Anatomical Reconstruction for Chronic Posterolateral Instability Combined with Posterior Cruciate Ligament Reconstruction

Surgical Technique

Sung-Jae Kim, MD, PhD, Sung-Hwan Kim, MD, Hee-Don Han, MD, In-Sung Lee, MD, Sung-Guk Kim, MD, and Yong-Min Chun, MD, PhD

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Introduction

We present surgical techniques for the anatomical reconstruction of the popliteus tendon and the lateral collateral ligament (LCL) with use of a tibialis posterior allograft for posterolateral corner insufficiency combined with anterolateral transtibial single-bundle posterior cruciate ligament (PCL) reconstruction with use of an Achilles tendon-bone allograft with a one-incision technique.

Numerous techniques have been introduced and studies have been conducted to address the treatment of PCL and posterolateral corner injuries of the knee. For the PCL reconstruction, one-incision versus two-incision¹, single-bundle versus double-bundle²⁻⁶, and conventional anteromedial versus anterolateral transtibial techniques have been investigated⁷⁻⁹, whereas primary repair, a sling technique, biceps rerouting tenodesis, and anatomical reconstruction of posterolateral corner structures have been proposed to address posterolateral corner insufficiency¹⁰⁻¹⁷. Although the optimal reconstructive options restore the injured structures as close to their original anatomical configurations as possible, these procedures are technically demanding and time-consuming.

Our combined procedures consisting of anatomical reconstruction of the popliteus tendon and the LCL with a tibialis posterior allograft for posterolateral corner insufficiency combined with anterolateral transtibial single-bundle PCL reconstruction with use of an Achilles tendon-bone allograft with a one-incision technique have several advantages: they are relatively easy to perform compared with arthroscopic inlay PCL reconstruction, they reduce graft angulation in the coronal plane compared with that associated with a conventional anteromedial transtibial technique, and

they enable anatomical reconstruction of the LCL and popliteus tendon.

These reconstructions are performed in six steps:

Step 1: Create the portals

Step 2: Prepare the tibial tunnel and femoral socket for the PCL reconstruction

Step 3: Prepare, pass, and fix the graft for the PCL reconstruction

Step 4: Make the skin incision and develop the surgical plane for the posterolateral corner reconstruction

Step 5: Prepare, pass, and fix the graft for the posterolateral corner reconstruction

Step 6: Postoperative rehabilitation

Step 1: Create the Portals

Use a parapatellar high anteromedial portal, a far anterolateral portal, and a high posteromedial portal.

- We recommend using three unique portals for the PCL reconstruction: a parapatellar high anteromedial portal created at the highest point possible on the medial parapatellar line just off the medial border of the patellar tendon and the inferior border of the patella; the far anterolateral portal created just above the joint line, 5 mm anterior to the lateral femoral condyle and 1.5 cm lateral to the lateral border of the patellar tendon; and the high posteromedial portal created 3 cm proximal to the joint line and just posterior to the medial femoral condyle¹⁸.
- Under direct visualization through the parapatellar high anteromedial portal, insert the spinal

needle as high as possible through the posteromedial side of the knee, aimed at the tibial attachment of the PCL. Then insert the scalpel parallel with the needle. This high posteromedial portal facilitates an excellent view of the PCL stump and posterior aspect of the capsule, which must be identified while you are preparing the fossa for the PCL.

Step 2: Prepare the Tibial Tunnel and Femoral Socket for the PCL Reconstruction

To reduce the graft/socket divergence, (1) flex the knee >100°, (2) push the proximal part of the tibia backward as much as possible, and (3) introduce the cannulated headed reamer through the far anterolateral portal with a smooth plastic sheath and push up posteriorly to make contact with the lateral femoral condyle.

- To clearly identify the fossa for the PCL, completely remove the remaining PCL stump and elevate the posterior aspect of the capsule from the tibial ridge. Introduce a PCL guide tip through the parapatellar high anteromedial portal and place it on the PCL fossa, which is located approximately 1.5 cm below the articular surface and just lateral to the midline on the PCL fossa when viewed through the high posteromedial portal. Make a 3 to 4-cm longitudinal skin incision just lateral to the tibial tuberosity to create the tibial tunnel on the anterolateral aspect of the tibia to reduce graft angulation on the coronal plane^{7,9}. Strip off the tibialis anterior muscle and retract it laterally.
- Expose the starting point of the tibial tunnel, which is placed about 2 cm posterolateral to the anterior aspect of the tibia. With a use of calibration on the PCL guide, accurately measure the distance from the anterolateral cortex of the tibia to the tip of the guide placed on the PCL fossa. Mark the same length on the guide pin to prevent inadvertent past-point drilling, which may cause neurovascular injury¹⁹. Check for optimal guide pin placement on the PCL footprint by viewing from the high posteromedial portal and pushing the posterior aspect of the capsule backward with a PCL guide arm. Ream the tibial tunnel incrementally with a 6 to 11-mm-diameter cannulated reamer. While reaming, be careful that the sharp guide pin moving with the reamer does not pierce the posterior aspect of the knee. Complete the final reaming manually. Then, chamfer the upper edge of the tibial aperture

with a rasp to prevent graft abrasion and stretching.

- For the femoral socket, prepare the footprint of the anterolateral bundle of the PCL and identify the center of the femoral socket, which is located 7 to 8 mm posterior to the articular margin at the 10:30 o'clock position in the left knee and the 1:30 o'clock position in the right knee. Then, introduce the cannulated headed reamer with a smooth plastic sheath through the far anterolateral portal.
- We used three unique methods to reduce the graft/socket divergence while introducing the cannulated headed reamer: (1) flex the knee >100°, (2) push the proximal part of the tibia backward as much as possible, and (3) introduce the cannulated headed reamer through the far anterolateral portal with a smooth plastic sheath and push up posteriorly to make contact with the lateral femoral condyle^{2,13,19} (Fig. 1). During reaming, this smooth plastic sheath covers the reamer shaft to prevent articular cartilage damage on the femoral condyle. Generally, create a femoral socket with a depth of 35 mm, and chamfer the sharp edge of the femoral aperture, especially the posterior half, to reduce graft abrasion and stress concentration²⁰.

Step 3: Prepare, Pass, and Fix the Graft for the PCL Reconstruction

Tie a 9-mm EndoPearl device securely to the tip of the tendon to improve the fixation strength.

- Generally, use an Achilles tendon-bone allograft. Trim the bone plug of the graft for tibial fixation to 25 mm in length and 11 mm in width. Prepare the tendon portion for the femoral fixation to be 60 mm in length and 11 mm in width, and thread the end of the Achilles tendon to be 30 mm in length in a whip-stitch fashion. Then, tie a 9-mm EndoPearl device (ConMed Linvatec, Largo, Florida) securely to the tip of the tendon to improve the fixation strength²¹ (Fig. 2).
- Introduce an intravenous plastic tube connected to the leading suture into the tibial tunnel and pull out through the cannula placed in the far anterolateral portal. Introduce a Beath pin into the femoral socket through the cannula in the far anterolateral portal and drill further through the medial aspect of the femoral socket to exit through the anteromedial skin of the distal part of the femur. Thread the leading suture into the eyelet of the Beath pin, pull the

Beath pin out of the femoral socket, and pull the leading suture on the femoral side. Thus, the EndoPearl and tendon portion of the graft are introduced into and passed through the tibial tunnel before engaging with the femoral socket. Monitor this graft passage with direct arthroscopic guidance.

- Secure the graft in the femoral socket with an absorbable interference screw through the far anterolateral portal with the knee at 100° of flexion. Currently, the graft pretensioning and tibial fixation for PCL reconstruction are performed after posterolateral corner reconstruction.

Step 4: Make the Skin Incision and Develop the Surgical Plane for the Posterolateral Corner Reconstruction

Create a 7-mm fibular tunnel in a counterclockwise direction to avoid breaking the lateral cortex of the fibular tunnel or injuring the peroneal nerve.

- With the knee extended, make a skin incision on the lateral aspect of the knee from just anterior to the fibular head to the lateral femoral epicondyle (Fig. 3). Develop the plane upward between the posterior aspect of the iliotibial band and biceps femoris tendon to expose the lateral epicondyle of the femur, fibular head, posterolateral corner of the tibia, and Gerdy's tubercle.
- Place one anterior cruciate ligament (ACL) guide tip on the posterolateral corner of the knee 10 mm below the knee joint and 5 mm medial to the posterior aspect of the proximal tibiofibular joint, and the other tip on Gerdy's tubercle (Fig. 4). Insert the guide pin under fluoroscopic guidance, and create the 7-mm tibial tunnel with a cannulated reamer. Through the cannulated reamer, introduce a looped wire into the anterior aperture, and pull out from the posterior aperture.
- Place one tip of the ACL guide at the point just posteromedial to the LCL insertion on the fibular head, and the other tip at the anteroinferior aspect of the fibular head at an angle of 70° in an anteroinferior-to-posterosuperior direction (Fig. 5). Then, insert the guide pin and create a 7-mm fibular tunnel in a counterclockwise direction to avoid breaking the lateral cortex of the fibular tunnel or injuring the peroneal nerve. In the same manner, pass the double looped wire through the fibular tunnel.

Step 5: Prepare, Pass, and Fix the Graft for the Posterolateral Corner Reconstruction

Change the patient's position to a lateral or semi-lateral decubitus position to prevent an inappropriate posterolateral corner reconstruction by the posterolateral corner of the knee sagging in the supine position due to gravity.

- For LCL and popliteus tendon reconstruction, prepare the tibialis posterior allograft so that it is 7 mm in width. Thread both ends of the graft in a whip-stitch fashion, and securely tie the EndoPearl to one end. Leave the remaining end empty, which will be introduced through the tibial and fibular tunnels by the previously inserted looped wire. Connect the empty end of the graft to the looped wire at the posterior aperture of the tibial tunnel, and pull out in an anterior direction. Then reconnect the graft to the looped wire at the anterior aperture of the fibular tunnel, and pull out in a posterior direction (Fig. 6). Fix the graft in the tibial and fibular tunnels, respectively, with absorbable interference screws (7 mm in diameter and 20 mm in length) through the anterior aperture.
- Because the posterolateral corner of the knee sags in the supine position secondary to gravity, change the patient's position to a lateral or semi-lateral decubitus position to prevent an inappropriate posterolateral corner reconstruction. Before draping, we place a vacuum bag underneath the patient in a supine position. Thus, if necessary, we change the patient's position from supine to a lateral or semi-lateral position and make the vacuum bag hard by running the vacuum. Then, the vacuum bag holds up the patient in a lateral or semi-lateral position.
- Expose the lateral epicondyle and popliteal sulcus of the distal part of the femur. To reconstruct the popliteus tendon (exiting the tibial tunnel), the isometric point is placed approximately on the anterior one-fifth of the popliteus sulcus and about 15 mm distal and 10 mm anterior to the femoral epicondyle. For the LCL (exiting the fibular tunnel), the isometric point is located at the anterosuperior margin of the lateral epicondyle.
- Insert the 0.045-in (0.11-cm) Kirschner wire at a tentative isometric point, wrap each end of the graft around the Kirschner wire, and check the isometricity to determine whether the graft migrates >2 mm during flexion and extension

(Fig. 7). After confirming the isometricity, create a 7-mm femoral socket 40 mm in depth over the Kirschner wire.

- Attach a 7-mm EndoPearl to the empty end of the graft, and connect it to the leading suture. First, route one end of the graft exiting from the tibial tunnel to the anterior one-fifth of the popliteal sulcus (reconstructing the popliteus tendon) by pulling the leading suture, and secure it with an absorbable interference screw (Fig. 8). In the same manner, pull the other end exiting from the fibular tunnel into the femoral tunnel at the anterosuperior margin of the epicondyle (reconstructing the LCL), and secure it with an absorbable interference screw (Fig. 9). Suture the distal part of the popliteus graft to the posterosuperior periosteal tissue of the fibular head to augment the popliteofibular ligament.
- Pretension the graft by moving the knee through a full range of motion twenty times. Then, apply 120 N with the tensioner (SE [Stress Equalization] Graft Tensioning System; ConMed Linvatec) (Fig. 10). Secure the bone plug of the PCL graft in the tibial tunnel with an absorbable interference screw at 70° of knee flexion while pulling the proximal part of the tibia anteriorly to restore the normal anterior tibial step-off.

Step 6: Postoperative Rehabilitation

Immobilize the knee in extension, with the proximal part of the tibia supported with cotton pads to prevent posterior drooping, which may lead to graft stretch or failure.

- Protect the operatively treated knee with a hinged knee brace for seven to eight weeks, and encourage the patient to do quadriceps strengthening and patellar mobilization exercises immediately postoperatively. Although the knee is immobilized in extension for the first four to five weeks, take off the brace three times per day to begin the protected range-of-motion exercises, such as passive flexion exercise as tolerated at the third postoperative week. While the knee is immobilized in extension, the proximal part of the tibia should be supported with cotton pads to prevent gravity-induced posterior drooping of the proximal part of the tibia, which may lead to graft stretch or failure^{2,13}.
- After this period, patients may bear weight gradually with crutch assistance and flex the knee as tolerated, increasing up to 110° flex-

ion while wearing an unlocked hinged brace. At seven to eight weeks postoperatively, closed-chain exercise is allowed. At ten to twelve weeks, stationary bicycle, stair-stepping, and single-limb-stance exercises are allowed. Full flexion or squatting is prohibited for the first three months after surgery. At four to five months after surgery, fast walking and pool swimming are allowed. After six months, when the affected knee symmetry index is $\geq 90\%$ in a single hop test, the patients are allowed to return to their full activities or preinjury level of sports activities.

Results

We performed a two-year follow-up study comparing the procedures described here (Group A) with the same PCL reconstruction technique combined with a modified biceps rerouting tenodesis to address the posterolateral corner deficiency (Group B). The techniques described here resulted in similar side-to-side differences (mean and standard error, 3.5 ± 0.4 mm in Group A and 4.3 ± 0.4 mm in Group B) seen on posterior stress radiography performed with use of a Telos device with a posterior load of 15 kPa applied to the proximal part of the tibia and with 90° of knee flexion in neutral tibial rotation. However, Group A showed significantly better results with regard to the side-to-side difference in external rotatory instability on the dial test at 30° ($4^\circ \pm 1^\circ$ in Group A and $7^\circ \pm 1^\circ$ in Group B; $p < 0.05$) and at 90° ($4^\circ \pm 1^\circ$ in Group A and $7^\circ \pm 1^\circ$ in Group B; $p < 0.05$) and on varus stress radiography at 30° with the Telos device (1.2 ± 0.2 mm in Group A and 2.4 ± 0.3 mm in Group B; $p < 0.05$). In Group B, five patients showed overtightening of the posterolateral corner after biceps rerouting tenodesis, which is consistent with a decrease in external rotation of about -5° to 0° compared with the normal contralateral knee.

Group A had significantly better clinical outcomes as measured with the Lysholm knee score (mean and standard error, 89.1 ± 1.4 in Group A compared with 82.7 ± 2.0 in Group B; $p < 0.05$) and the International Knee Documentation Committee (IKDC) knee score (classified as normal [A] or nearly normal [B] in sixteen patients [76%] in Group A compared with ten patients [40%] in Group B; $p < 0.05$). Measurement of knee motion at two years showed the side-to-side difference in limitation of the terminal flexion angle was $4.0^\circ \pm 1.2^\circ$ in Group A and $8.8^\circ \pm 1.3^\circ$ in Group B. This difference was significant ($p < 0.05$). Five patients in Group B had $>15^\circ$ of terminal flexion loss (20%) compared with only one patient (5%) in Group A.

What to Watch For

Indications

- Chronic posterolateral rotatory instability on a reverse pivot-shift test and $>10^\circ$ of external rotation instability on a dial test at 30° and 90° , compared with the normal contralateral knee, in the context of concomitant grade-II or higher posterior translation on a posterior stress radiograph

Contraindications

- Varus thrust or varus malalignment of the affected limb
- Severe osteoarthritis of the knee
- Acute extensive injury to the joint capsule that can cause extravasation of irrigating fluid during arthroscopic surgery
- Active infection

Pitfalls & Challenges

- Uncorrected varus thrust or malalignment of the affected limb can contribute to graft stretching or failure of the reconstruction.
- To prevent inadvertent past-point drilling when creating the tibial tunnel for the PCL reconstruction, it is necessary to accurately measure the distance from the anterolateral tibial cortex to the tip of the PCL guide placed on the PCL fossa and mark this distance on the guide pin.
- During reconstruction of the posterolateral corner, when reaming the final 7 mm of the fibular tunnel, it is necessary to ream in a counterclockwise direction to avoid breaking the

fibular lateral cortex or injuring the peroneal nerve.

Clinical Comments

Question: When creating the femoral socket, what measures should you take to reduce the graft/socket angle?

Answer: We suggest the three techniques mentioned above: (1) flex the knee $>100^\circ$, (2) push the proximal tibia backward as much as possible, and (3) introduce the cannulated headed reamer through the far anterolateral portal with a smooth plastic sheath and push up posteriorly to make contact with the lateral femoral condyle^{2,13,18}.

Question: Does a successful reconstruction of the PCL and posterolateral corner herald the end of meticulous care?

Answer: Even after a successful reconstruction of the PCL and posterolateral corner, care must be taken to ensure proper healing and restoration of function. During the interval between the final graft fixation and application of a hinged knee brace in extension, the surgeon should make sure to always support the proximal part of the tibia to limit gravity-induced droop in the posterior or posterolateral direction. This is especially important when the patient is in the supine position, as the graft may become stretched out and fail. Furthermore, even when the hinged knee brace is in place, it is important to apply cotton pads at the proximal part of the tibia to prevent the posterior drooping^{2,13}.

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Sung-Jae Kim, MD, PhD

Sung-Hwan Kim, MD

Hee-Don Han, MD

In-Sung Lee, MD

Sung-Guk Kim, MD

Yong-Min Chun, MD, PhD

Department of Orthopaedic Surgery, Arthroscopy and Joint Research Institute, Yonsei University Health System, CPO Box 8044, 134, Shinchon-dong, Seodaemun-gu, Seoul 120-752, South Korea. E-mail address for S.-J. Kim: sungjaekim@yuhs.ac. E-mail address for S.-H. Kim: orthohwan@yuhs.ac. E-mail address for H.-D. Han: yaedrra@daum.net. E-mail address for I.-S. Lee: domlee1975@naver.com. E-mail address for S.-G. Kim: p10001@hanmail.net. E-mail address for Y.-M. Chun: min1201@hanmail.net

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Figures

Fig. 1

Creating the femoral socket for posterolateral corner reconstruction in the medial femoral condyle. The knee is flexed $>100^\circ$, and the proximal part of the tibia is pushed back as far as possible. The cannulated reamer with a smooth plastic sheath is introduced (in the direction indicated by the arrows).

Fig. 2

The Achilles tendon-bone allograft for the reconstruction of the PCL. The bone plug was trimmed for tibial fixation. The tendon portion for femoral fixation was threaded in a whip-stitch fashion, and the EndoPearl device was attached.

Fig. 3

Skin incision for posterolateral corner reconstruction, starting from the anterior aspect of the fibular head and extending to the femoral epicondyle.

Fig. 4

Creating the tibial tunnel for posterolateral corner reconstruction. One arm of the ACL guide is placed 10 mm below the knee joint and 5 mm medial to the proximal tibiofibular joint. The other arm is placed on Gerdy's tubercle.

Fig. 5

Creating the fibular tunnel for posterolateral corner reconstruction. At a 70° angle, the guide pin is introduced in an anteroinferior-to-posterosuperior direction.

Fig. 6

Each end of the graft passed out of the tibial and fibular tunnels. The empty end of the graft (white arrow) is used to reconstruct the LCL, and the EndoPearl-attached end (black arrow) is used to reconstruct the popliteus tendon.

Fig. 7

Isometricity test. The surgeon marks a point on the graft (arrow) and assesses whether this point migrates >2 mm.

Fig. 8

Femoral fixation for reconstructing the popliteus tendon (arrow).

Fig. 9

Femoral fixation for reconstructing the LCL (black arrow) over the popliteus tendon (white arrow)

Fig. 10

The tensioner for the graft in tibial fixation.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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Fig. 7

Fig. 8

Fig. 9

Fig. 10