

Technical Note

Revision Anterior Cruciate Ligament Surgery Using the Over-the-Top Femoral Route

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Abstract: Primary anterior cruciate ligament (ACL) reconstruction is considered a successful surgical procedure, but the results reported for revision ACL surgery are less satisfactory. The most common cause of technical failure in primary reconstruction is tunnel misplacement, particularly on the femoral side, although an anterior placement of the tibial tunnel may lead to graft impingement and failure. Several technical problems are encountered during revision procedures. We describe a technique for revision ACL surgery using a special jig for preparing the tibial tunnel that references the apex and roof of the intercondylar notch and an over-the-top routing for proximal femoral placement. This combination avoids graft impingement at the tibial tunnel exit and circumvents the problems associated with further femoral tunnel preparation. **Key Words:** Anterior cruciate ligament—Knee—Over-the-top route—Revision.

Misplacement of the femoral and tibial tunnels are the most common reasons for iatrogenic technical failure during primary anterior cruciate ligament (ACL) reconstructions.¹⁻⁴ During revision surgery, removal of retained fixation hardware, usually interference screws, may be difficult to perform, and repositioning of the femoral tunnel may require extensive bone grafting and a staged procedure. Avoiding this step by taking the new graft over-the-top (OTT) of the femoral condyle significantly reduces the technical difficulty, operating time, and morbidity encountered with revision surgery.

OTT graft placement is not a new concept and was

used commonly in the past for primary ACL reconstruction with both biological and synthetic graft materials. Its use, however, has been largely superseded by arthroscopically performed femoral tunnel placement, particularly when a bone block is used in conjunction with bone-patellar tendon-bone grafts. However, hamstring tendon lends itself to being suitable for OTT placement. Results comparing hamstring reconstruction placed either OTT or via a femoral tunnel report no difference in clinical results.⁵⁻⁷

We describe a technique of revision ACL reconstruction that employs a reproducible siting for the tibial tunnel, using a special jig that acts as a fixed navigational aid.⁸ OTT proximal, femoral fixation is undertaken, avoiding the necessity for redrilling, repositioning, or bone grafting of a previously sited femoral tunnel. This report reflects our experience and practice after revising failed primary procedures mostly performed with prosthetic scaffold implants.

SURGICAL TECHNIQUE

Revision surgery was undertaken in patients with recurrent instability who had failed to respond to

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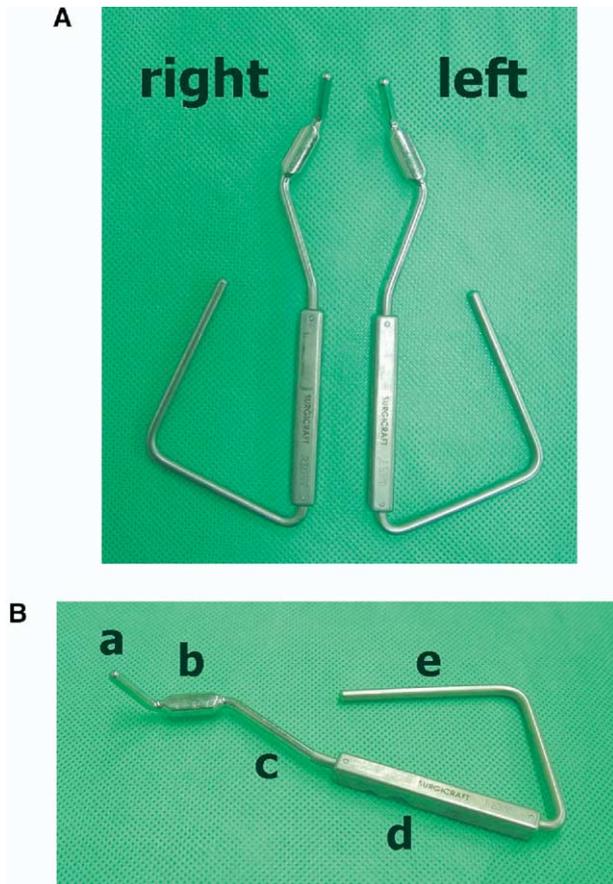


FIGURE 1. (A) There are 2 offset probes available for the right and the left knee, respectively. (B) The offset probe consists of an intra-articular and an extra-articular portion. The intra-articular portion consists of the upturned tip (a), the baffle (b), and the curved portion (c). The extra-articular portion consists of the attachment site (d) and the aiming device (e).

conservative treatment. We favored an unstaged approach with preparation of a fresh tibial tunnel using a specialized jig and an OTT femoral routing.

Before fresh preparation of the tibial tunnel, if an interference screw has been used in the primary procedure it must be located and removed. Again, if a screw has been used for femoral tunnel fixation it should be removed if the screw head is prominent; otherwise it can be ignored.¹⁰

After removal of the existing torn or stretched graft substitute, attention is directed toward the preparation of a fresh tibial tunnel and, to facilitate this step, a special jig (the Mayday Rhinohorn Jig) was used. The jig consists of a shank that accepts interchangeable right and left probes depending on the side involved. The offset probes have the following features (Fig 1). The intra-articular portion consists of an upturned tip that engages the apex

and roof of the intercondylar notch. Behind the tip is a thickened portion or baffle that serves to centralize the probe in the notch when the knee is extended. Behind the baffle, the probe is curved either to the right or to the left to avoid probe impingement by the medial femoral condyle when the knee is extended. The extra-articular portion consists of a section designed for attachment to the jig (Fig 2A) and a further extension provides an aiming device, which is aligned with the baffle and the upturned tip and provides an external guide to the orientation of the probe and jig.

After it has been attached to the jig, the appropriate left or right probe is passed into the joint through an antero-medial arthroscopic portal with the knee in 60° of flexion. The upturned tip engages the apex and roof of the intercondylar notch (Fig 2B). The knee is then fully extended with the foot in neutral; the baffle on the probe ensures that it is centered in the notch, avoiding wall impingement. The shank of the jig lies parallel and anteromedial to the long axis of the tibia and an adjustable rotating cam at the lower end of the shank aids this. The offset nature of the probe ensures that in the sagittal plane the angle of the tunnel is 60° to the long axis of the tibia and in the coronal plane the tunnel is angled approximately 20° medial to lateral. The aiming device on the probe, which is orientated perpendicular to the midpoint of the patella and long axis of the femur, fine tunes this position. This orientation ensures that the graft follows the anatomic course of the natural ACL and avoids impingement by the apex and roof of the notch in the sagittal plane and the lateral wall of the notch in the coronal plane when the knee is extended.

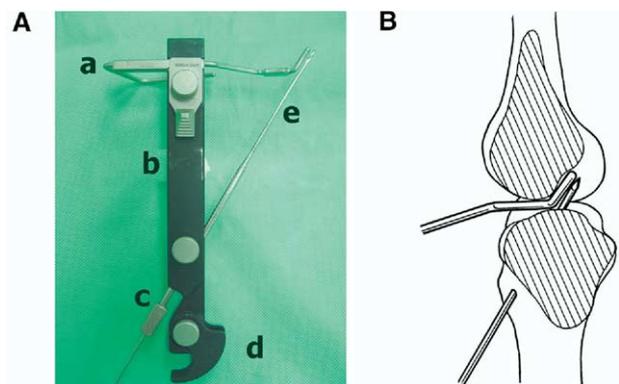


FIGURE 2. (A) The Mayday Rhinohorn jig consists of the offset probe (a), the shank (b), the guidewire sleeve (c), the guidewire (d), and the rotating cam (e). (B) The upturned tip of the jig engaging the roof of the intercondylar notch and a guidewire is drilled that exits 3 mm posterior to the tip. Overdrilling of the guidewire produces a tibial tunnel in an impingement-free site.

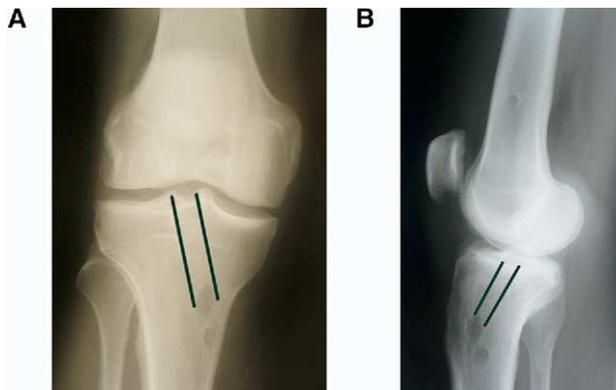


FIGURE 3. (A) The inclination of the tibial tunnel is 72° in the coronal plane and (B) 68° in the sagittal plane. The parallel black lines define the orientation of the tunnel.

Once the jig has been applied and the knee is fully extended, a guidewire sleeve is passed up through the shank of jig. The tip of the guidewire sleeve rests close to the surface of the tibial cortex, which has been exposed through a short longitudinal skin incision. The cortex should be predrilled before a guidewire is passed to avoid skidding of the tip of the guidewire on the hard cortical bone. A guidewire of predetermined length is passed up into the knee joint exiting posteriorly to the tip of the probe. The intra-articular position of the guidewire can be checked arthroscopically.

Once the guidewire has been placed, the jig can be removed. A tibial tunnel is fashioned by overdrilling the guidewire and its diameter is predetermined by the size of the graft to be used. The sharp margins of the intra-articular tibial tunnel exit are chamfered before passage of the implant to avoid fretting of the graft. The inclination of the tibial tunnel is 67° in the frontal and 71° in the sagittal plane (Fig 3).

A 5-cm lateral femoral incision is used to locate the OTT site, based distally on the lateral femoral epicondyle. The tensor fascia lata is divided in line with the incision. The vastus lateralis is reflected anteriorly and the superior lateral genicular vessels are identified where they pass through a hiatus in the lateral intermuscular septum. This hiatus is enlarged with blunt and sharp dissection to the point where the surgeon's index finger is able to palpate the OTT site medial to the lateral femoral condyle. The intra-articular portion of the OTT route, which lies on the medial surface of the lateral femoral condyle, is prepared using a special rasp that breaches the posterior capsule and also forms a groove to accommodate the graft. The tip of the rasp can be palpated and controlled through the OTT inci-

sion, protecting the soft tissue in the posterolateral aspect of the knee joint.

This preparation of the tibial tunnel and the OTT route is applicable to the different graft types and fixation techniques that may be chosen for revision. In all our revision cases, we have favored a biological autograft (hamstring tendon in 29 cases and quadriceps tendon in 4 cases). The autograft was attached to a specially designed soft tissue fixation device (Buttonhole Soffix; Surgicraft Ltd, Redditch, UK). This device consists of a double-looped polyester tape (Fig 4A). At either end there are 3 "buttonholes" in series separated by strong transverse braiding. This is the site where the hamstring tendons are interwoven and secured with a nonabsorbable suture material, leaving parallel tendon material in the center of the graft-soffix complex. The central 4 to 6 cm of the tape is excised after the tendons have been secured to either end of the soffix, thus leaving a window of free tendon material in the center of the graft-soffix complex (Figs 4B and 4C). This window corresponds to the intra-articular portion of the graft. Once the graft has been railroaded through the joint, it is fixed distally to the tibial cortex outside the tibial tunnel with a polysulphone bollard applied to the loop. Pretensioning can be undertaken before intra-articular application of the graft. Further pretensioning is carried out with the graft in situ after distal tibial fixation but before proximal fixation by applying tension to the proximal loop while the knee is flexed and extended. We favor closed drainage of the lateral femoral wound.

DISCUSSION

A technique for revision ACL reconstruction has been described that uses a fixed navigational aid for redrilling the tibial tunnel and that routes the graft OTT of the femoral condyle, avoiding the necessity for further preparation and resiting of a femoral tunnel.

Surgery for primary ACL reconstruction continues to increase and, therefore, it is likely that revision surgery will be required more often in the future. Most reports of the results of primary reconstruction indicate that there is a 10% to 20% incidence rate of failure. Failure following revision surgery is at a higher level, with reported failure rates ranging from 24% to 36%.^{10,11} However, the interpretation of results of revision surgery is hampered by the lack of controlled, randomized studies.

Specific difficulties are encountered during revision surgery and these are often related to misplace-

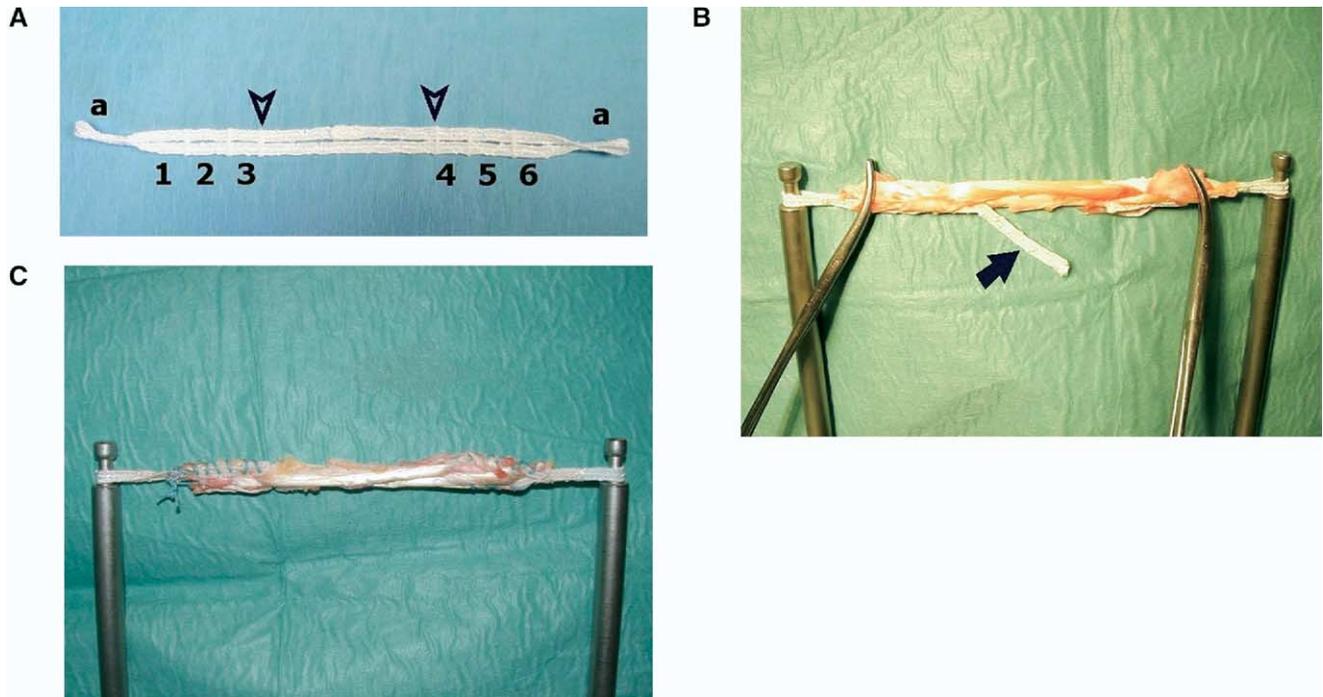


FIGURE 4. (A) The Buttonhole Soffix consists of a polyester tape with buttonholes (1-6) and loops at either end (a). Weaving of the hamstring tendon through the holes increases the fixation strength of the complex. The loops serve also to provide attachment of the Soffix to the poles on the preparation frame. The middle part of the tape is cut out (arrowheads), leaving tendon material in the joint. (B) The middle portion of the polyester tape (arrow) is cut out, leaving a window of 4 strands of tendon material in the center of the graft-soffix complex. This window is positioned intra-articularly. (C) The final appearance of the Soffix-hamstring tendon complex after excision of the middle portion of the tape. The hamstring tendons are interwoven through the buttonholes with nonabsorbable sutures and the middle portion of the tape is excised. The 2 loops at either end of the complex facilitate fixation to the tibial and the femoral cortices.

ment of either the tibial or more often the femoral tunnels. Complications related to tibial tunnel misplacement include tunnel enlargement and graft impingement, particularly with anterior tunnel siting.^{2,12} However, femoral tunnel misplacement is the most common reason for graft failure noted during revision surgery.^{4,10}

Bone grafting and resiting of these tunnels often requires staged procedures and difficulty in locating and removing tunnel fixation devices, such as interference screws, is frequently encountered. Our technique avoids staged surgery and there is no requirement for femoral tunnel grafting or redrilling. Although it is conceivable that tibial tunnel grafting may be indicated, as yet we have never found this particular step necessary in our revision series. Use of the Rhinohorn jig as a fixed navigational aid ensures the siting of a tibial tunnel, which exits posterior to the apex and roof of the intercondylar notch on the tibial plateau in the extended knee, avoiding graft impingement.

The challenge with regard to autologous hamstring

reconstruction is fixation, particularly proximally on the femoral side. Currently, most techniques use a femoral tunnel in both primary and revision surgery and there are several options with regard to fixation when reconstruction is performed with hamstring tendons. An interference fit in the femoral tunnel using standard, jumbo, or stacked interference screws is commonly used. Other options include post and washer, button and suture, suspension devices, or cross-pin fixation. Many of these devices will cause significant crushing damage to the graft.

During revision surgery when the posterior femoral wall is found to be deficient, the OTT route is the only remaining option.¹¹ However, it is our experience that a grooved OTT route option should not be regarded as a salvage procedure because it is easy to locate, biomechanically sound, reproducible, and clinically effective both in primary and revision surgery.⁵⁻⁸ The avoidance of a femoral tunnel also makes it particularly useful for ACL reconstruction in the adolescent knee. A perceived disadvantage of using this route is the necessity for a second incision.

With the technique described, 4 to 6 cm of free hamstring tendon graft crosses the knee joint and there is no intra-articular synthetic material present. The Soffix device is also suitable for use with other graft materials including quadriceps tendon and allografts.

The Soffix-hamstring complex together with loop and bollard fixation at both ends provides a method of fixation that, on biomechanical testing, is stronger than most other surgical techniques using 2 tunnels. In a biomechanical study of the Soffix fixation device using young human hamstring tendons, the mean tensile load to failure was $1,186 \pm 114$ N.¹³ Clinically, there have been no episodes of failure reported at the sites of femoral and tibial bollard-loop fixation.⁸ On biomechanical tensile testing, however, while the majority of failures occurred either in the tendons or at the tendon-tape interface, there have been a small number of failures adjacent to the loop.¹³

In conclusion, the technique described makes use of dedicated instrumentation for fashioning a tibial tunnel and routes the graft OTT for proximal fixation. The surgery is safe, reproducible, and relatively easy to perform.

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