

Evaluation and Treatment of the Multiligament-Injured Knee

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Abstract

A dislocated knee with tearing of both cruciate ligaments and one or both of the collateral ligaments is a severe injury that can result from high- or low-energy trauma. Vascular injuries (especially of the popliteal artery), nerve injuries, associated fractures, functional instability, and posttraumatic arthrosis all can occur with this injury complex. Most of these ligament injuries require surgical treatment, although some low-grade medial collateral ligament complex injuries can be treated with bracing. The timing of surgical treatment of acute multiple ligament injuries depends on the ligaments injured, the vascular status and skin condition of the injured extremity, the degree of knee instability, and the patient's overall health. It is important to correct all components of instability. Delaying reconstruction for 2 to 3 weeks may decrease the incidence of arthrofibrosis. Allograft tissue generally is preferred for these complex surgical procedures. Currently, there is no conclusive evidence that double-bundle posterior cruciate ligament reconstruction provides better results than single-bundle posterior cruciate ligament reconstruction in the knee with injuries to multiple ligaments.

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A dislocated knee with tearing of both cruciate ligaments and one or both of the collateral ligaments is a severe injury that can result from high- or low-energy trauma. The frequency of popliteal artery injuries during knee dislocation has been reported to range from 14% to 65%. Nerve injuries, associated fractures,

other structural injuries, functional instability, and posttraumatic arthrosis all can occur with this injury complex^{1,2} (Figure 1).

Classification

Knee dislocations can be classified based on the direction of tibial displacement, the anatomic structures

injured, open or closed injury status, and the energy level associated with the knee dislocation.³ The direction of tibial displacement generally is described as anterior, posterior, lateral, medial, or rotary; further subdivisions are anteromedial, posteromedial, anterolateral, and posterolateral. A classification system was proposed based on the type of ligamentous disruption and the presence or absence of an associated articular fracture⁴ (Table 1).

Mechanism of Injury

Hyperextension of the tibiofemoral joint leads to anterior tibiofemoral dislocation. This mechanism may stretch the popliteal artery and lead to intimal arterial damage, delayed thrombus formation, and ultimate arterial occlusion. The “dashboard-knee” mechanism of injury causes abrupt posterior tibial dislocation with the knee at 90° of flexion and may result in arterial transection. Tibiofemoral dislocation caused by a varus force may cause peroneal nerve injury; such varus force produces posterior, posterolateral, or medial knee dislocation.¹⁻³

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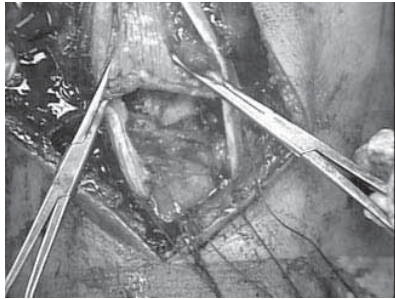


Figure 1 Patellar tendon avulsion in a patient with a dislocated knee. Injuries included ACL, PCL, posterolateral, posteromedial, and lateral meniscus tears.

Initial Evaluation

Initial evaluation of a knee with acute anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) injuries includes evaluating the deformity, locating the abrasions or contusions, and determining the neurovascular status of the extremity and the presence or absence of a dimple sign. The presence of normal pulses, normal Doppler studies, and normal capillary refill after reduction of the knee dislocation does not guarantee the absence of vascular injury. Serial physical examinations, ankle-brachial indices, or arteriography must be used as necessary to document intact arterial circulation to the injured lower extremity.⁵⁻²⁰

Physical examination of a knee with ACL and PCL injuries will show abnormal anteroposterior tibiofemoral laxity at 30° and 90° of knee flexion, the pivot shifting phenomenon will be present, the tibial step-off will be negative, the posterior drawer test will be positive, and abnormal varus and/or valgus laxity will be present at full extension and 30° of knee flexion.

Imaging studies include plain radiographs, MRIs, arteriograms, and venograms. Indications for immedi-

Table 1
Classification of Knee Dislocation (KD) Based on Extent of Ligamentous Injury

Class	Ligamentous injury
KDI	PCL-intact knee dislocation, usually ACL and LCL torn; also includes ACL-intact knee dislocation with complete PCL tear
KDII	ACL and PCL torn, collaterals intact
KDIIIM	ACL, PCL, and MCL-corner torn, lateral side intact
KDIIIL	ACL, PCL, and LCL-corner torn, medial side intact
KDIV	All four ligaments torn

PCL = posterior cruciate ligament, ACL = anterior cruciate ligament, LCL = lateral collateral ligament, MCL = medial collateral ligament
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ate surgery include an irreducible dislocation, vascular injury, compartment syndrome, inability to maintain reduction, and open dislocations.

Treatment

The current consensus is that surgical treatment of the multiligament-injured knee yields better results than nonsurgical treatment.²¹⁻²⁶ Technical advancements in the procurement, processing, and use of allograft tissue, arthroscopic surgical instruments, and graft fixation methods; improved surgical techniques; and a better understanding of the ligamentous structures and the biomechanics of the knee have led to more predictable and successful results in the treatment of these complex knee injuries. Various studies have reported excellent results with the return to a preinjury level of function documented with physical examination findings, arthrometer measurements, knee ligament rating scales, and stress radiography.^{2,23,27-33}

Surgical Timing

The timing of surgery for treating multiple acute knee ligament injuries depends on the vascular status of the involved extremity, the severity of injury to the collateral liga-

ments, the degree of instability, and postreduction stability. Delayed (2 to 3 weeks) or staged reconstruction after injury has demonstrated a lower incidence of arthrofibrosis than immediate surgery.^{31,32}

Surgical timing in acute combined ACL and PCL lateral-side injuries depends on the lateral-side classification³⁴ (Table 2). Arthroscopic combined ACL and PCL reconstruction with lateral-side repair and reconstruction can be done within 2 to 3 weeks after injury in knees with types A and B lateral posterolateral instability. Type C lateral posterolateral instability combined with ACL and PCL tears is often treated with staged reconstruction. The lateral posterolateral repair and reconstruction is performed within the first week after injury, followed by arthroscopic combined ACL and PCL reconstruction 3 to 6 weeks later.

Surgical timing in acute ACL and PCL medial-side injuries depends on the medial-side classification³⁵ (Table 3). Some medial-side injuries will heal with 4 to 6 weeks of brace treatment, if the tibiofemoral joint is reduced in all planes. Other medial-side injuries require surgical intervention. Types A and B medial-side injuries are repaired and recon-

structured as a single-stage procedure, combined with arthroscopic ACL and PCL reconstruction. Type C medial-side injuries combined with ACL and PCL tears often are treated with a single-stage or staged reconstruction. If a staged reconstruction is done, the posteromedial repair or reconstruction is done within the first week after injury, followed by arthroscopic combined ACL and PCL reconstruction 3 to 6 weeks later.^{1-3,32,35,36}

Surgical timing may be affected by factors beyond the surgeon's control and may cause surgical treatment to be performed either earlier or later than is optimal. Factors that can affect surgical timing include the vascular status of the injured extremity, an open injury, instability after reduction of the dislocation, poor skin conditions, multiple system injuries, other orthopaedic injuries, and meniscal and articular surface injuries.^{1,2}

Patients with chronic bicruciate ligament knee injuries often have progressive functional instability and possibly some degree of post-traumatic arthrosis. Treatment decisions require identifying all structural injuries, which can include ligament and meniscal injuries, bony malalignment, articular surface injuries, and gait abnormalities. Surgical procedures may include proximal tibial or distal femoral osteotomy, ligament reconstruction, meniscal transplant, and osteochondral grafting.

Graft Selection

The authors' preferred graft for PCL reconstruction is the Achilles tendon allograft for single-bundle reconstructions and Achilles tendon and tibialis anterior allograft for double-bundle reconstructions. For ACL reconstructions, on Achilles

Table 2
Classification of Posterior Instability: Lateral Side

Type	Structures Injured	Instability Pattern
A	Popliteofibular ligament Popliteus tendon	Increased tibial external rotation (≥ 10° more than normal knee)
B	Popliteofibular ligament Popliteus tendon Lateral collateral ligament	Increased tibial external rotation Mild (5-10 mm) varus opening to varus stress at 30° flexion
C	Popliteofibular ligament Popliteus tendon Lateral collateral ligament Lateral capsular avulsion Cruciate ligament disruption	Increased external rotation Marked varus instability (> 10 mm) at 30° flexion

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Table 3
Classification of Posterior Instability: Medial Side

Type	Structures Injured	Instability Pattern
A	Posteromedial capsule laxity	Increased tibial internal rotation (≥ 10° more than normal knee)
B	Posteromedial and capsule laxity Superficial medial collateral ligament laxity	Increased tibial internal rotation Valgus laxity with firm end point
C	Posteromedial and medial capsular laxity, disruption, or avulsion Superficial medial collateral ligament laxity, disruption, or avulsion	Increased tibial internal rotation Valgus laxity with no discernable end point

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tendon allograft or other allograft is preferred. For posterolateral corner injuries, allograft reconstruction is combined with a primary repair or a posterolateral capsular shift procedure. The preferred method for MCL and posteromedial reconstructions is a primary repair and/or posteromedial capsular advancement with allograft supplementation as needed.

Combined PCL and ACL Reconstruction: Surgical Technique

The principles of reconstruction in the multiligament-injured knee are to identify and treat all pathology, ensure accurate tunnel placement and anatomic graft insertion sites,

use strong graft material, obtain secure graft fixation, and institute a deliberate postoperative rehabilitation program.³⁷⁻³⁹

The allograft tissue is prepared, and arthroscopic instruments are placed with the inflow in the superolateral portal, the arthroscope in the inferolateral patellar portal, and the instruments in the inferomedial patellar portal. An accessory extra-capsular extra-articular posteromedial safety incision is used to protect the neurovascular structures and to confirm the accuracy of PCL tibial tunnel placement.

Notch preparation is performed first and consists of ACL and PCL stump débridement, bone removal, and contouring the medial wall of

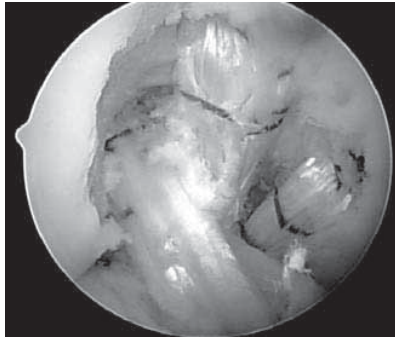


Figure 2 Arthroscopic combined double-bundle PCL and ACL reconstruction in a patient with a four-ligament knee injury.

the lateral femoral condyle and the intercondylar roof. Specially curved PCL instruments are used to elevate the capsule from the posterior aspect of the tibia.

The arm of the PCL-ACL guide is inserted through the inferomedial patellar portal to begin creation of the PCL tibial tunnel. The tip of the guide is positioned at the inferolateral aspect of the PCL anatomic insertion site. The bullet portion of the guide contacts the anteromedial surface of the proximal tibia at a point midway between the posteromedial border of the tibia and the tibial crest anterior, approximately 1 cm below the tibial tubercle. This will provide an angle of graft orientation that allows the graft to make two very smooth 45° turns on the posterior aspect of the tibia and avoids an acute 90° turn that may cause pressure necrosis of the graft. The position of the tip of the guide in the posterior aspect of the tibia is confirmed with the surgeon's finger through the extracapsular, extra-articular posteromedial safety incision. Intraoperative AP and lateral radiographs also can be used for a double safety check.

The appropriately sized, standard cannulated reamer is used to create the tibial tunnel, with the surgeon's finger through the extracapsular, extra-articular posteromedial incision monitoring the position of the guidewire. The drill is advanced until it comes to the posterior cortex of the tibia. The chuck is disengaged from the drill, and completion of the tibial tunnel is performed by hand for an additional margin of safety.

The PCL single-bundle or double-bundle femoral tunnels can be made from inside out. An appropriately sized, double-bundle aimer is inserted through a low anterolateral patellar arthroscopic portal to create the PCL anterolateral femoral tunnel. The double-bundle aimer is positioned directly on the footprint of the femoral anterolateral PCL insertion site. An appropriately sized guidewire is drilled through the aimer, through the bone, and out a small skin incision. The double-bundle aimer is removed, and an acorn reamer is used to endoscopically drill the anterolateral PCL femoral tunnel from inside out. For a double-bundle, double femoral tunnel PCL reconstruction, the same process is repeated for the posteromedial bundle of the PCL. Care must be taken to ensure that an adequate bone bridge (approximately 5 mm) will remain between the two femoral tunnels before drilling.

The ACL tunnels are created using the single-incision technique. The tibial tunnel begins externally at a point 1 cm proximal to the tibial tubercle on the anteromedial surface of the proximal tibia to emerge through the center of the stump or within the ACL tibial footprint. The femoral tunnel is positioned next to the over-the-top position on the medial wall of the lateral femoral condyle near the ACL anatomic in-

sertion site. The ACL graft is positioned and anchored on the femoral side, followed by ACL graft tensioning and tibial fixation (Figure 2).

Lateral Posterolateral Reconstruction

One technique for posterolateral reconstruction is a free graft, figure-of-8 technique using semitendinosus autograft or allograft, Achilles tendon allograft, or other soft-tissue allograft material.¹⁻³ This technique combined with capsular repair and/or posterolateral capsular shift procedures mimics the function of the popliteofibular and lateral collateral ligaments, tightens the posterolateral capsule, and provides a post of strong autogenous tissue to reinforce the posterolateral corner. When the proximal tibiofibular joint is disrupted, or a hyperextension external rotation recurvatum deformity is present, a two-tailed (fibular head, proximal tibia) posterolateral reconstruction is used.

A curvilinear incision is made in the lateral aspect of the knee, extending from the lateral femoral epicondyle to the interval between the Gerdy tubercle and the fibular head. The peroneal nerve is dissected free and protected throughout the procedure. The fibular head is exposed, and a tunnel is created in an anteroposterior direction in the area of maximal fibular diameter. The tunnel is created by passing a guide pin followed by a cannulated drill (usually 7 mm in diameter). The free tendon graft is then passed through the fibular head drill hole. An incision is then made in the iliotibial band in line with the fibers, directly over the lateral femoral epicondyle. The graft material is passed medial to the iliotibial band, and the limbs of the graft are crossed to form a figure-of-8. A longitudinal inci-

sion is made in the lateral capsule just posterior to the fibular collateral ligament. The graft material is passed medial to the iliotibial band and secured to the lateral femoral epicondylar region with a screw and spiked ligament washer, with the allograft insertion sites corresponding to the anatomic insertion sites of the fibular collateral ligament and the popliteus tendon. The posterolateral capsule that was previously incised is then shifted and sewn into the strut of figure-of-8 graft material to eliminate posterolateral capsular redundancy. The anterior and posterior limbs of the figure-of-8 graft are sewn to each other to reinforce and tighten the construct. The final graft tensioning position is approximately 30° to 40° of knee flexion (Figure 3).

Medial Posteromedial Reconstruction

Posteromedial and medial reconstructions are done through a medial hockey-stick incision.^{1-3,37} The superficial medial collateral ligament (MCL) is exposed, and a longitudinal incision is made just posterior to the posterior border of the superficial MCL. The interval between the posteromedial capsule and medial meniscus is developed. The posteromedial capsule is shifted anterosuperiorly. The medial meniscus is repaired to the new capsular position, and the shifted capsule is sewn into the MCL. When superficial MCL reconstruction is indicated, allograft or autograft material is attached at the anatomic insertion sites of the superficial MCL on the femur and tibia with a screw and spiked ligament washer or suture anchors. The posteromedial capsular is then advanced and sewn into the newly reconstructed MCL. The final graft tensioning position is approximately 30° to 40° of knee flexion (Figure 4).

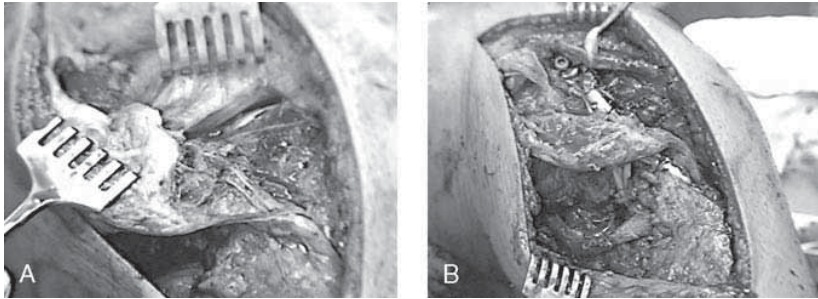


Figure 3 A, Midlateral and posterolateral capsular avulsion in a patient with ACL and PCL type C tears in a tibiofemoral multiligament-injured knee. B, Midlateral and posterolateral capsule avulsion was repaired with suture anchors. Posterolateral reconstruction was performed with semitendinosus figure-of-8 allograft through the head of the fibula combined with a tibialis anterior allograft through the proximal tibia to reconstruct the fibular collateral ligament and the popliteus tendon, respectively.

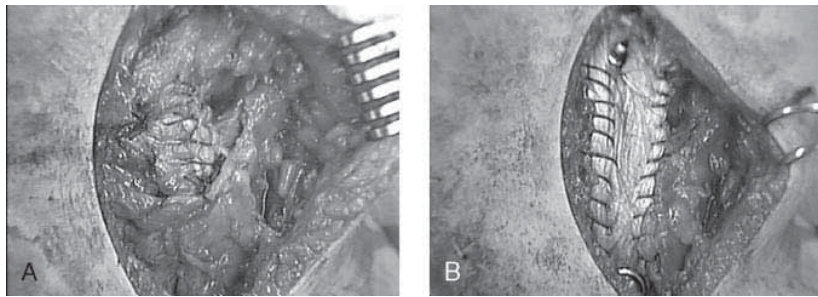


Figure 4 A, The posteromedial capsular shift procedure is used to eliminate capsular redundancy in step one of a posteromedial reconstruction. B, Superficial MCL reconstruction using Achilles tendon allograft is the second step of the posteromedial reconstruction.

Graft Tensioning and Fixation

The PCL is reconstructed first, followed by the ACL and the posterolateral complex and/or medial side. A mechanical tensioning boot is used for tensioning the ACL and PCL reconstructions. The knee is placed in 70° to 90° of flexion, the tensioning boot is tensioned to 20 lb to restore the normal tibial step-off, the knee is moved through a range of motion, and the PCL graft is fixed to the tibia with a bioabsorbable interference screw in the tunnel and a screw and spiked ligament washer as backup fixation. The knee is main-

tained at 70° to 90° of flexion, the tensioning boot is tensioned to 20 lb with tension on the ACL graft, the knee is moved through a range of motion, and the ACL graft is fixed with a bioabsorbable interference screw and ligament fixation button or spiked ligament washer.

Postoperative Rehabilitation

The knee is braced in full extension and non-weight-bearing status is maintained for 6 weeks.⁴⁰ The brace is unlocked, and progressive range of motion is begun 3 weeks after surgery. Crutches are discontinued

after progression to full weight bearing has been achieved. Progressive, closed kinetic chain strength training and range-of-motion exercises are continued. The brace is discontinued after the 10th week. Return to sports activities and heavy labor is allowed when sufficient strength, proprioceptive skills, and range of motion have returned, usually at 9 months after surgery. It should be noted that a loss of 10° to 15° of terminal flexion can be expected in these complex knee ligament reconstructions.

Outcomes

The surgical treatment of multiligament-injured (dislocated) knees has obtained excellent functional results, often achieving return to a preinjury level of function.^{2,23,27-33} Comparison of single- and double-bundle PCL reconstructions in knees with injuries to multiple ligaments have demonstrated no superiority for either surgical procedure.^{37,41} Both the single-bundle and double-bundle arthroscopically assisted transtibial PCL reconstruction techniques are successful in a high percentage of patients. Statistically significant improvements from preoperative to postoperative status, as evaluated by physical examination, knee ligament rating scales, arthrometer measurements, and stress radiography have been demonstrated.^{2,23,27-33} Factors contributing to the success of these surgical procedures include the identification and treatment of all pathology (especially posterolateral and posteromedial instability), accurate tunnel placement, the placement of strong graft material at anatomic graft insertion sites, minimizing graft bending, performing final graft tensioning at 70° to 90° of knee flexion, using a graft ten-

sioning boot, using primary and backup fixation, and instituting the appropriate postoperative rehabilitation program.

Summary

Injury to multiple knee ligaments constitutes a severe injury that may also involve neurovascular injuries and fractures. Surgical treatment offers good functional results. Some low-grade MCL complex injuries can be treated with bracing, but high-grade, medial-side injuries require repair and reconstruction. Lateral posterolateral injuries are most successfully treated with surgical repair and reconstruction. Surgical timing in patients with acute injuries to multiple knee ligaments depends on the ligaments injured, vascular status and skin condition of the injured extremity, the degree of instability, and the patient's overall health. Allograft tissue is preferred for these complex surgical procedures, and mechanical tensioning devices are helpful for cruciate ligament tensioning. Delayed reconstruction of 2 to 3 weeks may decrease the incidence of arthrofibrosis. It is important to treat all components of the instability. Currently, there is no conclusive evidence that double-bundle PCL reconstruction provides results superior to those of single-bundle PCL reconstruction in multiligament-injured knees.

References

1. Fanelli GC, Orcutt DR, Edson CJ: The multiple-ligament injured knee: Evaluation, treatment, and results. *Arthroscopy* 2005;21:471-486.
2. Fanelli GC, Edson CJ, Orcutt DR, Harris JD, Zijerdi D: Treatment of combined anterior cruciate-posterior cruciate ligament-medial-lateral side knee injuries. *J Knee Surg* 2005;18:240-248.
3. Schenck RC Jr, Burke R, Walker D:

The dislocated knee: A new classification system. *South Med J* 1992;85(suppl):S3-S61.

4. Schenck RC Jr, Hunter RE, Ostrum RF, Perry CR: Knee dislocations. *Instr Course Lect* 1999;48:515-522.
5. Abou-Sayed H, Berger DL: Blunt lower-extremity trauma and popliteal artery injuries: Revisiting the case for selective arteriography. *Arch Surg* 2002;137:585-589.
6. Dennis JW, Jagger C, Butcher JL, Menawat SS, Neel M, Frykberg ER: Reassessing the role of arteriograms in the management of posterior knee dislocations. *J Trauma* 1993;35:692-695.
7. Hollis JD, Daley BJ: 10-year review of knee dislocations: Is arteriography always necessary? *J Trauma* 2005;59:672-675.
8. Kaufman SL, Martin LG: Arterial injuries associated with complete dislocation of the knee. *Radiology* 1992;184:153-155.
9. Kendall RW, Taylor DC, Salvian AJ, O'Brien PJ: The role of arteriography in assessing vascular injuries associated with dislocations of the knee. *J Trauma* 1993;35:875-878.
10. Klineberg EO, Crites BM, Flinn WR, Archibald JD, Moorman CT III: The role of arteriography in assessing popliteal artery injury in knee dislocations. *J Trauma* 2004;56:786-790.
11. Martinez D, Sweatman K, Thompson EC: Popliteal artery injury associated with knee dislocations. *Am Surg* 2001;67:165-167.
12. Stannard JP, Sheils TM, Lopez-Ben RR, McGwin G Jr, Robinson JT, Volgas DA: Vascular injuries in knee dislocations: The role of physical examination in determining the need for arteriography. *J Bone Joint Surg Am* 2004;86:910-915.
13. Treiman GS, Yellin AE, Weaver FA, et al: Examination of the patient with a knee dislocation: The case for selective arteriography. *Arch Surg* 1992;127:1056-1062.

14. Miranda FE, Dennis JW, Veldenz HC, Dovgan PS, Frykberg ER: Confirmation of the safety and accuracy of physical examination in the evaluation of knee dislocation for injury of the popliteal artery: A prospective study. *J Trauma* 2002;52:247-251.
15. Wascher DC: High-velocity knee dislocation with vascular injury: Treatment principles. *Clin Sports Med* 2000; 19:457-477.
16. Sawchuk AP, Eldrup-Jorgensen J, Tober C, et al: The natural history of intimal flaps in a canine model. *Arch Surg* 1990;125:1614-1616.
17. Stain SC, Yellin AE, Weaver FA, Pentecost MJ: Selective management of nonocclusive arterial injuries. *Arch Surg* 1989;124:1136-1140.
18. Welling RE, Kakkasseril J, Cranley JJ: Complete dislocations of the knee with popliteal vascular injury. *J Trauma* 1981;21:450-453.
19. Witz M, Witz S, Tobi E, Shnaker A, Lehmann J: Isolated complete popliteal artery rupture associated with knee dislocation: Case reports. *Knee Surg Sports Traumatol Arthrosc* 2004;12:3-6.
20. Mills WJ, Barei DP, McNair P: The value of the ankle-brachial index for diagnosing arterial injury after knee dislocation: A prospective study. *J Trauma* 2004;56:1261-1265.
21. Dedmond BT, Almekinders LC: Operative versus nonoperative treatment of knee dislocations: A meta-analysis. *Am J Knee Surg* 2001;14:33-38.
22. Liow RY, McNicholas MJ, Keating JF, Nutton RW: Ligament repair and reconstruction in traumatic dislocation of the knee. *J Bone Joint Surg Br* 2003;85:845-851.
23. Harner CD, Waltrip RL, Bennett CH, Francis KA, Cole B, Irrgang JJ: Surgical management of knee dislocations. *J Bone Joint Surg Am* 2004;86:262-273.
24. Wascher DC, Becker JR, Dexter JG, Blevins FT: Reconstruction of the anterior and posterior cruciate ligaments after knee dislocation: Results using fresh-frozen nonirradiated allografts. *Am J Sports Med* 1999;27: 189-196.
25. Talbot M, Berry G, Fernandes J, Ranger P: Knee dislocations: Experience at the Hopital du Sacre-Coeur de Montreal. *Can J Surg* 2004;47: 20-24.
26. Yeh WL, Tu YK, Su JY, Hsu RW: Knee dislocation: Treatment of high-velocity knee dislocation. *J Trauma* 1999;46:693-701.
27. Shapiro MS, Freedman EL: Allograft reconstruction of the anterior and posterior cruciate ligaments after traumatic knee dislocation. *Am J Sports Med* 1995;23:580-587.
28. Noyes FR, Barber-Westin SD: The treatment of acute combined ruptures of the anterior cruciate and medial ligaments of the knee. *Am J Sports Med* 1995;23:380-389.
29. Noyes FR, Barber-Westin SD: Reconstruction of the anterior and posterior cruciate ligaments after knee dislocation: Use of early protected postoperative motion to decrease arthrofibrosis. *Am J Sports Med* 1997;25: 769-778.
30. Wascher DC, Becker JR, Dexter JG, Blevins FT: Reconstruction of the anterior and posterior cruciate ligaments after knee dislocation: Results using fresh-frozen nonirradiated allografts. *Am J Sports Med* 1999;27: 189-196.
31. Fanelli GC, Gianotti BF, Edson CJ: Arthroscopically assisted combined anterior and posterior cruciate ligament reconstruction. *Arthroscopy* 1996;12:5-14.
32. Fanelli GC, Edson CJ: Arthroscopically assisted combined anterior and posterior cruciate ligament reconstruction in the multiple ligament injured knee: 2-10 year follow-up. *Arthroscopy* 2002;18:703-714.
33. Fanelli GC, Edson CJ: Combined posterior cruciate ligament-posterolateral reconstructions with Achilles tendon allograft and biceps femoris tendon tenodesis: 2- to 10-year follow-up. *Arthroscopy* 2004;20: 339-345.
34. Fanelli GC, Feldmann DD: Management of combined ACL/PCL/posterolateral complex injuries of the knee. *Oper Tech Sports Med* 1999;7: 143-149.
35. Fanelli GC, Harris JD: Late medial collateral ligament reconstruction. *Tech Knee Surg* 2007;6:99-105.
36. Fanelli GC, Harris JD: Surgical treatment of acute medial collateral ligament and posteromedial corner injuries of the knee. *Sports Med Arthrosc* 2006;14:78-83.
37. Fanelli GC, Edson CJ, Reinheimer KN, Garofalo R: Posterior cruciate ligament and posterolateral corner reconstruction. *Sports Med Arthrosc* 2007; 15:168-175.
38. Fanelli GC (ed): *Posterior Cruciate Ligament Injuries: A Practical Guide to Management*. New York, NY, Springer-Verlag, 2001.
39. Fanelli GC (ed): *The Multiple Ligament Injured Knee: A Practical Guide to Management*. New York, NY, Springer-Verlag, 2004.
40. Edson CJ: Rehabilitation of the multiligament-reconstructed knee. *Sports Med Arthrosc* 2001;9:247-254.
41. Garafalo R, Jolles BM, Moretti B, Siegrist O: Double-bundle transtibial posterior cruciate ligament reconstruction with a tendon-patellar bone-semi-tendinosus tendon autograft: Clinical results with a minimum 2 years' follow-up. *Arthroscopy* 2006;22:1331-1338.

