Anatomic Reconstruction of Posterior Cruciate Ligament Using Autogenous Semitendinosus Tendons

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An isolated posterior cruciate ligament injury is a difficult clinical and surgical problem. Most authors agree that multidirectional rotatory instability of a knee resulting from either medial or lateral ligamentous laxity in combination with a posterior cruciate ligament (PCL) injury requires surgical stabilization.[1,2] However, indications for surgical reconstruction of an isolated posterior cruciate ligament injury still remain controversial. This lack of agreement over the surgical indications for this injury appears to stem from a lack of clear understanding of the natural course of PCL-deficient knee, and current limitations in surgical technique to reproduce posterior stability in a predictable fashion.

Although the PCL has been demonstrated to be responsible for 95% of posterior stability against posterior translation,[3] many authors still report a good clinical outcome with non-surgical treatment.[1,4,5,6] They agree that strengthening of the quadriceps is the most important component of the rehabilitation. However, unlike the anterior cruciate-deficient knee, instability is not the chief complaint in these patients. They present with activity-related knee pain, swelling, and impaired functional activities such as running, jumping, stair-walking, and cutting.[7,8] It also appears that the non-operatively treated PCL-deficient knee ultimately results in progressive and symptomatic degenerative changes of the knee.[9] Clancy reports that up to 31% of his patients with a PCL-deficient knee showed radiographic changes consistent with arthrosis involving the medial compartment and patellofemoral joint. Moreover, if the injury occurred more than four years previously, up to 90% had some type of cartilage injury at the time of surgery.[7]

Unlike anterior cruciate ligament (ACL) reconstruction, the PCL reconstruction technique is more demanding, and it is not as well established. It appears that with the current surgical technique for PCL reconstruction, the results are not as predictable as for ACL reconstruction. However, with the advancement of arthroscopic technique and equipment, the PCL reconstruction technique is evolving, as did ACL reconstruction. We have reported our progress in this subject over the past several years, with the last study utilizing a combination of allograft and autograft semitendinosus tendons.[10,11,12]

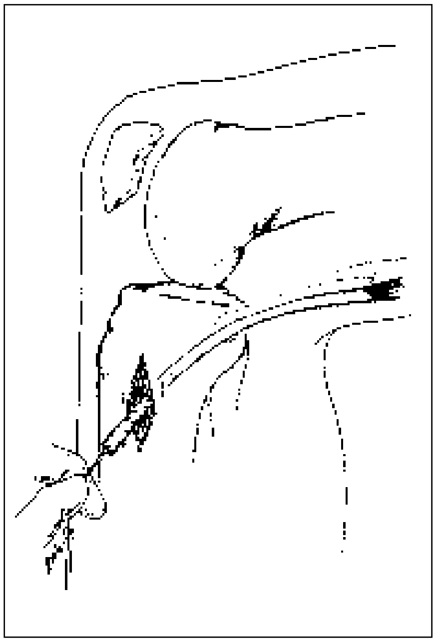

Figure 1. Pes Anserine incision with semitendinosus tendon isolated. "Whipstitch" is placed prior to tendon harvesting.

The purpose of this paper is to describe a new surgical technique for PCL reconstruction utilizing two autogenous semitendinosus tendons. A reconstruction of the PCL is performed using semitendinosus tendons from the uninjured and injured leg to reconstruct anatomically the anterolateral and posteromedial fibers of the PCL, utilizing two femoral tunnels and two tibial tunnels.

SURGICAL PROCEDURE

Patient Positioning

The patient is placed supine on the operating table. A general or regional anesthetic is administered. After a complete examination of the knee, a padded tourniquet is placed on the injured leg and secured into an arthroscopic leg holder. This leg is allowed to hang freely over the distal edge of the table. The well leg is positioned next to the operative leg. Again a well-padded tourniquet is placed on the thigh. A padded holder is also secured into an arthroscopic leg holder, which is used later to rest the well leg. After obtaining the semitendinosus tendon from the well leg, it is placed onto the padded holder, allowing adequate exposure of the operative leg (Fig. 1). Both legs are then prepared in a sterile fashion from the toes to the level of the tourniquets and draped with a bilateral extremity sheet.

Graft Harvesting from Contralateral Leg

The contralateral leg is exsanguinated, and the tourniquet is inflated to the appropriate pressure. Starting at the level of the tibial tubercle, a 3-cm vertical incision is made 1 to 2 cm medial to the tubercle (Fig. 2). After the skin incision, the subcutaneous layer is sharply incised to the sartorius fascia. Both semitendinosus and gracilis tendons are palpated, and the sartorius fascia between the two tendons is incised along the direction of the tendons. The semitendinosus tendon is bluntly dissected and separated from the gracilis tendon and detached from its tibial attachment. A whipstitch is placed on the distal end using a No. 2 nonabsorbable suture. Retinacular and gastrocnemius attachments are sharply detached from the main tendon, and the tendon is stripped from the muscle with an open-ended tendon harvester. After repairing the sartorius fascia with a No. 1 absorbable suture, the incision is closed in layers. A compressive dressing is applied, and the tourniquet is

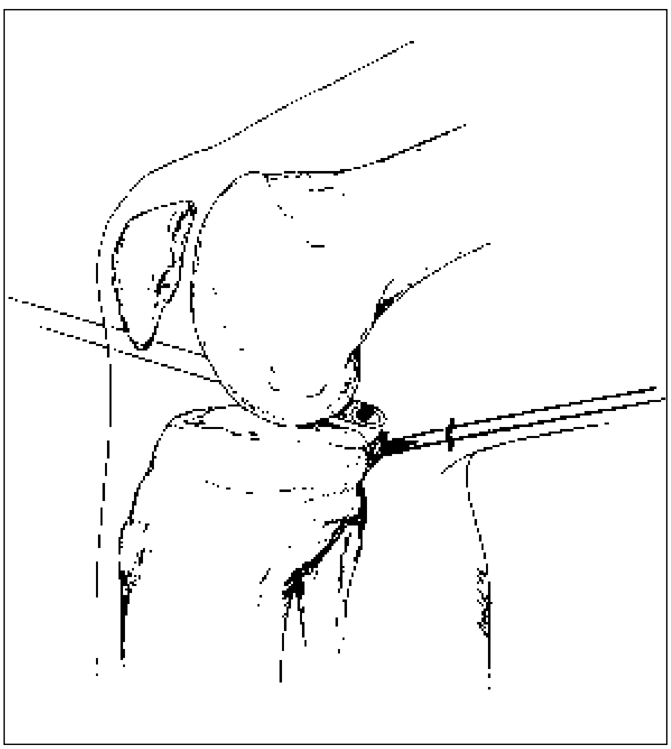

Figure 2. A 70° arthoscope is introduced through the anterolateral portal to visualize the PCL. An arthroscopic shaver is placed through the posteromedial portal to remove the PCL stump.

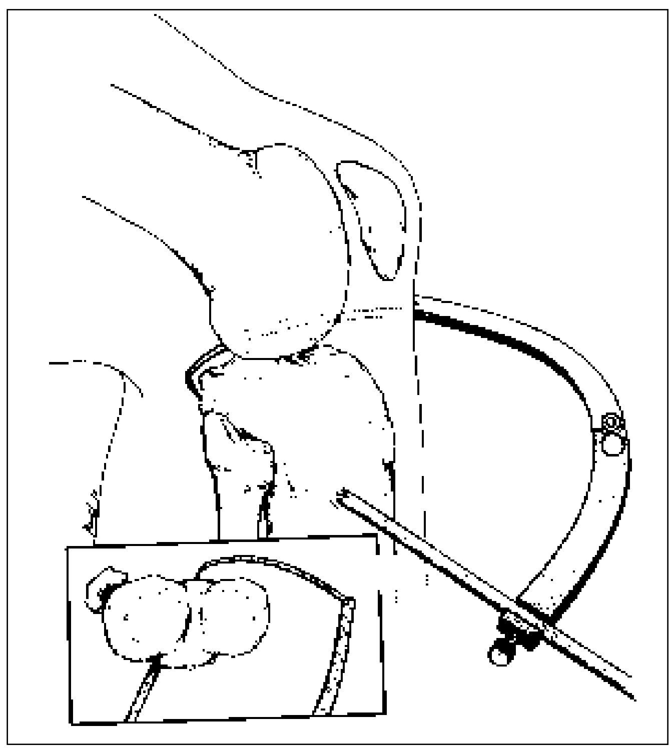

Figure 3. The tip of a tibial guide is inserted using the posteromedial portal and placed at the posterior capsular attachment. The sleeve is lowered onto the lateral tibial cortex.

released. The leg is then positioned on the top of the padded holder as previously described.

To prepare the tendon to be used as a graft, the remaining muscle is removed from the harvested tendon, and the proximal end is tubularized using a 3.0 absorbable suture. Again, a whipstitch is placed using a No. 2 nonabsorbable abraded suture at the tubularized end. The tendon is doubled over No. 5 Dacron tape, sized, and wrapped in a moist sponge until it is ready to be used. A marking is made 2 cm from the folded end with a surgical marker.

Surgical Technique

After harvesting the tendon from the contralateral leg, a complete diagnostic arthroscopy of the injured leg is performed using anterolateral and anteromedial portals. An egress tubing is inserted through the superolateral portal and the joint is distended by gravity flow. A 4-mm 30° arthroscope with a 5.5-mm scope sleeve is used for the diagnostic arthroscopy. A 70° arthroscope is also used to assess posterolateral and posteromedial compartments and the tibial attachment of the posterior cruciate ligament. Meniscectomy and chondroplasty are performed as necessary.

After completing the diagnostic arthroscopy, an anterolateral incision is made to harvest the semitendinosus. A 6- to 8-cm vertical incision is then made, starting at the level of the tibial tubercle, immediately lateral to the patellar tendon. A full thickness skin flap is created medially and laterally. After retracting the skin medially, the semitendinosus tendon is palpated and again harvested in a similar fashion as previously described above. Because the incision is lateral and the tendon stripper has to be directed around the curvature of the tibia medially to harvest the semitendinosus, one should pay special attention to the alignment of the tendon stripper, as a misdirected tendon stripper can truncate the semitendinosus tendon. A more lateral incision is used on the operative side to expose the tibial tunnel site without an additional incision. This incision can also be extended posterolaterally for posterolateral ligament repair or reconstruction. The muscles of the anterior compartment of the tibia are stripped from the proximal tibia. This area is usually at the diaphyseal and metaphyseal junction. Both the diagnostic arthroscopy and graft harvesting can be done without using a tourniquet.

Tibial Tunnels

The leg is exsanguinated, and the tourniquet is inflated to appropriate pressure. The arthroscope is reintroduced, and remnants of the posterior cruciate ligament are debrided from femoral attachment. Using a 70° arthroscope through the anterolateral portal and power instruments through the posteromedial portal, the remaining posterior cruciate ligament on the tibia can be removed (Fig. 3).

A tibial guide is introduced through the posteromedial portal and placed at the tibial attachment site of the posterior cruciate ligament. The guide is positioned at the posterior capsular attachment. Placement of the guide is visualized utilizing a 70° arthroscope. After retracting the anterior tibial muscles laterally, a guide pin sleeve is placed on the lateral tibia (Fig. 4). The guide pin is drilled from the proximal lateral tibia until the posterior cortex is penetrated and the end of the pin is visualized arthroscopically. Similarly, a second pin is placed 1.5 to 2.0 cm inferiorly at the anterolateral tibia. This pin is directed approximately 5 to 6 mm inferior to the first pin at the posterior tibial cortex (Fig. 5). At this point the pin placement can be checked using a portable fluoroscan.

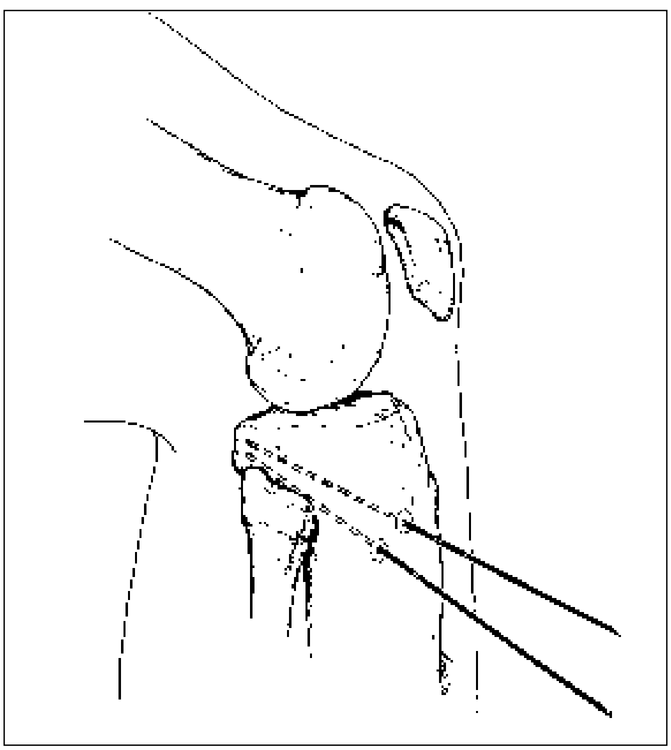

Figure 4. Properly inserted tibial guide pins. The two pins are separated by 1.5 to 2 cm anteriorly and 5 to 6 mm posteriorly.

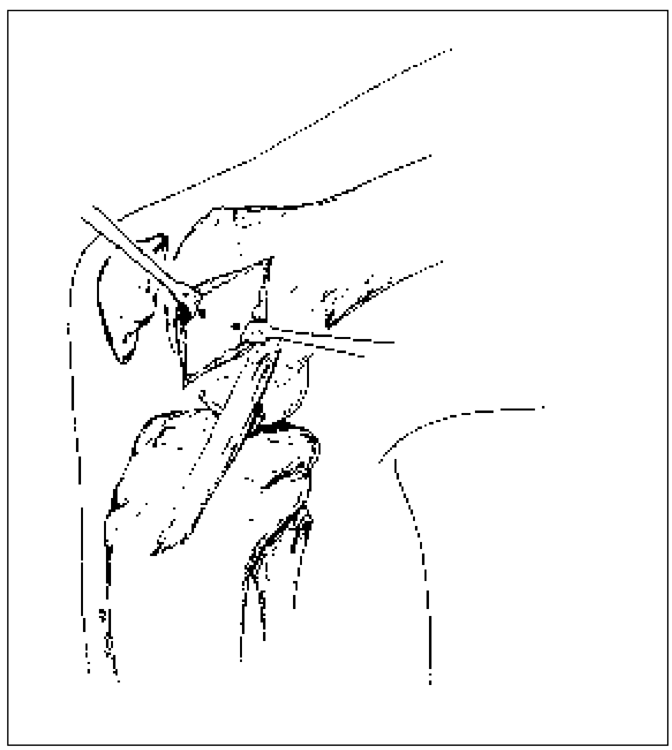

Figure 5. A longitudinal incision is made between the medial edge of the patella and the posterior edge of the medial femoral condyle. The skin and the subcutaneous tissue are mobilized enough to have good exposure of the medial side for femoral guide pin insertion without interference.

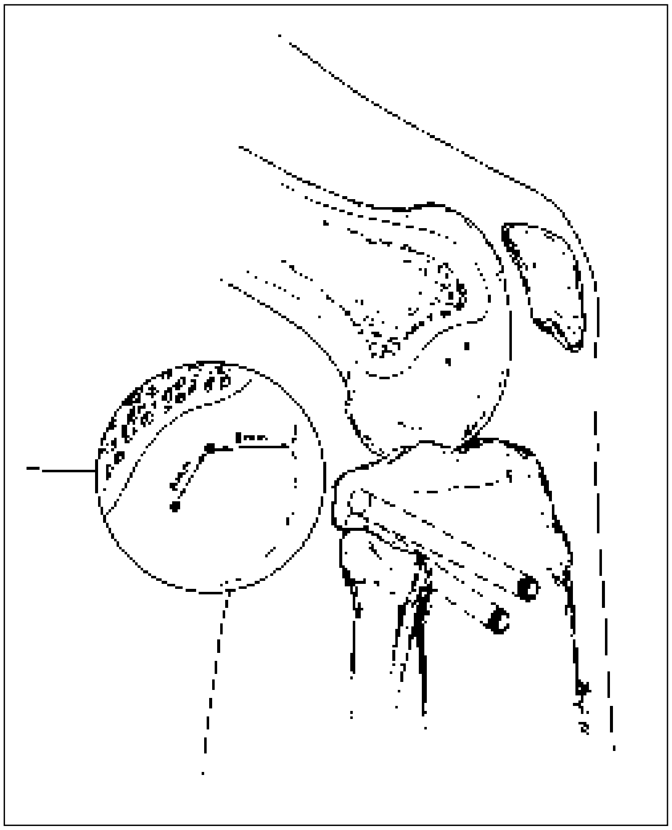

Figure 6. The anterior femoral tunnel for the grafts on the inner cortex of the femoral condyle is located 8 mm posterior to the articular edge. The posterior tunnel is approximately 6 mm behind the anterior tunnel.

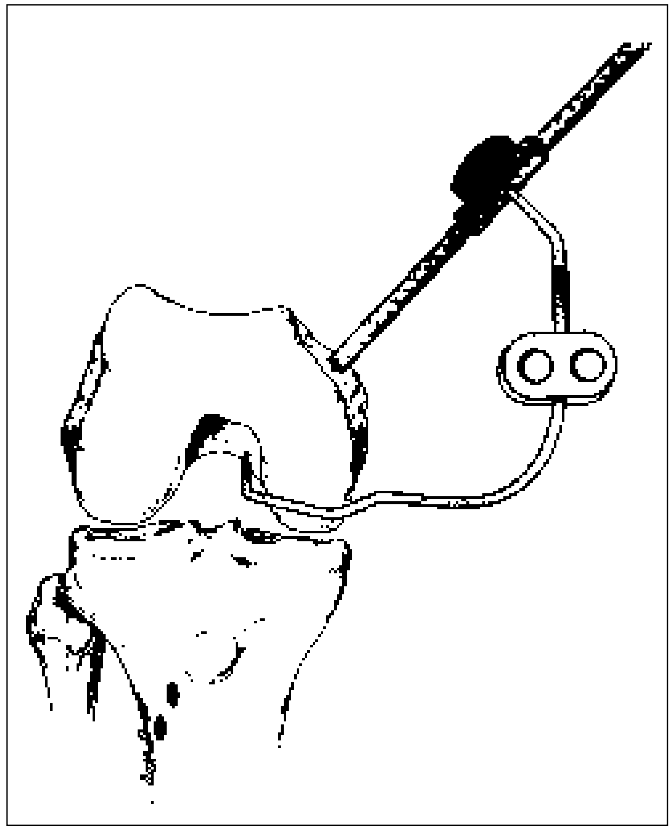

Figure 7. The tip of the guide pin is placed on the anterior femoral tunnel site on the inner cortex of the femur through the anteromedial portal. The drill sleeve is then placed on the medial femoral condyle over the vastus medialis muscle.

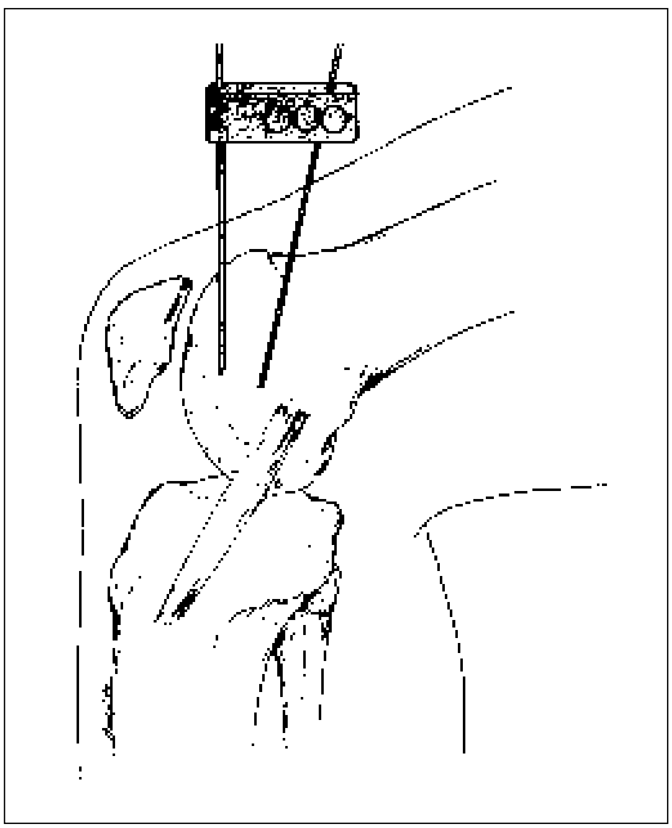

Figure 8. After placing the anterior femoral guide pin, the femoral guide assembly is removed and, using the converging femoral guide, a second guide pin is inserted. The calibration on the pins provide proper separation of the pins at the inner cortex of the femoral condyle.

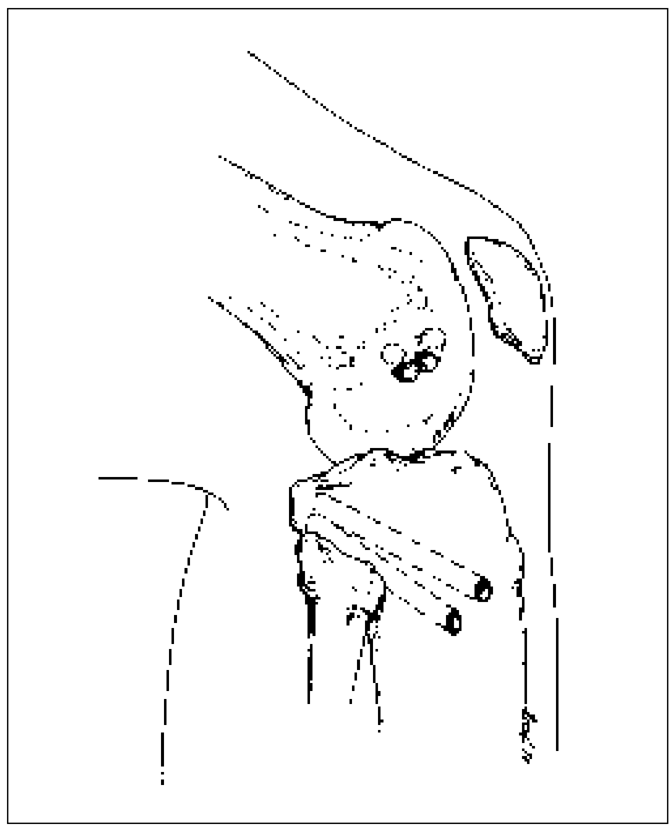

Figure 9. Completed tibial and femoral tunnels.

An appropriate size cannulated reamer, as determined by the size of the doubled semitendinosus tendon, is then utilized to make tibial tunnels. Usually, a doubled semitendinosus has a diameter of approximately 6 mm. To reduce the chance of neurovascular injury, we prefer the use of a reciprocating drill (Synthes, Switzerland). A large curette is placed directly posterior to the guide pin to prevent the pin from migrating posteriorly. The bony and soft tissue debris are meticulously cleaned from the joint and the tibial tunnel. Teflon plugs are then placed in these tunnels to prevent excessive fluid leakage.

Femoral Tunnels

A second longitudinal incision is made between the medial edge of the patella and the posterior edge of the medial femoral condyle (Fig. 6). The skin and the subcutaneous tissues are sharply dissected and mobilized enough to prevent interference with femoral guide pin placement. The PCL femoral drill guide is passed through the anteromedial portal. The point of the guide is directed into the medial femoral cortex. The initial intra-articular point is 8 mm posterior to the edge of the articular surface. This point corresponds approximately to the anterolateral fiber attachment of the PCL (Figs. 7, 8). The skin is retracted superiorly and the guide sleeve is placed

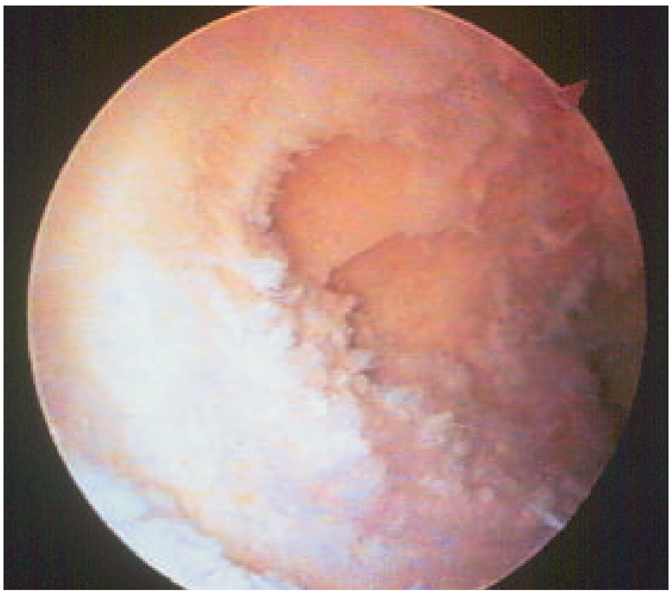

Figure 10. An arthroscopic view of the completed femoral tunnels.

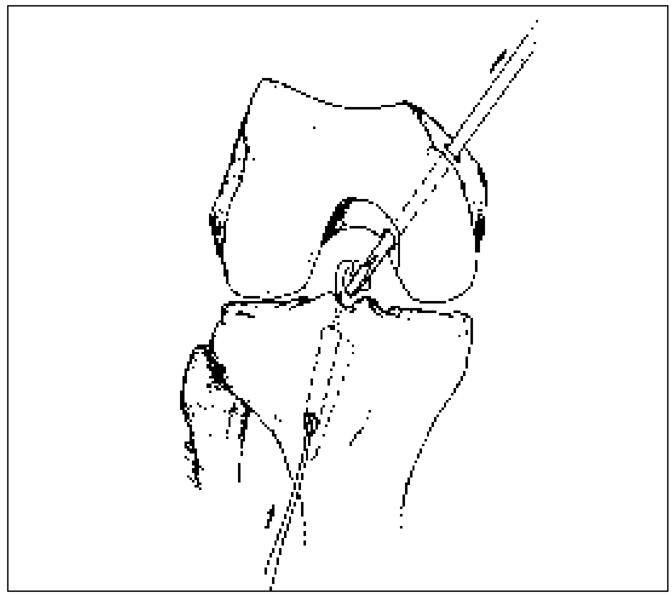

Figure 11. A 18-gauge wire loop with a bent tip is placed from the superior tibial tunnel and directed upward. A grasper placed through the anterior femoral tunnel and the wire loop is brought out.

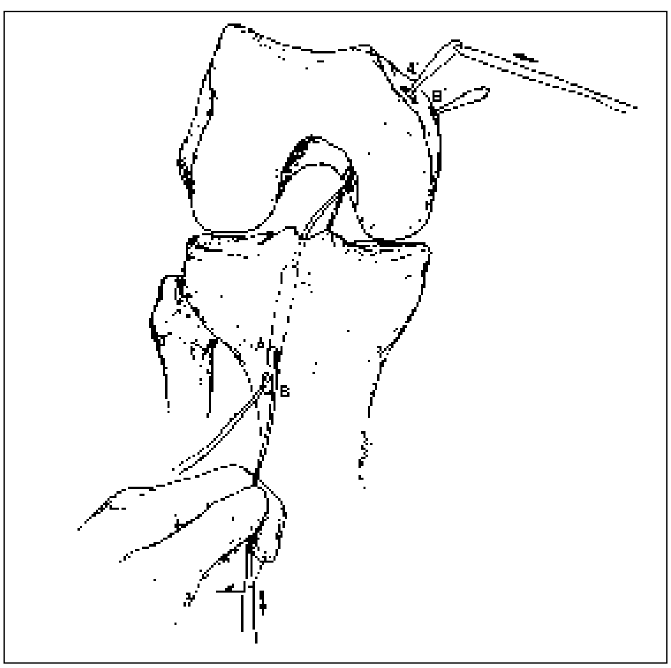

Figure 12. After two wire loops are passed from the tibial tunnels to the femoral tunnels, these loops are exchanged. Another looped wire is placed in the loop of the first wire. The first loop is then pulled back from the tibial tunnel, delivering the looped portion of the second wire on the tibial side.

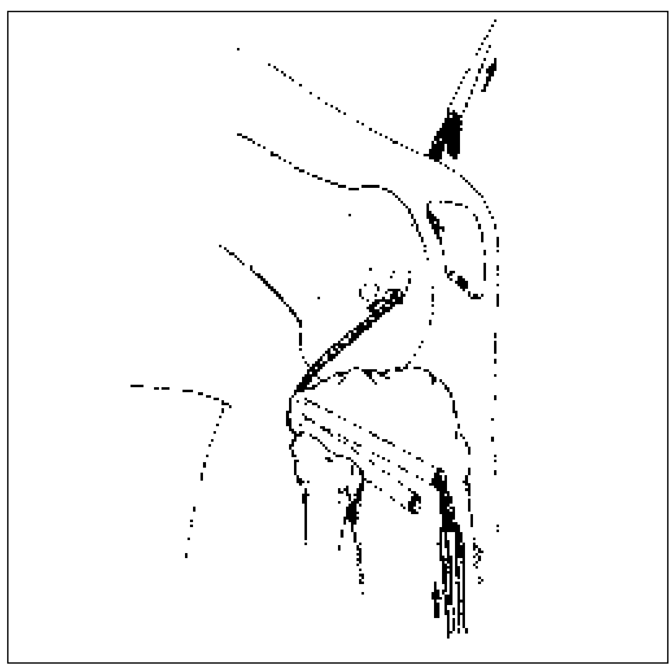

Figure 13. Dacron tape is placed around the wire loop, and the wire is pulled out from the femoral side one at a time, delivering the Dacron tape to the femoral side.

on the medial femoral epicondyle 10 mm posterior to the articular surface. The intra-articular placement of the guide is checked once more, and then the guide pin is drilled until it just breaks the inner cortex of the medial femoral condyle. When correctly directed, the pin points to the posterolateral cortex of the tibia. The PCL femoral drill guide assembly is then removed, and the converging femoral drill guide is placed onto the already drilled guide pin (Fig. 9). These guide pins are calibrated to give the desired distance between two pins at the inner cortex of the femur by triangulation. Ideally, the pins should be separated at the inner cortex by a distance equivalent to the diameter of the double semitendinosus tendon. The second pin is then drilled from an outside-to-inside direction by the use of the converging femoral guide, until the tip of the pin is visualized. The exiting point of the second pin should be posterior and inferior to the first pin, corresponding to the posteromedial attachment site. When the pins are placed in satisfactory positions, the converging guide is removed and the pins are advanced until 5 to 7 mm of the tips are exposed. The femoral tunnels are then reamed using the same size reamer that was used for the tibia. The inner edges of the tunnels are then rasped, and all bone fragments are removed. When completed, the two femoral tunnels are immediately adjacent to each other in the inner femoral cortex (Figs. 10, 11). Depending on the size of the femur, 1 to 2 cm of bone bridge will exist on the outer cortex of the femur.

Graft Passage

After completing the double tibial and femoral tunnels, the doubled semitendinosus tendons are ready for passage. An 18-gauge wire loop with a bent tip is passed from the superior tibial tunnel and directed upward. Using a grasper from the anteromedial portal, the wire is directed toward the posterior femoral tunnel. A second arthroscopic grasper is inserted from outside of the anterior femoral tunnel, and the wire loop is brought out through the tunnel (Fig. 12). If the femoral tunnel is too small to pass the grasper, a small probe may be used to hook onto the loop and direct the loop through the tunnel. Similarly, a second wire loop, preferably of different size, is passed from the inferior tibial tunnel to the anterior femoral tunnel. Another looped 18-gauge wire is then placed in the loop of the first wire (Fig. 13). The first loop is then pulled back from the tibial tunnel, delivering the looped portion of the wire on the tibial side. The same maneuver is done with the second wire. The Dacron tapes from the previously prepared grafts are placed around each of the wire loops. The wires are then pulled out from the femoral side one at a time delivering the Dacron tapes (Fig. 14). When both sets of the Dacron tapes are retrieved, the grafts are pulled through the tibial tunnel into the joint. The grafts are then pulled into the femoral tunnels until the previously marked area is flush with the inner cortex. It is best to pull the posteromedial graft first. If the anterolateral graft is pulled into the femoral tunnel first, it can obscure the marking on the posterolateral graft. The grafts should not be pulled in and out repeatedly through the femoral tunnels, since this can abrade the grafts and significantly weaken them.

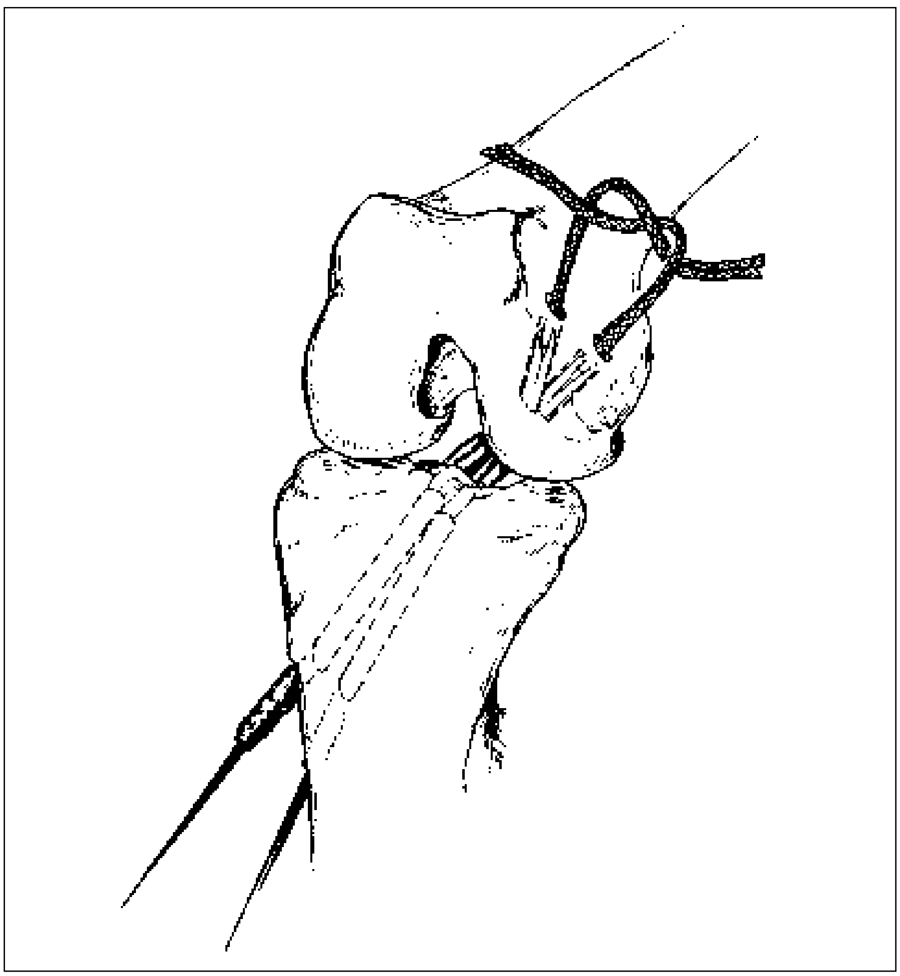

Figure 14. The Dacron tapes are tied to each other over the bony bridge.

Graft Fixation

When graft passage is completed, two Dacron tapes are brought out in the open through the small defects in the vastus medialis obliquus created when the tunnels were drilled. The muscle and soft tissue between these two areas are separated from the underlying femur using a hemostat. Again using a hemostat, the superior tape is retrieved under the muscle and brought out through the inferior defect. These two tapes are then tied to each other over the bony bridge or to a screw and washer placed behind the medial epicondyle (Fig. 15). Passing the superior suture under the muscle, instead of tying over the muscle, frees the vastus medialis muscle. With the grafts secured on the femoral side, a maximum tension is applied to the whipstitches exiting the tibial tunnel. The graft is visualized arthroscopically through a full range of motion. If impingement of the tunnel is present, more bony resection should be performed.

The knee is flexed to 90 degrees of flexion while an anterior drawer is applied to the proximal tibia. Each limb of the anterolateral graft, which corresponds to the graft exiting from the superior of the two tibial tunnels, is separated and maximum tension is applied to both limbs. This graft is then secured to the tibia using a bicortical screw and a soft-tissue washer (Fig. 16). We use the 6.5-mm Concepts screw with a 17-mm Concepts soft-tissue washer. The knee is then flexed to 30 degrees of flexion. Again an anterior drawer is placed on the proximal tibia. Each limb of the posteromedial graft, exiting from the inferior tibial tunnel, is separated and placed around a bicortical screw with a washer (Fig. 17). Each limb again is pulled with maximum tension during screw fixation.

Following fixation of the grafts to the tibia, posterior drawer force is applied, and the endpoint is assessed. The arthroscope is again introduced, and tension on the graft is checked using a probe, while the knee is being taken through a full range of motion. The joint is again well irrigated and any loose debris is removed. All incisions are closed over suction drainage.

POSTOPERATIVE MANAGEMENT AND REHABILITATION

Patients are usually admitted overnight for pain control and initiation of physical therapy. The drain is then removed the following day. Crutch training, quad sets, and straight-leg raise exercises are taught to patients. They are seen one week after surgery for stitch removal, when formal physical therapy sessions are initiated (Fig. 18). The patients are allowed to shower in the brace following stitch removal but are not allowed in a pool or tub for two weeks following surgery.

The knee is placed in a postoperative brace (Donjoy, Carlsbad, Calif.), locked at 15 degrees of flexion immediately postoperatively. Range of motion is only allowed during exercise sessions; otherwise, the knee remains locked at 15 degrees for the first four weeks. Passive range of motion is allowed from 0 to 60 degrees initially and is advanced as tolerated after the first week. Active range of motion from 0 to 30 degrees is initiated during the second week post surgery and advanced to 60 degrees during the fourth week. Flexion is increased 10 degrees per week thereafter. Full extension is usually achieved by four weeks, and full flexion is obtained by eight weeks.

The patient remains toe-touch weight bearing for five weeks postoperatively. Partial weight at 25% is begun at the sixth week and advanced 25% per week until full weight bearing is achieved at the ninth week.

The brace is locked at 15 degrees for the first four weeks. It is worn full-time during the first three weeks. The patients are then allowed to take a shower without the brace after three weeks. The brace is unlocked at the fourth week, and extension/flexion parameters are set according to the limits of the active range of motion. The patients are allowed to sleep without the brace after five weeks.

Early strengthening and aerobic conditioning are emphasized. Quad sets and straight-leg raises with the brace set at 15 degrees are initiated immediately postoperatively. Early aerobic conditioning exercises, consisting of cycling with well leg and upper-body exercises are begun as soon as the patient can tolerate them. Short-arc quads from 0 to 30 degrees are added at the second week and increased to 0 to 70 degrees after three months. Mini-squats and leg presses are added the sixth week, and stationary cycling and walking programs are added the eighth week. Stairmaster, cross-country ski machine, and rowing are begun after three months postoperatively. A running and jogging program are initiated at the sixth month. Power training with hamstring curls and isokinetics are also added at this time.

The patients are allowed to return to sports at a minimum of 12 months following the operation, after they demonstrate near 100% quadriceps and

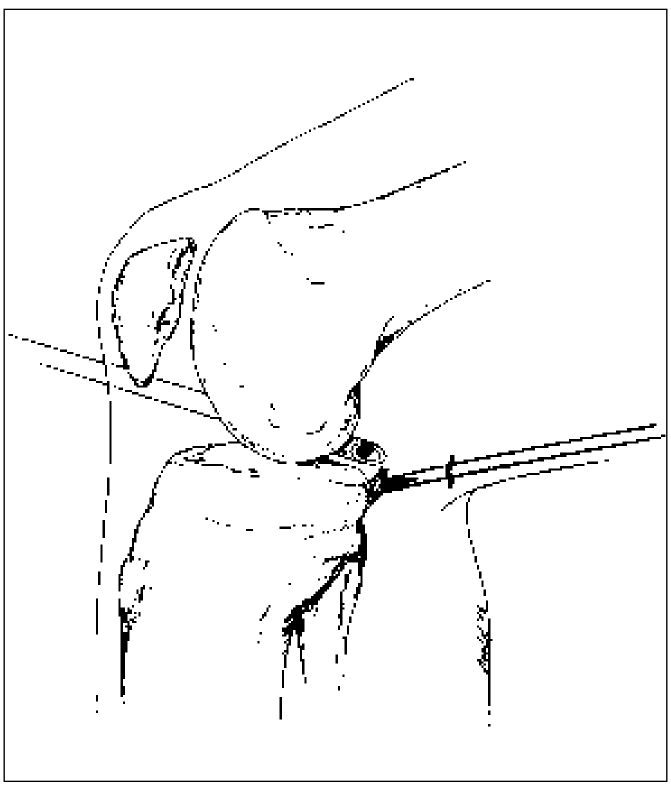

Figure 15. The anterolateral graft is secured to the tibia at 90 degrees of knee flexion using a 6.5-mm Concepts screw and a 17-mm Concepts soft tissue washer.

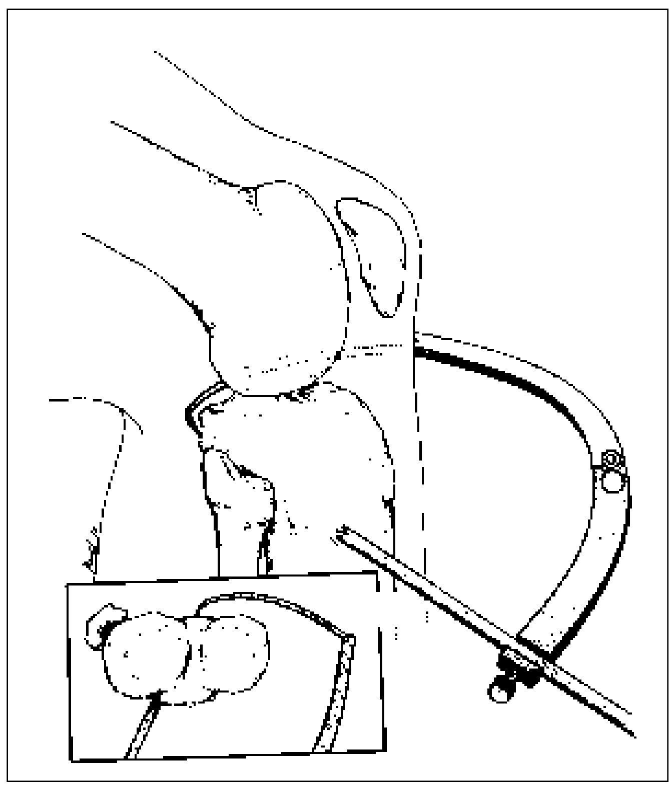

Figure 16. The posteromedial graft is secured to the tibia at 30 degrees of knee flexion using a screw and a soft tissue washer.

80% hamstring strength of the opposite knee. They also must have completed a jogging and running program with no evidence of swelling and range of motion from 0 to 140 degrees.

CONCLUSION

Despite numerous reconstructive methods, posterior cruciate ligament reconstruction still remains a challenging and difficult procedure. Current techniques have been unable to recreate precisely the normal anatomy of the ligament. Nevertheless, these techniques have provided the functional posterior stability. We present a newly developed technique, utilizing semitendinosus tendons from both legs to recreate anatomically the anterolateral and posteromedial fibers of the posterior cruciate ligament. Our early experience with this procedure resulted in a more reproducible and predictable posterior stability to the PCL-deficient knee. Patient selection is especially important, since one of the patient's tendons is harvested from the uninjured leg. This procedure requires advanced arthroscopic skills as well as meticulous attention to details. We believe that this technique, applied to patients who are highly motivated, and with well-supervised physical therapy, will provide a successful PCL reconstruction. STI

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