Primary Repair of Knee Dislocations: Results in 25 Patients (28 Knees) at a Mean Follow-up of Four Years

Brett D. Owens, MD, Mark Neault, MD, Emily Benson, MD, and Brian D. Busconi, MD

Objective: To investigate the outcomes of knee dislocations treated with primary repair and an early rehabilitation protocol.

Design: Retrospective.

Settings: Level 1 Trauma Center.

Patients: Consecutive patients with knee dislocation referred to a single surgeon for care between 1994 and 2002 were included, for a total of 27 patients with 30 knee dislocations. Twenty-five patients (28 knees) were evaluated by an independent observer at a mean of 48 months (13–82 months).

Intervention: All patients underwent primary repair of all injured ligaments using a consistent technique and early rehabilitation protocol.

Main Outcome Measurements: In addition to range of motion and stability assessment, Lysholm and Tegner scores were used to evaluate outcome.

Results: The mean post-operative Lysholm score was 89.0. Range of motion analysis for the 22 unilateral dislocations available for examination showed a mean extension loss of 1.9° and mean flexion loss of 10.2°, with a mean arc of motion of 119.3°. Overall, the knees were found to be clinically stable.

Conclusions: Primary repair of ligaments coupled with an early rehabilitation program provides comparable outcomes to published results of ligament reconstruction. Primary repair of ligaments in the dislocated knee should be considered as an effective option in the trauma population.

Key Words: knee dislocation, primary repair

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The treatment of knee dislocations is controversial. Although surgical management has been shown to be superior to nonoperative treatment,[1–3] multiple surgical techniques and protocols have been described.

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From the Department of Orthopedics, University of Massachusetts Medical School, Worcester, MA.
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Reprints: Brett D. Owens, MD, Keller Army Hospital, West Point, NY 10996 (e-mail: b.owens@us.army.mil).

Early experience with primary repair of injured ligaments resulted in postoperative stiffness that limited the success of this technique.[4,5] However, these early repairs were not coupled with a modern rehabilitation program. As techniques for cruciate ligament reconstruction were refined, techniques for knee dislocations using cruciate ligament reconstruction were reported.[6–11] Unfortunately, stiffness has remained the most problematic complication.[6] The purpose of this study was to review the outcomes of a series of patients with traumatic knee dislocations who underwent primary ligament repair using a uniform technique and following a consistent postoperative rehabilitation protocol.

PATIENTS AND METHODS

We performed a review of consecutive patients with a knee dislocation treated operatively by a single surgeon. All patients presented acutely to a Level 1 trauma center. Diagnosis of a dislocated knee was made in one of two ways: clinical appearance with positive radiographs or multidirectional instability with a magnetic resonance imaging indicating bicruciate ligament injury. Patients were initially managed with immediate closed reduction if their knees were grossly dislocated. Immediate vascular consultation was obtained to determine the need for an arteriogram. In the cases of obvious arterial injury, patients were brought to the operating room emergently for vascular reconstruction.

Surgical Technique

Surgery was scheduled as soon as the patient was stable, with the goal of surgical repair within 14 days of injury. In order to help prevent stiffness the knee was placed into a continuous passive motion (CPM) machine set at 0 degrees to 90 degrees as tolerated until the time of surgery.

Patients were positioned supine with a bump under the ipsilateral pelvis. A tourniquet was used only if there was no nerve or vascular injury, and was inflated for no longer than 2 hours. An anterior approach to the knee was performed through a midline skin incision and a vastus medialis splitting arthrotomy. The patella was subluxated laterally, and the cruciate ligaments and menisci were evaluated (Fig. 1). Next, a posterolateral incision was made, with care to maintain a 7- to 8-cm skin bridge. Injured structures were identified for repair. Neurolysis of the peroneal nerve was performed (Fig. 2) in all patients with a posterolateral ligamentous injury, regardless of the severity of neurologic injury.

The ligaments were repaired in the following order. The injured posterior cruciate ligament (PCL) was identified

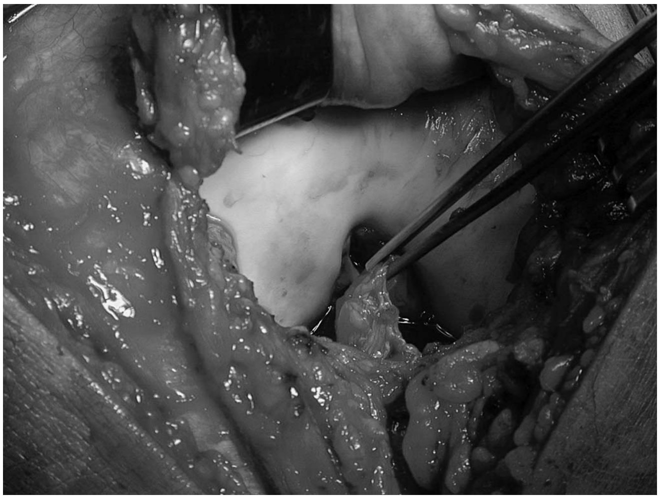

FIGURE 1. Anterior cruciate ligament avulsed from its femoral insertion seen through an anteromedial arthrotomy.

and a no. 2 braided nonabsorbable suture whip stitch was used in the substance of the ligament for repair. Next the Arthrex guide (Arthrex, Naples, FL) from the anterior cruciate ligament (ACL) instrumentation was used to allow precise drill-hole placement. The PCL was reattached into its anatomic position either in the medial femoral condyle or the tibia, depending on the site of detachment. Two drill holes were created with a bony bridge between them. A suture passer was used to bring each limb of the suture through each drill hole. Next, attention was turned toward the ACL. A similar technique was used to repair the ACL back to its anatomic position based on the site of injury. Midsubstance tears were repaired using the same technique: placing whip stitches in the torn ligament segment with greatest remaining integrity and passing these sutures through the opposing ligament segment and then drill holes through bone. The posterolateral corner complex was approached through the posterolateral incision.

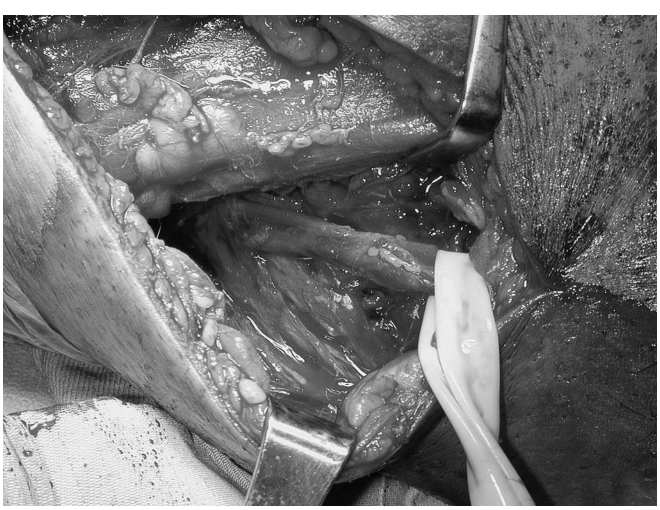

FIGURE 2. Common peroneal neurolysis through a posterolateral incision.

The structures were repaired in the following order. First the lateral meniscus tear (when present) was repaired, followed by the popliteus, popliteofibular ligament, capsule, lateral collateral ligament (LCL), iliotibial (IT) band, and the biceps femoris. Two to five nonabsorbable suture anchors were used to repair these structures to the epicondyle of the femur, the fibular head, or the lateral tibia. If the injury was midsubstance, it was directly repaired with nonabsorbable sutures. The next step was the tying of the sutures. The PCL was secured first with the knee flexed to 90 degrees and an anterior drawer force applied. The ACL was secured with the knee held in full extension and a posterior drawer force applied. The sutures from both cruciate repairs were tied over a bony bridge. When the posterolateral complex sutures were tightened, the knee was held flexed to approximately 20 degrees, and an internal rotation force was applied. Only complete medial collateral ligament (MCL) avulsions were repaired. Partial injuries were not treated surgically. Prior to wound closure, the knee was tested for a minimum range of motion of 0 to 90 degrees. A gentle posterior drawer and Lachman were applied to the knee to ensure the reestablishment of stability. The wounds were closed in layers over a drain (removed at 24 hours) and the knee was placed in a hinged knee brace locked in extension.

Rehabilitation Protocol

Postoperatively, all knees were treated with a uniform rehabilitation protocol. On the first post-operative day after drain removal, the CPM was started at 0 to 30 degrees as tolerated. The patient was discharged from the hospital after clearing physical therapy and maintained a CPM machine at home, advancing to 90 degrees of flexion by postoperative day 10. The CPM was discontinued at this point. From postoperative weeks 1 through 4, a PCL protocol was followed, emphasizing quadriceps strengthening and avoiding hamstring cocontraction. After week 4, hamstring cocontraction was begun. Nonweightbearing status using crutches was maintained for the first 2 months. Patients with bilateral injuries required bed-to-chair transfers and wheelchair use. Range of motion was advanced to 120 degrees of flexion by 2 months postoperatively. From the second to the third postoperative month, partial weightbearing with crutches was initiated, with the goal of full weightbearing and no crutches by 3 months. If a patient did not have 0- to 120-degree range of motion by the third postoperative month, manipulation and arthroscopic lysis of adhesions were considered. At 3 months, closed-chain exercises and hamstring cocontraction were initiated. At 4 to 6 months, patients began open-chain exercises. Unrestricted activity was allowed at 8 to 12 months.

Follow-up

Patients were contacted and examined by an independent observer (orthopaedic chief resident). Lysholm and Tegner scores were used to evaluate outcome based on function and change in activity level from their preinjury state.[12,13] The Lysholm score is a 100 point maximum subjective questionnaire evaluating the following areas: limp, use of supportive devices, locking, instability, pain, swelling, stair climbing, and squatting. The Tegner score is a subjective activity measure with ascending numerical scores for activity with increasing demand, from a 0 for an individual unable to work or recreate due to disability to a 10 for participation in competitive sports at a national or international level.

In addition to activity and function, stability and range of motion were evaluated clinically. The standard four grade (grades 0–3) ligament scoring scale was used, where 0 equals no laxity, 1 indicates 0 to 5 mm of translation, 2 equals 5 to 10 mm of translation, and a 3 is greater than 10 mm of laxity. Clinical examination included a Lachman test to evaluate the ACL and a posterior drawer test to evaluate the PCL. Varus and valgus stability was tested at 0 and 30 degrees to evaluate the collateral ligaments and posterolateral corner. Stability of the posterolateral corner was specifically tested using the "dial test" (prone external rotation with the knee flexed to 30 degrees). Because posterolateral laxity normally varies between individuals, it was decided that the injured knee would be compared to the uninjured knee for prone external rotation. This resulted in an analysis of the posterolateral corner of only the patients with unilateral knee dislocations. Range of motion was evaluated using a goniometer for both the affected and unaffected knees. The bilateral knee dislocation patients were excluded from range-of-motion analysis.

Statistical analysis was performed using SAS (Cary, NC). A two-sample t test (with Satterthwaite correction for unequal variance) was used to evaluate Lysholm scores from different groups. Significance was set at $P < 0.05$.

RESULTS

Between 1994 and 2002, a total of 27 consecutive patients with 30 knee dislocations were treated by a single surgeon at a Level 1 trauma center. Two patients/two knees were lost to follow-up after their 3 month follow-up visit. The remaining 25 patients (19 men, 6 women, 28 knees) were available for evaluation (93% follow-up) at a mean follow-up of 48 months (range 13 to 82 months) and constitute the study group (Table 1). One patient was available for a telephone evaluation but not a physical examination due to a long-distance move and is included in the analysis. The mean age of these patients at injury was 35 years (range 14 to 67 years). Twenty-one of the 28 knee dislocations (75%) were high-velocity injuries. Motor vehicle or motorcycle accident (including one pedestrian struck by a vehicle) was the mechanism for 17 of our knees. Industrial injuries and downhill ski

TABLE 1. Injury Characteristics

Patient ID	Age	Sex	Side	Mechanism	KD	ACL	PCL	MCL	LCL	PLC	Meniscus	Lysholm Score	Tegner Pre	Tegner Post	Complications
BILAT															
DC	17	F	R	MVA	IV	X	X		X	X	X	92	4	4	
DC	—	F	L	MVA	IV	X	X		X	X		82	4	4	
OT	32	F	R	MVA	V	X	X	X	X	X	X	68	6	1	Heterotopic bone
OT	—	F	L	MVA	V	X	X	X	X	X		68	6	1	Heterotopic bone
PS	41	M	R	MCA	V	X	X	X	X	X		100	6	5	
PS	—	M	L	MCA	IV	X	X		X	X		95	6	5	
UNILAT															
JK	61	F	R	Dance	IV	X	X		X	X		85	3	3	
SP	24	M	R	ATV	V	X	X	X	X	X	X	83	6	3	Fibrosis
CR	14	M	R	Football	IV	X	X		X	X	X	100	10	9	Stitch granuloma
AT	46	M	R	MCA	IV	X	X		X	X	X	87	5	3	
MH	30	F	R	Skiing	II	X	X					75	3	3	Fibrosis
ET	45	F	L	MVA	V	X	X	X	X	X		88	4	2	Fibrosis
JL	43	M	L	Skiing	III	X	X	X				79	8	6	
CG	28	M	L	Basketball	V	X	X	X	X	X	X	99	7	7	Fibrosis
WF	36	M	L	MVA	IV	X	X		X	X		95	5	5	Fibrosis
CR	31	F	L	MVA	IV	X	X		X	X		90	6	4	
RS	30	M	R	MCA	IV	X	X		X	X	X	88	7	3	Stitch granuloma
KP	26	M	L	Fall	IV	X	X		X	X	X	95	6	6	
KW	38	M	R	Industrial	V	X	X	X	X	X	X	70	6	3	
DL	53	M	R	MVA	IV	X	X		X			100	6	5	
JD	31	M	L	Industrial	V	X	X	X	X	X	X	90	6	5	
MS	21	M	L	MCA	IV	X	X		X	X	X	93	7	6	
PM	21	M	R	MVA	IV	X	X		X	X	X	95	6	5	
RT	49	M	L	Badminton	V	X	X	X	X	X		100	4	4	
PS	17	M	L	MVA (ped)	IV	X	X		X	X		81	4	4	
ES	27	M	R	Softball	IV	X	X	X	X	X		95	5	5	
AP	53	M	L	MVA	IV	X	X		X		X	100	6	6	
GM	67	M	R	Fall	IV	X	X		X	X	X	99	5	5	
MEAN	35.2											89.0	5.6	4.4	

racing accounted for two each of the other four high-velocity injury mechanisms. As for the low-velocity patients, mechanisms of injury included basketball, football, softball, badminton, ballroom dancing, and falls (2). The mean time to surgery was 17 days (range 1 to 101 days).

Ligament injury patterns consisted of a complete ACL and PCL disruption in 28 knees. The posterolateral corner was injured in 24 knees. LCL was injured in 26 knees and the MCL injured in 11 knees. Meniscus tears requiring repair or debridement were present in 14 knees. Using Schenck's classification system,[14] there were 1 KDI, 1 KDII, 17 KDIV, and 9 KDV injuries.

Vascular complications occurred in one patient who sustained a popliteal artery injury as well as a popliteal vein disruption. This patient underwent a reverse saphenous vein graft arterial reconstruction and a popliteal vein repair by our vascular surgery service on an emergent basis.

The common peroneal nerve was the nerve injured in our patient population. Nerve injury was defined as either complete or a deficit in the motor and/or sensory distribution. Some degree of peroneal nerve injury was present in 21 knees (75%). Four of these were complete motor and sensory loss (19%), 9 were partial motor and sensory loss (43%), and 8 were partial sensory loss (38%).

All 26 patients with a posterolateral ligamentous injury underwent peroneal neurolysis at the time of their posterolateral repair. The degree of nerve damage at the time of surgery was incompletely documented. Of the 21 extremities with preoperative peroneal nerve injury, 14 (67%) experienced complete neurologic recovery, 3 (14%) had residual sensory deficits, and 4 (19%) had no recovery of motor or sensory nerve function [two undergoing tendon transfer and two requiring permanent use of an ankle foot orthosis (AFO)]. The four patients with complete peroneal palsies were the same patients without recovery of motor or sensory function. There were no additional postoperative nerve palsies as a result of the neurolysis.

Associated fractures were common in our population. Fractures of varying severity existed in 11 knees. Most fractures were relatively minor, such as a proximal fibula or a tibial spine avulsion. However, several of the patients had significant fractures including four patients with ipsilateral tibial plateau fractures (one Schatzker type I, one Schatzker type II, and two Schatzker type IV). Many of these patients sustained injuries to other extremities in addition to head, chest, and abdominal trauma.

The 28 knees in 25 patients had a mean Lysholm score of 89.0. The 17 KDIV injuries recovered to a mean Lysholm score of 92.5, whereas the 9 KDV knees reached a mean score of 85.1. This difference was not statistically significant (P = 0.16). A post-hoc analysis revealed a power of 52% for this calculation. The 20 patients who underwent surgery within 14 days of injury had a mean Lysholm score of 91.2, whereas the eight receiving a delayed surgery (greater than 14 days) had a mean score of 83.6; however, this difference was also not significant (P = 0.16). A post-hoc analysis revealed a power of 51% for this calculation. On a 10 point scale, patients returned to within a mean of 1.25 levels of their activity level before injury. The mean preinjury Tegner score was 5.6, which decreased only to 4.4 at latest follow-up. With only two exceptions, our patients were able to return to their previous job with little or no activity modification. Those two patients sustained bilateral knee dislocations and were unable to return to any employment. Both patients had been previously employed as cashiers/waitresses in restaurants and were unable to continue in this work secondary to knee pain with prolonged standing.

Clinical stability was acceptable. Using the four-point grading system, the mean laxity was calculated for each examination. The mean Lachman was 0.8 and the mean posterior drawer was 0.4. Mean varus stability at 0 degrees was 0.1 and at 30 degrees was 0.8. Mean valgus stability at full extension was 0.0 and at 30 degrees was 0.5. The mean change in prone external rotation at 30 degrees compared between the injured and the uninjured knee (excluding the bilateral knee dislocations) was a decrease of 0.6 degrees.

Comparing the injured to the uninjured knee, range of motion in the injured knee yielded a mean loss of extension of 1.9 degrees and a mean loss of flexion of 10.2 degrees. The overall mean arc of motion in the injured knees was 119.3°, compared to a mean arc of motion in the uninjured knees of 131.4 degrees.

Arthrofibrosis was the most common complication. Five of our patients required manipulation and arthroscopic lysis of adhesions at a mean of 16 weeks (range 8 to 36 weeks). Two patients developed a stitch granuloma (both along the anteromedial incision) that required local debridement. No deep infection was noted in either case. One of the patients with bilateral knee dislocations developed mild heterotopic bone formation in both knees.

DISCUSSION

The surgical treatment of the dislocated knee is challenging. The goal of a painless functional knee with good range of motion and stability is difficult to achieve. Although many techniques have been reported, results in the literature are difficult to interpret because of the small series of patients and wide spectrum of injuries. Multiple techniques performed by multiple surgeons over a longtime period are often reported.[2,3,15,16]

We report a consecutive series of knee dislocations treated with a consistent surgical and rehabilitation protocol. This approach was developed in order to allow early rehabilitation to help prevent stiffness, which is the most reported complication of all surgical techniques used to treat knee dislocations. It was anticipated that as patients returned to their previous activity, they may experience functional instability and desire a delayed reconstruction. However, it was noted that the first few patients treated in this manner were able to return to their previous activity and were limited by stiffness, not instability.

The functional results in this study (mean Lysholm = 89) are comparable to recent reports of ligament reconstruction by Wascher et al[10] (mean Lysholm = 88), Yeh et al[11] (mean Lysholm = 84), Liow et al[7] (mean Lysholm = 79), Harner et al[6] (mean Lysholm = 87), and Talbot et al[17] (mean Lysholm = 72). Our patients with KDIV injuries had higher scores (92.5) than those sustaining KDV injuries (85.1). Our patients who underwent surgery within 14 days of injury had higher scores (91.2) compared with those receiving surgery greater than 14 days from injury (83.6). Although these numbers may have some clinical significance, our small patient series precludes reporting a statistical significance.

The presence of nerve function is an important factor in achieving a good outcome.[10] Peroneal nerve injury has been reported in approximately 25% of knee dislocations[16] and in 41% of knees with an injury to the posterolateral ligament complex.[18] Some degree of peroneal nerve injury was present in 21 knees (75%) in the current study. All patients with peroneal nerve injury also had a concomitant posterolateral ligamentous injury. Four of the peroneal palsies were complete while 17 were partial. The four patients with complete injuries experienced no recovery of motor or sensory function. Although this rate is higher than previously reported, we documented all nerve injuries, even mild sensory loss. That 75% of our patients experienced high energy traumatic mechanisms of injury may serve as another explanation of this high rate of nerve injury. In addition, all but two of the knees in our population experienced a posterolateral ligamentous injury. We wish to stress the importance of a complete peroneal neurolysis as part of the approach to this region of the knee as one study cited that a limited neurolysis around the fibular head resulted in missed peroneal nerve lesions that required delayed intervention.[19]

The most problematic complication in our study patients was stiffness (5 of 28, 18%). All the patients with fibrosis requiring manipulation or surgery had undergone a surgical repair of their dislocation within 10 days of injury. This is similar to the report from Harner et al,[6] which noted 4 of their 31 patients (13%) experienced significant stiffness, all of which were in their acute treatment group. Stiffness is a potential concern when surgically treating knee dislocations, independent of technique. However, the results in this study and others[6,7] were better in the patients treated acutely within 14 days.

This study has both strengths and limitations. This population is a consecutive series of patients treated by a single surgeon using a consistent technique. Follow-up was performed in 93% of our population at a mean of 48 months by an independent observer. There is the possibility for recall bias in our gathering preinjury subjective activity assessments at a mean of 48 months after treatment. Also, our patients with bilateral injuries were not included in the physical examination analysis due to their absence of a contralateral control extremity. The absence of a control treatment group for comparison, as well as small numbers in our study population, limits our ability to interpret our results. In addition, this study lacks objective stability measurements, such as KT-1000 or stress radiographs. Despite these concerns, the size of our study and our results are comparable to other recent reports using reconstructive techniques.[6,7,10,11,17,20]

Although the initial development of this approach included continued follow-up and counseling for possible delayed reconstruction of cruciate ligaments, the patients in our study population did not experience instability that limited their return to function. In fact, stiffness was the limiting factor. Although this technique may not allow a high-level athlete to return to competition, early primary repair of all injured structures may allow a patient who experienced a knee dislocation in a motor vehicle accident to begin functional rehabilitation and return to work and leisure activities. To our knowledge, none of our patients have undergone subsequent ligamentous reconstructions in their injured knees.

Primary repair of all injured structures is an effective option for the treatment of knee dislocations. Although there are still concerns about the integrity of cruciate ligament repair and resultant instability, early repair allows initiation of rehabilitation to prevent stiffness, which is the most common complication with these injuries.

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Invited Commentary

I would like to congratulate the authors of this paper and commend them for their good results with primary repair of knee dislocations. However, I believe that it is imperative to provide a brief review of the literature to avoid "relearning" lessons that, in many cases, have only been learned the hard way.

Several authors have reported poor results with primary repair of anterior cruciate ligament (ACL) tears. Feagin and Curl,[1] in 1976, reported a follow-up study of a cohort of West Point cadets. Although they had reported good preliminary results with primary repair of ACL injuries, this study showed that at 5-year follow-up, more than 50% of these Army officers reinjured their knee. Weaver et al[2] reported a failure of 36% to 48% at 42 months after ACL primary repair. Anderson et al[3] found that more than 60% of the ACLs that they repaired elongated or retore. More recently, Strand et al,[4] in a Norwegian study, reported a failure of more than 50% of their repairs at long-term follow-up. Finally, Drogset et al,[5] in another study from Norway, showed a revision rate in their primary ACL repaired knees *10 times as high* as their ACL reconstructions with grafts.

Although there are fewer reports of primary repair of the posterior cruciate ligament (PCL), repair of complete midsubstance PCL injuries is generally considered ill advised. Richter et al,[6] in a study of PCL repairs in Germany, reported that one third of their repairs were unsatisfactory. When one considers that some of these may have been avulsions or "peel-off lesions" that are known to do well with primary repair, it is likely that complete midsubstance ruptures represented a large portion of their failures.

Primary repair of posterolateral corner injuries is also generally not recommended unless it is supplemented with a free graft. Stannard et al[7] compared failure rates in patients with primary repair and reconstruction with primary repair alone. Patients with primary repair and reconstruction had a 9% failure rate, but patients with primary repair alone had a failure rate of 37%.

In sum, although the authors of the present study had good results with primary repair of knee dislocations, please consider the preponderance of literature that suggests that we should not change our treatment algorithm immediately, but instead, proceed with caution.

Mark D. Miller, MD
Professor and Head
Division of Sports Medicine
University of Virginia
Charlottesville, VA

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In Response:

We would like to thank Dr. Miller for his comments. We agree that primary repair of ligamentous injuries associated with knee dislocations may not be the optimal treatment for this devastating injury and may not be recommended for most athletic injuries. However, this approach should be considered as an acceptable treatment for high-energy injuries.

We agree with the dismal results of primary repair of isolated ligamentous injuries. Although the majority of the North American literature recommends reconstruction of cruciate ligaments in knee dislocation, the few available comparison studies between repair and reconstruction have shown similar results with each.[1,2] Our results with primary repair are comparable with recent series of ligament reconstruction.[3–7] Although the previously reported results of primary repair were poor, these repairs were not coupled with an early rehabilitation program. These protocols involved postoperative casting, and the failures were due to pain and stiffness, not instability.[8,9]

Although the choice of surgical technique in this study may stimulate discussion, we would like the reader to take note of the rehabilitation protocol with an emphasis on early motion. It is the uniform use of early motion that allowed the patients in this series to achieve good results. We appreciate Dr. Miller's comments and the opportunity to respond.

Brett D. Owens, MD
Keller Army Hospital, West Point, NY, USA
Brain D. Busconi, MD
University of Massachusetts Medical School
Worcester MA, USA

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