, calibrated drill with an adjusted pre-mounted stop is chosen based on the measured thickness of the prepared hamstring graft. The external stopper is tightened at the calculated length of the graft socket on the external scale.
6. With the knee still in 120° of flexion, the slotted cannula (corresponding to the size of the cannulated, calibrated drill) is passed over the guidewire to rest on the medial cortex of the lateral femoral

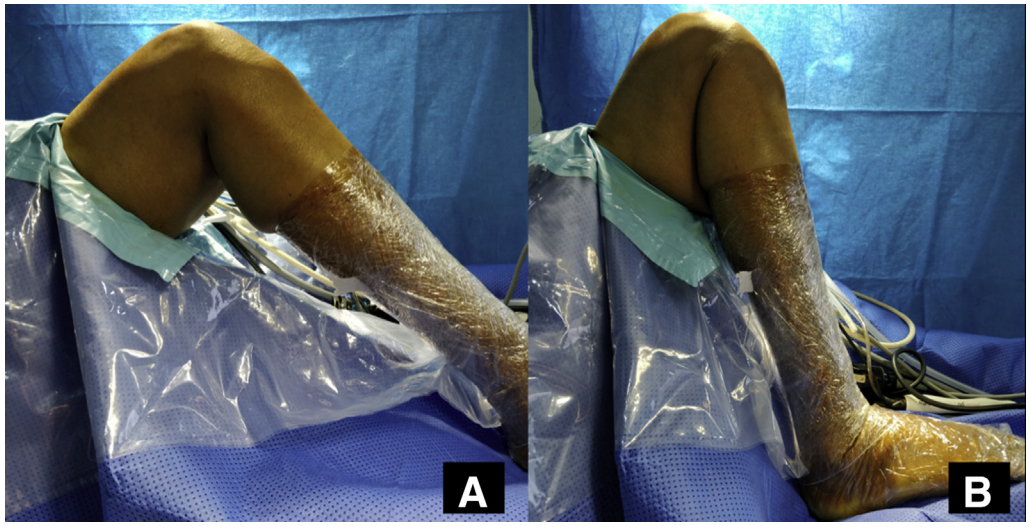

Fig 3. Patient setup. The patient is placed supine with the right lower limb prepared and draped for anterior cruciate ligament reconstruction. (A) The limb is maintained at 90°, resting on the foot support. (B) Free hyperflexion of the knee is shown, which is desired for femoral tunnel drilling and graft socket preparation.

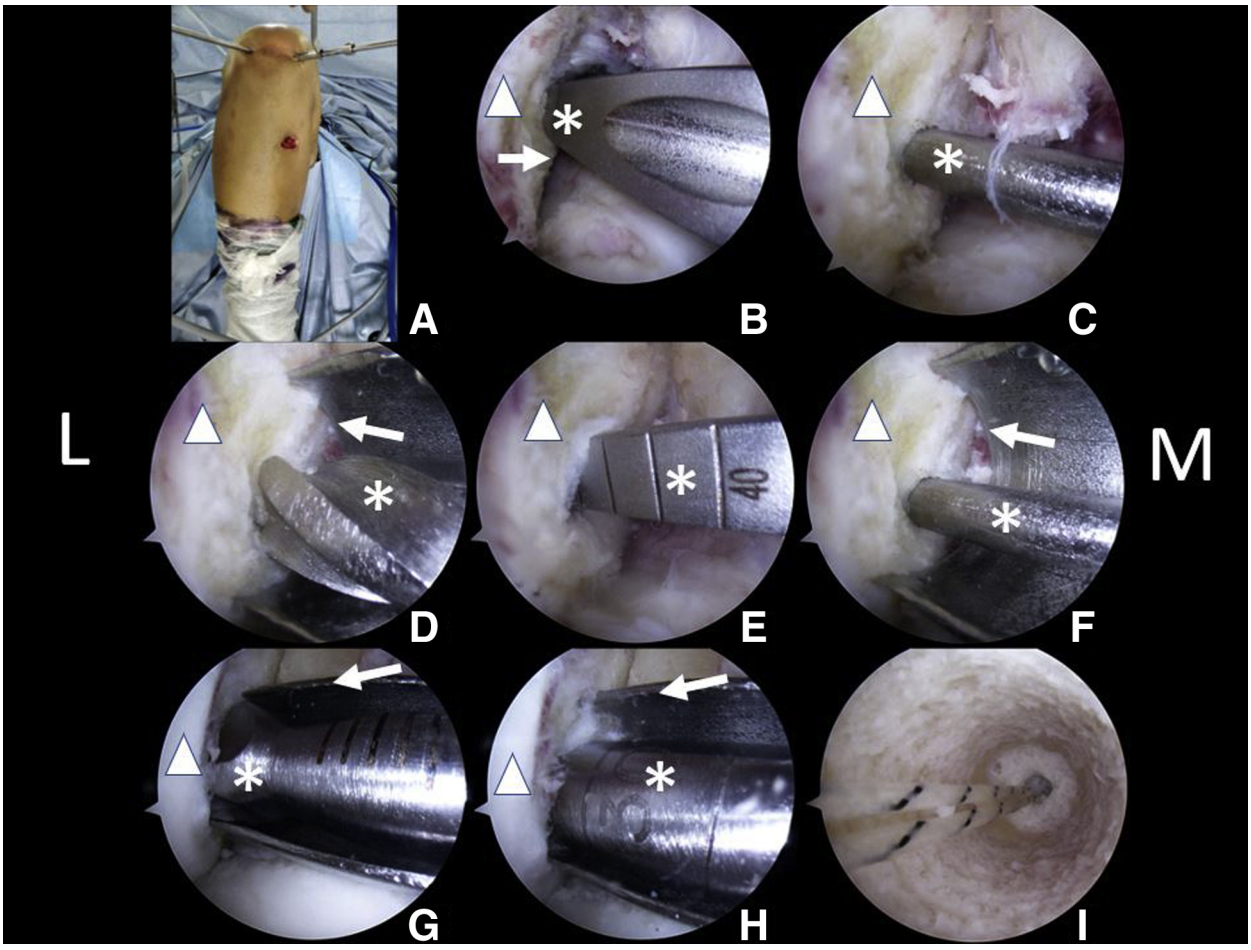

Fig 4. Sequential steps for femoral tunnel drilling and graft socket preparation for anterior cruciate ligament reconstruction. (A) Right knee in hyper-flexed position. (B-H) Arthroscopic views of the sequential steps as visualized with the arthroscope in the anterolateral knee arthroscopy portal and the instruments used via the anteromedial portal in the right knee. The triangle indicates the lateral femoral condyle. (B) Femoral aimer (asterisk) resting on posterior cortical margin of lateral femoral condyle. (C) Guidewire (asterisk) placed in anatomic location. (D) Initial 4.5-mm drill (asterisk) for femoral tunnel with slotted cannula (arrow). (E) Femoral tunnel length of 34 mm measured using depth gauge (asterisk). (F) Slotted cannula (arrow) of 9-mm cannulated, calibrated drill passed over guidewire (asterisk) through anteromedial portal resting on medial cortex of lateral femoral condyle. (G) Nine-millimeter cannulated, calibrated drill (asterisk) passed over guidewire visualized through distal slit of slotted cannula (arrow) resting on medial cortex of lateral femoral condyle. (H) Graft socket drilled with 9-mm drill (asterisk) to length of 29 mm (arrow demarcates the femoral aimer). (I) Arthroscopic view of prepared graft socket as seen with camera and arthroscope in anteromedial portal. By following the surgical steps in the sequence described, a femoral graft socket of accurate length for the anterior cruciate ligament can be drilled with the cannulated, calibrated drill with an adjustable stop and slotted cannula. (L, lateral side; M, medial side.)

condyle, protecting the MFCC and surrounding soft tissues from the drill. The chosen drill with its mounted stopper is passed over the guidewire. The appropriately sized graft socket is prepared by drilling over the guidewire until the external stopper rests against the base of the slotted cannula. The depth of drilling can also be confirmed on the standard scale by arthroscopic visualization through the distal slit of the slotted cannula.

7. The intact lateral cortex can be visualized by passing the scope through the AMP into the tunnel.
8. Looped shuttle suture for graft passage is passed from the AMP and retrieved through the femoral tunnel.

The ACL tibial tunnel is prepared per the standard of practice (Fig 5).

Graft Passage and Fixation

The prepared hamstring graft mounted on a suspensory device is passed through the tibial and femoral tunnels (Fig 6). The graft is secured on the femoral side as the suspensory button is flipped on the lateral femoral cortex. On the tibial side, the graft is secured using an interference screw.

Rehabilitation

The standard rehabilitation protocol is followed, depending on surgeon preference.[3]

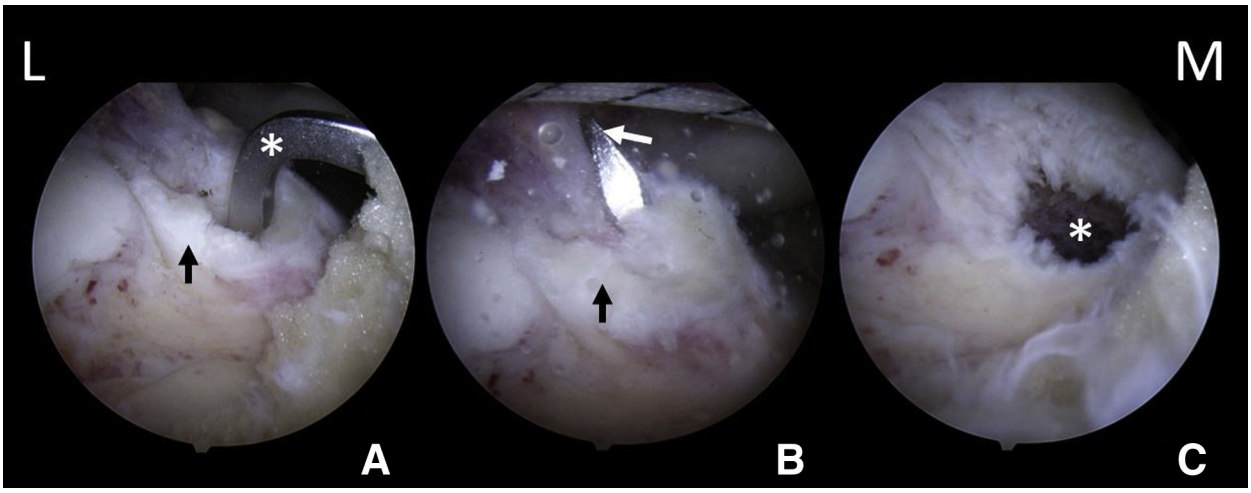

Fig 5. Sequential steps of tibial tunnel preparation for anterior cruciate ligament (ACL) reconstruction. A right knee is shown with the arthroscope in the anterolateral knee arthroscopy portal and the instruments used through the anteromedial portal. (A) ACL tibial aimer (white asterisk) placed in center of remnant ACL tibial stump (black arrow). (B) Tip of guidewire (white arrow) for drilling ACL tibial tunnel in anatomic location in center of remnant ACL tibial stump (black arrow). (C) Visualized aperture of tibial tunnel (asterisk) in anatomic location. (L, lateral side; M, medial side.)

Discussion

The described technique of graft socket preparation for ACL reconstruction and Video 1 depict a simple modification to the widely used technique for ACL reconstruction. It effectively addresses the concerns related to the graft socket preparation step in ACL reconstruction using the AMP drilling technique. This technique is simple, easily adaptable, and versatile in application (Table 2). Although there are significant clinical advantages to the technique, additional instruments are needed and hospital scrub staff members need to become acquainted with the use, handling, and application of these instruments (Table 2).

Placing the knee in hyperflexion for femoral tunnel drilling in the anatomic position decreases the available knee joint space, posing difficulty in passage of the correctly sized drill over the Beath pin through the AMP.[2] Forcing the drill over the Beath pin increases the chance of MFCC damage.[2] In the position of hyperflexion, intra-articular visualization is also limited. This poor visualization is further compromised by the drill debris generated by femoral drilling.[2] Poor visualization of the scale markings on the drill risks drilling through the lateral femoral cortex, hampering use of femoral suspensory fixation for the ACL graft.[2] Use of the cannulated, calibrated drill with an adjustable stop and slotted cannula effectively addresses these concerns in femoral graft socket preparation. The slotted cannula protects the MFCC and fibers of the PCL from the sharp ends of the drill during insertion and advancement through the AMP. This technique also has the advantage of precise drilling. This is ensured using the

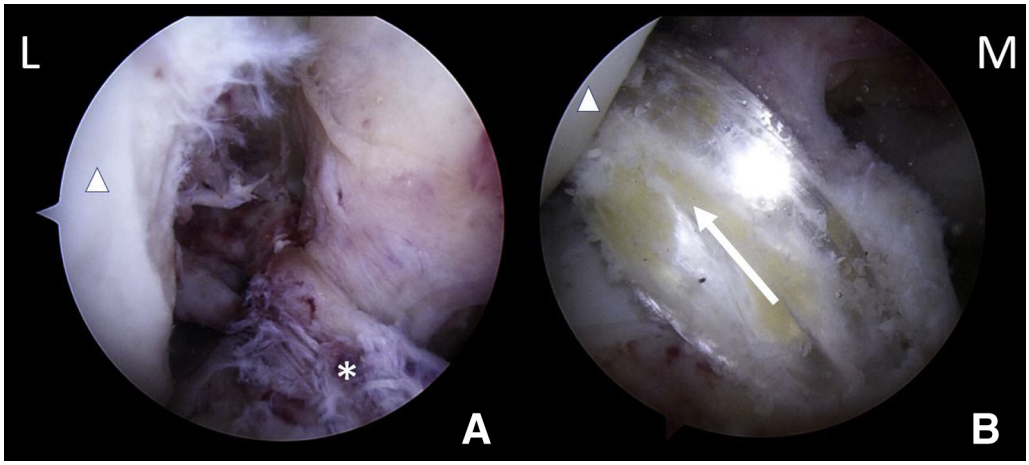

Fig 6. Arthroscopic view of torn and reconstructed anterior cruciate ligament (ACL) in right knee joint with arthroscope in anterolateral knee arthroscopy portal. (A) Torn ACL (asterisk) at start of surgery. (B) Reconstructed ACL (arrow). The triangle indicates the lateral femoral condyle. (L, lateral side; M, medial side.)

Table 2. Advantages and Disadvantages

Advantages
Protection against damage to MFCC and PCL fibers
Preparation of ACL graft socket of accurate length
Prevention of drilling through lateral femoral cortex by dual-check mechanism
No significant change in surgical time with use of cannulated, calibrated drill with adjustable stop and slotted cannula
Simple, easily adaptable, and versatile in application and can be used with fixed or adjustable femoral suspensory fixation devices
Disadvantages
Use of additional instruments
Training of hospital staff and surgical assistant to become acquainted with cannulated, calibrated drill with adjustable stop and slotted cannula

ACL, anterior cruciate ligament; MFCC, medial femoral condyle cartilage; PCL, posterior cruciate ligament.

standard scale and external scale with a stopper. The distal slit in the slotted cannula provides vision for checking the length of the tunnel being drilled using the markings on the standard scale, similarly to drilling using conventional drills. In addition, a second check for the graft socket length is the adjustable stopper fixed on the external scale of the cannulated, calibrated drill. This adjustable stopper is fixed on the external scale at the calculated graft socket length. When the required graft tunnel length is drilled, the stopper rests on the wider proximal base of the slotted cannula, preventing further drilling (Table 2). The pearls and pitfalls of the technique and its associated risks and limitations are described in Tables 3 and 4.

Other techniques of femoral graft socket preparation have been described in the literature. Femoral tunnel drilling with the transtibial technique is protective of the MFCC.[4] However, transtibial placement of the Beath pin and drill is constrained and has a low margin of error. There is a higher chance of drilling a vertical femoral tunnel, leading to persistent rotational instability.[4] Osti et al.[5] have shown that AMP drilling for femoral tunnel preparation in ACL reconstruction is superior to the transtibial drilling technique.

Table 3. Pearls and Pitfalls

Pearls
Use of double calibrated drill
No alteration to existing femoral graft socket preparation technique in ACL reconstruction
Simple addition to existing technique to make graft socket preparation safe, reliable, and accurate with dual check for prepared graft socket length
Use of slotted cannula does not affect intra-articular visibility during drilling
Pitfalls
Assistant to hold slotted cannula in position during graft socket preparation
Additional step to assemble stopper and drill

ACL, anterior cruciate ligament.

Table 4. Risks and Limitations

Risks
A wider anteromedial portal may be required for slotted cannula insertion.
An additional step is required to assemble the stopper and drill, which is prone to human error.
The technique may lead to over-reliance on the instruments for graft socket preparation.
Limitations
A hyper-flexed knee position is still needed for anatomic drilling of the femoral graft socket even with the use of the cannulated, calibrated drill with a slotted cannula.

Additional described pearls for AMP drilling include inferior and far-medial placement of the AMP for a perpendicular trajectory of the drill to the lateral femoral condyle. Even with these pearls, placing the limb in a position of hyperflexion risks damage to the MFCC. The "composite at 90°" technique has been described to prevent cartilage damage.[2] In this technique, the Beath pin—drill composite is placed in the trochlear notch beyond the medial femoral condyle with the knee in 90° of flexion. Then, the knee is placed in hyperflexion, and the femoral tunnel is prepared by drilling over the Beath pin in the anatomic location of the ACL footprint. Although the technique provides for safe drilling, it is technically demanding and not widely practiced.

One more effective method for safe drilling of the femoral graft socket makes use of flexible drills.[6] With their use, hyperflexion of the knee is avoided, and thus, the probability of damage to the MFCC and PCL fibers is decreased and visualization is not as poor as in a hyperflexed knee. Flexible drills, although avoiding the need for hyperflexion, have no mechanism to check overdrilling of the lateral femoral cortex. In addition, flexible drills are more expensive, thus adding to the overall cost of surgery. In comparison, the cannulated, calibrated drill with an adjustable stop and slotted cannula—although requiring additional instruments—is inexpensive and can be easily integrated into the conventional technique widely followed by orthopaedic surgeons (Table 2). In conclusion, the use of a cannulated, calibrated drill with an adjustable stop and slotted cannula for femoral graft socket is an effective, inexpensive, accurate, and universally applicable method in conventional ACL reconstruction.

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