

# Controversies in the Treatment of Knee Dislocations and Multiligament Reconstruction

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## Abstract

A systematic approach to evaluation and treatment is needed for the patient with knee dislocation. There is a paucity of high-level evidence on which to base treatment decisions. Reported controversies related to the treatment of the multiligament-injured knee include the selective use of arteriography for vascular assessment, serial physical examination with the ankle-brachial index, acute surgical treatment of all damaged structures, the selective application of preoperative and postoperative joint-spanning external fixation, arthroscopic reconstruction of the anterior cruciate ligament and posterior cruciate ligament, simultaneous open reconstruction with repair of the posterolateral corner, reconstruction and/or repair of the posteromedial corner, and the use of allograft tissue.

Perspectives on Modern Orthopaedics articles provide an objective appraisal of new or controversial techniques or areas of investigation in orthopaedic surgery.

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Multiligament knee injury is a complex problem that may or may not present as acute knee dislocation. Knee dislocation is a severe injury caused by violent trauma. This injury results in disruption of at least three of the four major ligaments of the knee and leads to significant functional instability. Vascular and neurologic damage, as well as associated fractures, may contribute to the challenge of caring for the patient with a multiligament-injured knee. Historically, treatment was primarily limited to closed reduction and casting or cast-bracing immobilization. However, with the advent of better instrumentation and technique, combined anterior and posterior cruciate ligament (ACL/PCL) tears associated with medial and/or lateral collateral ligament (MCL/LCL) disruption is typically managed surgically. A systematic approach to evaluation and treatment is required to optimize management of multiligament injuries of the knee. Phys-

ical examination and imaging studies enable the surgeon to make a correct diagnosis and formulate a treatment plan.<sup>1-3</sup>

There is a paucity of high-level evidence on which to base treatment decisions for multiligament knee injuries. In the fall of 2007, a group of orthopaedic surgeons from Canada and the United States with a special interest in multiligament knee injuries assembled in Minneapolis, Minnesota. From that meeting, a Knee Dislocation Study Group was established to promote further research into these complex injuries.

## Physical Examination

### Vascular Assessment

Popliteal artery injury and the potential for loss of the limb are of major concern following knee dislocation. Whether a patient should be evalu-

Figure 1



Photograph demonstrating Doppler probe measurement of the systolic pressure at the dorsalis pedis artery to determine the ankle-brachial index.

ated with physical examination alone, examination plus measurement of the ankle-brachial index (ABI), or routine arteriography remains controversial.

Numerous studies published in the past decade support selective arteriography in patients who have an abnormal physical examination. Ten studies, including two prospective studies, evaluated the use of selective

arteriography in a total of 543 patients with knee dislocation.<sup>4,13</sup> In each of these studies, physical examination alone was sufficient to detect all clinically significant vascular injuries.

To appreciate the logic behind the move from routine arteriography to selective arteriography in only those patients with an abnormal physical examination, it is important to understand the current treatment of patients with arterial intimal tears. Many of the arterial injuries documented following knee dislocations are non-flow-limiting intimal tears. Previously, it was believed that intimal tears frequently progressed to complete arterial occlusion as a result of thrombus formation at the site of arterial wall damage. Because of that belief, the recommended treatment involved excision of the damaged arterial wall segment.<sup>14</sup> Animal and clinical studies have demonstrated that non-flow-limiting intimal tears rarely progress to occlusive lesions.<sup>15-17</sup>

Today, vascular surgeons frequently use observation and serial examination to manage intimal tears in patients with a normal vascular

physical examination. Arteriograms are obtained in only those patients who have an abnormal physical examination. Most selective arteriography protocols advocate serial examinations for at least 48 hours. This helps in the diagnosis of patients who develop occlusive lesions on a delayed basis.<sup>6,9,18</sup>

### Ankle-brachial Index

Some authors advocate use of the ABI in addition to physical examination to determine the need for arteriography.<sup>9,19</sup> Mills et al<sup>19</sup> reported 100% sensitivity, specificity, and positive predictive value for significant arterial injury when patients had an ABI <0.9. Some other protocols advocate using an ABI measurement of 0.8.<sup>9</sup>

In an ABI examination, the patient is placed supine, and a blood pressure cuff is placed proximal to the ankle of the injured limb. Systolic pressure is determined with a Doppler probe at either the posterior tibial artery or the dorsalis pedis artery (Figure 1). The same measurement is made on the ipsilateral uninjured upper extremity limb. The ABI is calculated as the systolic pressure of the

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injured limb divided by the systolic pressure of the uninjured limb:<sup>20</sup>

$$\text{ABI} = \frac{\text{Doppler systolic arterial pressure in injured limb (ankle)}}{\text{Doppler systolic arterial pressure in uninjured limb (brachial)}}$$

The ABI measurement may be inaccurate in patients with risk factors for peripheral arterial disease, such as diabetes and hypertension. Vessel calcification, as seen in the elderly, may also increase the risk of false-positive results. When the ABI falls within the normal range, no further diagnostic screening is necessary. However, it is imperative to continue to observe the patient's lower extremity vascular status with serial physical examinations. The ABI is a noninvasive test that is easy to perform, and the surgeon should not hesitate to order it if the results of the physical examination are uncertain. Recent noninvasive tests such as computed tomography angiograms may provide additional data. Further studies are needed to determine the role of these tests.

### Surgical Versus Nonsurgical Management

Series published between 1930 and 1984 favored strategies of "watchful neglect," predominantly for uncomplicated cases, that is, those not involving open injury, irreducible dislocations, or fracture-dislocations requiring open reduction and internal fixation.<sup>21-24</sup> Recent investigations have been undertaken to determine the optimal treatment of acute multiligament knee injury following

reduction of dislocation. These investigations have been limited by small sample sizes and variations in surgical reconstructive techniques and rehabilitation protocols as well as by the heterogeneous nature of the injuries themselves.

In a meta-analysis of surgical versus nonsurgical management published in 2001, results of pooled data from primarily retrospective investigations in 132 knees suggested improved motion with surgical reconstruction.<sup>25</sup> Differences in stability and return to work were not statistically significant; however, average Lysholm scores were almost 20 points higher in the surgically treated group. These data have been the primary impetus toward acute surgical management, and recent prospective investigations have reported similar satisfactory postreconstruction Lysholm scores, with means ranging from 71.7 to 91 points.<sup>26-30</sup> Moreover, Richter et al<sup>31</sup> demonstrated superior International Knee Documentation Committee (IKDC) scores and return to higher levels of activity with surgical management.

Surgical management, in particular early surgical reconstruction and/or repair, is currently favored by the members of the Knee Dislocation Study Group. Absolute indications for surgery would include irreducible dislocations, dysvascular limbs, and open injuries. Associated fractures and/or avulsion-type injuries often do better with early repair (within 2 to 3 weeks) as anatomic dissection is facilitated in the absence of scar tissue and tissues are robust enough to accommodate suture repair. In cases of vascular injury requiring surgical revascularization—and in some cases complicated by morbid obesity, ligamentous hypermobility, and/or extensive soft-tissue loss requiring grafting—a period of immobilization may be indicated with delayed recon-

struction, as indicated by residual instability.<sup>3</sup>

The heterogeneous and rare nature of these injuries makes it difficult to study them in a traditional randomized trial design. A definitive answer to the question of whether early surgical management improves outcomes in the long term will come only from prospectively collected data, analyzed with nonexperimental or observational methods. This will be a primary focus of the efforts of the Knee Dislocation Study Group in years to come.

### Preoperative External Fixation Versus Hinged Knee Bracing

Open dislocation, history of vascular repair, and joint reduction that cannot be maintained adequately in a splint are the current indications for the application of a joint-spanning knee external fixator in the setting of acute knee dislocation.<sup>32</sup> The main advantage of initial external fixation is the ability to assess the skin, compartments, and neurovascular status of the affected limb with serial examinations.

Currently, there are no data in the literature comparing initial spanning external fixation with splinting or bracing before multiligament knee reconstruction. Investigators at the Mayo Clinic recently presented information comparing these two variables.<sup>33</sup> Thirty-one knees in 30 consecutive patients were treated for acute knee dislocation, with an average follow-up of 27 months (range, 16 to 40 months). Patients who fulfilled the aforementioned criteria for initial spanning external fixation (group A) were compared with those initially treated with a hinged knee brace (group B). Both groups then underwent multiligament knee reconstruction. Group A consisted of 8

Figure 2



Preoperative anteroposterior radiograph of a knee dislocation.

knees in 8 patients, and group B consisted of 23 knees in 22 patients. No statistically significant differences were found between group A and group B with regard to patient age (34 versus 31 years,  $P = 0.89$ ), duration of follow-up (29 versus 27 months,  $P = 0.73$ ), mean IKDC scores (65 versus 74,  $P = 0.66$ ), mean Lysholm scores (77 versus 83,  $P = 0.79$ ), and need for manipulation (2 versus 2 patients,  $P = 0.27$ ). Only range of motion (ROM) differed significantly between those with and without joint-spanning external fixation (flexion,  $102^\circ$  versus  $129^\circ$ , respectively;  $P = 0.02$ ). There was an inherent selection bias in this study. The more complex, higher-energy knee dislocations were typically those selected for application of initial joint-spanning external fixation. Thus, the reduced final ROM in Group A may be the result of the complexity of the injury as opposed to the external fixator itself.

### Open Versus Arthroscopic Reconstruction

The selection of arthroscopic versus open reconstruction in a complex

knee injury depends on the timing of the surgery as well as the nature of the injury itself. No randomized trial has compared open versus arthroscopic reconstruction; thus, the advantages of either are theoretical.

In the case of an open knee dislocation, irrigation, débridement, and repair of fixable lesions may be indicated in the first few weeks.<sup>1-3</sup> Because the capsular tissue may be torn, open reconstruction or repair may be necessary in the first few weeks to avoid extravasation of fluid into the compartments, which runs the risk of compartment syndrome. Injuries suited for repair (ie, bony avulsions) would be better treated open and early after injury.

In most cases, the preferred treatment of knee dislocations under ideal circumstances consists of arthroscopic ACL and PCL reconstruction, with open reconstruction being reserved for the LCL/posterolateral corner (PLC) and/or the MCL/posteromedial corner (PMC)<sup>3</sup> (Figures 2 and 3). The advantages of arthroscopic reconstruction in the ACL and PCL include better appreciation of concomitant intra-articular pathology, including meniscal tears; potential decreased infection rate; and possibly a lesser insult to articular cartilage during what is often a lengthy procedure.

Currently, it is not possible to reconstruct the PLC arthroscopically because of the close proximity to neurovascular structures. Additionally, its relatively subcutaneous location, similar to that of the PMC, makes open repair or reconstruction the best treatment option. An open technique should be used in the presence of an irreducible dislocation.<sup>34</sup> In this situation, early, open repair of the interposing capsule would be preferred. However, there have been reports of arthroscopic treatment of an entrapped MCL complex in the

presence of an irreducible dislocation.<sup>35</sup>

### Early Versus Late Ligament Reconstruction

Four retrospective comparative studies have reported outcomes with early (<3 weeks) versus delayed ligament reconstruction after knee dislocation.<sup>26,27,36,37</sup> Harner et al<sup>27</sup> reported on 31 patients who underwent surgery following knee dislocation, including 19 patients treated <3 weeks after injury (acute) and 12 patients treated  $\geq 3$  weeks after injury (chronic). Minimum follow-up was 24 months (mean, 44 months). Patients treated in the acute period had a higher mean Knee Outcome Survey Sports Activity Score (89 versus 69,  $P = 0.04$ ). Also, fewer patients treated in the acute period had a positive Lachman test (2+) on postoperative physical examination (3 versus 6,  $P = 0.04$ ). In patients who underwent surgery in the acute period, the final mean Lysholm score (91 versus 80,  $P = 0.07$ ) and Knee Outcome Survey Activities of Daily Living score (91 versus 84,  $P = 0.07$ ) were also somewhat better. Final knee ROM was similar regardless of time to treatment, although four acutely reconstructed patients required manipulation under anesthesia for arthrofibrosis (21%).

In a recent study by Tzurbakis et al,<sup>36</sup> 44 patients with a knee dislocation were treated in the acute (<3 weeks of injury, 35 patients) or chronic ( $\geq 3$  weeks of injury, 9 patients) setting. Minimum follow-up was 24 months (mean, 51 months). A statistically greater percentage of patients treated in the acute period rated their outcomes as normal (A) or near-normal (B) on the IKDC knee form subjective (86% versus 44%,  $P = 0.008$ ) and symptom (85% versus 56%,  $P = 0.04$ ) subgroups.

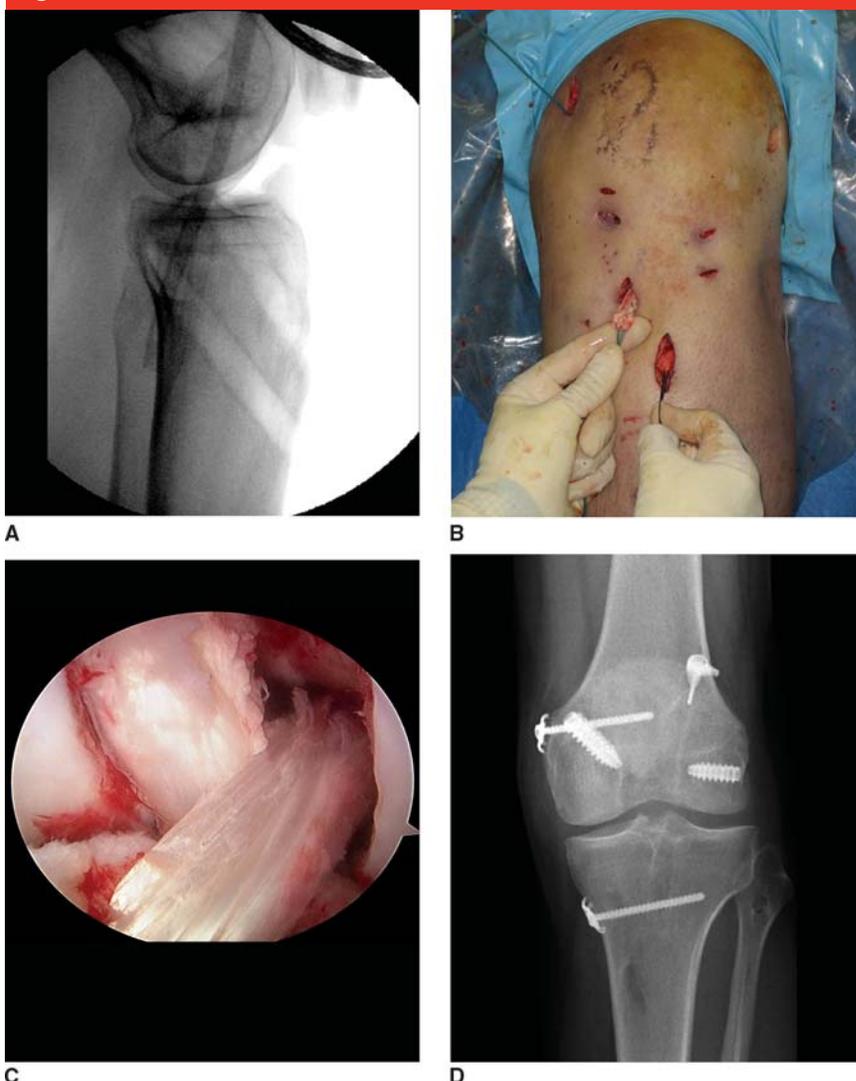
Overall IKDC normal or near-normal rating (77% versus 55%), mean Lysholm score (88 versus 82), and final knee ROM were not significantly different between the groups.

Liow et al<sup>26</sup> published a retrospective review of 22 knee dislocations treated in the acute (<2 weeks after injury, 8 knees) or chronic (6 to 72 months after injury, 14 knees) period. Mean follow-up was 32 months (range, 11 to 77 months). The authors reported a higher mean Lysholm score (87 versus 75) and Tegner activity rating score (5 versus 4.4) for the acute treatment group. Arthrometer testing revealed a greater percentage of acutely treated knees with anterior tibial translation <5 mm (86% versus 69%). No difference in knee ROM or PCL reconstruction clinical outcome was noted between the two groups. Statistical analysis was not provided for this cohort.

Fanelli et al<sup>37</sup> reported on surgical treatment of 10 acute (<4 weeks after injury) and 11 chronic (≥4 weeks) knee dislocations. No statistically significant differences between the groups were evident based on Lysholm score, Tegner activity level score, and Hospital for Special Surgery (HSS) score at a minimum 24-month follow-up.

Several potential differences between the acute and chronic groups in the aforementioned studies may have affected final clinical and functional outcomes. Ligamentous reconstruction in patients with severe soft-tissue trauma or the management of concomitant nonorthopaedic injuries may have been deferred for weeks before definitive surgical treatment, resulting in worse outcomes for patients treated in the chronic rather than the acute period. Prospective trials with closely matched participants are necessary to minimize confounding factors and thus to more clearly delineate the benefits of early versus late ligamentous reconstruction after knee dislocation.

**Figure 3**



**A**, Intraoperative fluoroscopic lateral view demonstrating anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) tunnel position. **B**, Intraoperative photograph of the same patient as in panel A demonstrating the ACL and PCL grafts before tibial fixation. **C**, Arthroscopic view of the ACL and PCL grafts after fixation. **D**, Anteroposterior radiograph taken after multiligament knee reconstruction.

### Staged Surgery

Surgical timing in the acute bicruciate multiligament-injured knee is dependent on the vascular status of the involved extremity, the severity of collateral ligament injury, the degree of instability, postreduction stability, the presence of open wounds, and the condition of the skin. In some series, a lower incidence of arthrofi-

brosis has been demonstrated following delayed or staged reconstruction at 2 to 3 weeks postinjury.<sup>38,39</sup>

Surgical timing in acute ACL/PCL/lateral side injuries is dependent on lateral side classification, described by Fanelli and Feldmann.<sup>40</sup> Type A injuries (ie, increase in external rotation only) are consistent with injury to the popliteofibular ligament and popliteus tendon. Type B injuries (ie,

increase in external rotation and increased varus laxity of approximately 5 mm at 30° of flexion) are consistent with injury to the popliteofibular ligament, popliteus tendon, and lateral collateral ligament. Type C injuries (ie, increase in external rotation and gross varus laxity of approximately 10 mm at 30° of flexion) are consistent with injury to the popliteofibular ligament, popliteus tendon, lateral collateral ligament, and lateral capsule.

Arthroscopic combined ACL/PCL reconstruction with lateral side repair and reconstruction can be performed within 2 to 3 weeks postinjury in knees with types A and B lateral posterolateral instability. Type C lateral posterolateral instability combined with ACL/PCL tears is often treated with staged reconstruction. The lateral posterolateral repair-reconstruction is performed within the first week after injury, followed by arthroscopic combined ACL/PCL reconstruction 3 to 6 weeks later. When the surgeon prefers a single-stage reconstruction, the cruciate and lateral side repair and reconstructions are performed as an open or as a dry arthroscopic procedure.

In acute ACL/PCL/medial side injuries, surgical timing is dependent on the medial side classification described by Fanelli and Harris.<sup>41</sup> Type A injuries demonstrate axial rotation instability (either anteromedial or posteromedial) with no valgus instability. Type B injuries demonstrate axial rotation instability and valgus laxity at 30° of flexion with a firm end point. Type C injuries demonstrate axial rotation instability and valgus laxity at 30° of flexion with no end point.

Some medial side injuries heal with 4 to 6 weeks of brace treatment, provided that the tibiofemoral joint is reduced in all planes. Type A and type B medial side injuries are repaired or reconstructed in a single-stage procedure with combined arthroscopic ACL/PCL

reconstruction. Type C medial side injuries combined with ACL/PCL tears are often treated with staged reconstruction. The medial posteromedial repair/reconstruction is performed within the first week after injury, followed by arthroscopic combined ACL/PCL reconstruction 3 to 6 weeks later.<sup>1-3,39-42</sup> When the surgeon prefers a single-stage reconstruction, the cruciate and medial side repair and reconstructions are performed as open procedures or as a dry arthroscopic reconstruction.

Surgical timing may be affected by factors beyond the surgeon's control. These factors include injured extremity vascular status, open or closed injury, reduction stability, skin conditions, multiple system injuries, other orthopaedic injuries, and meniscus and articular surface injuries.<sup>1,2</sup>

### Ligament Repair Versus Reconstruction

Several authors have noted improved outcomes with acute reconstruction compared with repair of the ACL, PCL, and PLC structures after knee dislocation.<sup>31,43,44</sup> Stannard et al<sup>44</sup> recently reported the results of a level II prospective trial in which 57 PLC tears (56 patients) were managed with either repair or reconstruction. Forty-four patients had sustained multiligament knee injury. Minimum follow-up was 24 months. The repair failure rate was 37%, compared with a reconstruction failure rate of 9%. On clinical examination, the difference in stability between repair and reconstruction was statistically significant ( $P < 0.05$ ). External validity was decreased because of a selection bias due to the variable acuity of patients who sustained multiligament knee injury. For example, patients were not randomized for either repair or reconstruction but rather were selected for repair only if tis-

ues were favorable. This may have led to an overestimation of functional results in the repair group.

A recently presented study from the Mayo Clinic reported on the results of patients who underwent repair of the PLC and/or PMC structures in the setting of multiligament knee reconstruction.<sup>45</sup> A total of 18 repairs were performed with concomitant ACL/PCL reconstruction. There were 11 repairs of the PLC and 7 repairs of the PMC. Mean follow-up was 31 months (range, 13 to 42 months). No patients were lost to follow-up. Five PLC (45%) and two PMC (29%) repairs required revision to reconstruction, with an overall repair failure rate of 39%. These findings are similar to those reported by Stannard et al<sup>44</sup> for the PLC. Several limitations were present in the study by Levy et al,<sup>45</sup> including the heterogeneity of the patient populations and the small sample size.

Several authors have noted satisfactory outcomes with repair and/or reconstruction of the MCL.<sup>46,47</sup> Yoshiya et al<sup>47</sup> recently reported on the reconstruction of the superficial MCL using autogenous hamstring tendons. Twenty-four patients had satisfactory IKDC scores at a minimum 2-year follow-up.

Mariani et al<sup>43</sup> performed a level IV retrospective review comparing direct repair of the central pivot (ACL and/or PCL) versus reconstruction for patients who sustained acute knee dislocation. Patients were followed for an average of 6.9 years (range, 2 to 19 years). Improved stability and ROM were demonstrated in patients with combined ACL/PCL reconstruction compared with those who underwent ACL/PCL repairs. This study was limited by small sample size (23 patients), which precluded statistical conclusions as to which ligaments, if any, should be reconstructed.

Owens et al<sup>46</sup> recently published

the results of their retrospective review of 25 consecutive patients who sustained knee dislocation and were treated with primary repair of all injured ligaments, including the ACL and PCL. Mean follow-up was 48 months (range, 13 to 82 months). All but two patients were able to return to their previous jobs, with little or no activity modification. Arthrofibrosis was the most common complication, with five patients requiring manipulation and arthroscopic lysis of adhesions. This level IV study should be interpreted with caution because most of the literature does not support primary repair of the ACL, PCL and PLC structures.

### Graft Selection

Free graft reconstruction has largely replaced direct ligamentous repair of cruciate and some collateral ligament injuries. Allograft tissues in particular have become a staple in the armamentarium of orthopaedic surgeons who manage multiligament-injured knees. In knee ligament reconstruction, allograft tissues provide several benefits over autograft tissues, including absence of donor site morbidity, multiple graft size options, and less tourniquet time.<sup>28,48,49</sup> Additionally, excellent clinical results have been demonstrated with allograft.<sup>2,27,28,37,39,50-54</sup> The market quality of available grafts is potentially heterogeneous, and an allograft supplier should be chosen on the basis of strict adherence to US Food and Drug Administration/American Association of Tissue Banks guidelines.<sup>55</sup> The risk of HIV disease transmission has been estimated at 1 in 1.6 million, provided that there is adequate donor screening and appropriate graft testing and sterilization.<sup>56,57</sup>

Our preferred graft for the PCL is the Achilles tendon allograft because of its large cross-sectional area and strength,

absence of donor site morbidity, and easy passage with secure fixation. Excellent results have been reported using single-bundle Achilles tendon allograft for the PCL.<sup>39</sup> When double-bundle PCL reconstruction is performed, we use Achilles tendon allograft for the anterolateral bundle and tibialis anterior allograft for the posteromedial bundle. We prefer Achilles tendon allograft or other allografts for ACL reconstruction. The preferred graft material for the PLC has not been determined, but we prefer allograft tissue combined with the appropriate capsular procedure. Cases requiring MCL and PMC surgery may necessitate primary repair, reconstruction, or both, also incorporating allograft tissues. When autograft tissue is preferred, multiple sources are available from the contralateral and ipsilateral knee, depending on the injury pattern. Donor site morbidity is an important consideration when choosing autograft tissue.

### Graft Tensioning and Fixation

The PCL is reconstructed first, followed by the ACL, the lateral side, and the medial side, in that order. Good results have been shown with the use of a tensioning boot for ACL and PCL reconstructions, but manual tensioning is also acceptable.<sup>2,39,50</sup> Fixation is achieved on the PCL femoral side using a resorbable interference screw and backup fixation with a polyethylene knee ligament fixation button. Manually or with a tensioning boot, tension is placed on the PCL graft distally, and the knee is cycled through full ROM cycles to allow pretensioning and settling of the graft. The knee is placed in 70° to 90° of flexion, the tensioning boot is tensioned to 20 lb to restore normal tibial step-off, and fixation is achieved on the tibial side of the PCL

graft with a screw, spiked ligament washer, and an interference screw. Then the knee is placed into full extension, the tensioning boot is tensioned to 20 lb with tension on the ACL graft, and final fixation of the ACL graft is achieved with an interference screw and ligament fixation button or spiked ligament washer backup fixation.

Both PCL and ACL reconstructions have primary (ie, resorbable interference screw) and backup (ie, button or post and washer) fixation on both the femoral and tibial sides of the graft. The knee is then placed in 30° of flexion, the tibia is internally rotated, slight valgus force is applied to the knee, and final tensioning and fixation of the PLC is achieved. With the knee in 30° of flexion, reconstruction and tensioning of the MCL and PMC are performed after the ACL, PCL, and PLC reconstructions. These tensioning and fixation methods have provided consistently good results.<sup>2,39,50</sup>

### Postoperative External Fixation Versus Hinged Knee Bracing

Many surgeons currently use a hinged knee brace following reconstruction of knee dislocations. Others advocate the use of postoperative external fixation to help protect graft tissue from excessive force, especially in larger individuals. The Compass Knee Hinge (CKH) (Smith & Nephew, Memphis, TN) is a hinged, multiplanar, external fixator that can be applied at the isometric point of the knee joint (Figure 4).

A prospective, randomized study is ongoing at the University of Alabama at Birmingham comparing outcomes with the CKH versus a hinged knee brace. Preliminary results are available at this time.<sup>58</sup> Forty-three patients with 46 dislocations have

Figure 4



Compass Knee Hinge (Smith &amp; Nephew) spanning external fixator.

been enrolled and have been followed for at least 2 years. Twenty-one patients with 22 dislocations were randomized to the control group and received a hinged knee brace following reconstruction of a total of 71 torn ligament groups. Twenty-two patients with 24 dislocations were randomized to the CKH group following reconstruction of a total of 77 torn ligament groups. Six control patients (27%) had recurrent instability of at least one ligament group compared with only one patient in the CKH group (4%). In the control group, 16 ligament groups failed (23%), compared with two ligament group failures (3%) in the patients treated with the CKH. The difference in stability is significantly different ( $P < 0.05$ ) whether calculated in terms of patients with instability or ligament groups with instability. These preliminary results suggest that there may be a role for hinged external fixation following reconstruction in patients with knee dislocations.

### Rehabilitation

Postoperative rehabilitation of the multiligament reconstructed/repared

knee begins with restoration of motion while protecting the reconstructed/repared ligaments. This is followed by a gradual, progressive strengthening program leading to functional training and activities of daily living. Some patients will progress to sport-specific drills and ultimately return to sport.<sup>39,50</sup>

Several authors have developed specific protocols for rehabilitation after multiligament knee reconstruction/repair.<sup>59,60</sup> The protocol established by Fanelli and Edson<sup>39,50</sup> has demonstrated excellent long-term results. Patients are immobilized in full extension for the first 3 weeks postoperatively. Beginning with the 4th postoperative week, the brace is unlocked, permitting gentle and pain-free prone passive ROM to protect PCL graft integrity. Patients remain non-weight-bearing for the first 6 weeks. Pain and swelling are controlled, and quadriceps strength is maintained through isometric exercises.<sup>59</sup> Biomechanical work by Shelburne and Pandey<sup>60</sup> demonstrated that activation of the hamstrings increases the forces on the PCL. Based on this work, the authors recommend avoiding hamstring activation before 6 weeks because this may lead

to increased forces on the PCL graft.

In the 7th week postoperatively, the patient begins progressive weight bearing until full weight bearing is achieved. Closed kinetic chain techniques are employed to regain muscle strength.<sup>59</sup> These exercises involve co-contraction of opposing muscle groups (eg, quadriceps, hamstrings) and are thought to produce minimal translational forces at the knee joint.<sup>61</sup>

Recent evidence suggests that open kinetic chain exercises, which allow isolated muscle group strengthening, may also be safely performed within a prescribed ROM.<sup>61</sup> Open kinetic chain exercises between 30° and 60° of knee flexion minimize translation at the knee joint and thus prevent undue stress on reconstructed ligaments. Some authors advocate avoiding >60° of knee flexion during open kinetic chain and closed kinetic chain exercises for 5 months.<sup>61</sup> This does not seem practical given that the expectation is both for soft-tissue grafts to heal within the tunnels and for ROM to reach 120° by 3 months.

From 4 to 6 months, muscle strengthening is continued through graduated open kinetic chain resistance exercise until the injured limb regains at least 70% strength compared with the contralateral side. Straight line jogging is commenced, advancing to sport-specific drills.<sup>59</sup> The patient continues to focus on strength and function from 6 to 12 months, at which time he or she may be fitted with a functional brace and released to full activity pending successful quadriceps and hamstring Biodex (Biodex Medical Systems, Shirley, NY) and functional testing.<sup>59</sup>

### Summary

Based on a review of the literature combined with author experience, the Knee Dislocation Study Group has developed

several recommendations for the treatment of patients with a multiligament-injured knee. (1) Vascular assessment should include serial physical examination and ABI measurement, with the selective use of arteriography. (2) Acute surgical management should be done of all damaged ligamentous structures. (3) Selective use of preoperative and postoperative joint-spanning external fixation is advocated. (4) Arthroscopic reconstruction of the ACL and PCL should be done, rather than repair of these structures. (5) Primary open reconstruction rather than repair of the LCL/PLC should be done, either staged or with concomitant ACL/PCL reconstructions. (6) Primary open repair or reconstruction of the MCL/PMC should be done, either staged or with concomitant ACL/PCL reconstructions. (7) Allograft or autograft tissue should be used for all ligamentous reconstructions. Donor site morbidity should be considered when choosing autograft tissue.

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*Evidence-based Medicine:* References 11, 13, 19, and 44 are level II prospective, randomized studies. References 43, 46, and 47 are level IV studies (case series).

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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