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Clinical outcomes after multiligament injured knees: medial versus lateral reconstructions

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Abstract
Purpose The purpose of this study was to analyse the clinical outcomes of multiligament injured knees with respect to the medial collateral ligament and posteromedial corner (PMC) repair or reconstruction versus the posterolateral corner (PLC) reconstruction in patients operated according to a codified surgical protocol.
Methods Patients were divided into two groups depending on whether PMC or PLC was injured. Cruciate ligaments as well as PMC or PLC were reconstructed/repaired in a one-stage procedure. At minimum of 1-year follow-up, objective and subjective International Knee Documentation Committee (IKDC) forms, Lysholm score and sports activity level were recorded.
Results Thirty-nine patients with a median follow-up time of 57 months (range 12–129) were reviewed. No significant difference was found for functional scores between acute PMC and PLC subgroups. In Group PLC, subjective outcomes tend to be better in the acute than in chronic reconstruction subgroup.
Conclusions A one-stage protocol with early surgery rather than delayed reconstruction produced better clinical outcomes whatever the injured collateral ligament, medial or lateral. In the future, early and chronic reconstructions as well as each injury pattern should be considered as separate entities in studies on multiple ligament injured knees to reach a better level of evidence.
Level of evidence IV.

Keywords Multiligament injured knees · Posterolateral corner · Posteromedial corner

Introduction

Knee dislocations (KDs) have historically been defined as a clinical or radiological loss of tibiofemoral congruence [35]. Given that many KDs could be spontaneously reduced [41], multiligament knee injuries are equivalent to KDs with regard to the mechanism of injury, the severity of the ligamentous injury and the frequency of neurovascular damage or periarticular fracture [47]. Therefore, the modern definition of KDs includes all ligament injuries that involve two or more major knee ligamentous structures [4].

A better evaluation and management of such severely injured knees with multiligament lesions resulted in an improvement in functional results over the last few years [12]. Nonetheless, multiligament knee reconstruction outcomes are difficult to assess because the low incidence, the heterogeneity of lesion patterns and the variety of different treatments lead to difficulties when comparing studies [30]. Therefore, evidence-based treatment algorithms are lacking and treatment options remain controversial [38]. The available literature dedicated to multiligament injured knees did not report individual outcomes for injury patterns or clinical timing [15], and KD outcomes have commonly been reported all together. To our knowledge, the present study is the first to compare posteromedial sutures or reconstructions to posterolateral reconstructions in multiligament

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injured knees classified according to the anatomic Schenck classification [40].

The purpose of this study was to analyse the clinical outcomes of multiligament injured knees with respect to medial collateral ligament (MCL) and posteromedial corner (PMC) repair or reconstruction versus posterolateral corner (PLC) reconstruction in patients operated according to a codified surgical protocol. The hypothesis was that the clinical outcomes would be equivalent after surgery, regardless of the collateral ligament injured.

Materials and methods

Between 2003 and 2011, 97 patients (99 knees) presented to our institution (the A. Mignot Hospital in Versailles) with multiligament injured knees. Patients were either given emergency care or secondarily referred to our service from other institutions.

Inclusion criteria were the following: (1) injury to ACL and/or PCL associated with the posterolateral corner (PLC) or the PMC diagnosed clinically and by MRI, (2) multiligament knee reconstruction performed by one of three senior orthopaedic surgeons at our institution, and (3) a minimum 1-year follow-up. Patients were excluded from this study if one of the following conditions applied: (1) combined PMC and PLC injuries (KD IV in Schenck classification), (2) initial vascular and/or neurological injuries, (3) open knee dislocation, and (4) femoral or tibial fracture. In accordance with these criteria, 43 patients were excluded from the study, leaving 54 patients who met the inclusion criteria.

Ligamentous injuries were classified in accordance with the Schenck anatomic classification used for KDs [40, 41]. KD I involved an injury to one of the cruciate ligaments (ACL or PCL) associated with collateral ligament injury. KD III involved injuries of both cruciate ligaments and one of the collateral ligaments. The KD III group was subdivided into medial-sided (KD III-M) and lateral-sided (KD III-L) injuries. Eighteen patients (46 %) were KD I, 13 (33 %) were KD III-M, and eight (21 %) were KD III-L (Table 1).

The patients were divided into two groups depending on whether the PMC or the PLC was injured. The PMC group included patients with LCM/PMC injury associated with an ACL and/or PCL tear. The PLC group included patients with an LCL/PLC injury associated with an ACL and/or PCL tear.

Surgical procedure and rehabilitation

Three senior orthopaedic surgeons performed all the reconstructions. All of the injured structures (ACL/PCL/PLC and PMC) were systematically repaired/reconstructed in a one-stage procedure. The mean operation time was 133 min (range 90–190 min).

The first step was the arthroscopic central pivot reconstruction. ACL reconstruction was performed using a classic inside–out technique with a semitendinosus or patellar tendon autograft. In acute cases (first 21 days), PCL reconstruction was performed by using an artificial ligament (LARS®, Arc-sur-Tille, France). In chronic cases (after the third week), PCL reconstruction was performed with quadriceps or patellar tendon autografts.

In the PMC group, regarding the medial and posteromedial complex, the deep and superficial MCL and the posteromedial structures with the posterior oblique ligament (POL) and the capsule were repaired using sutures, anchors

Table 1 Demographic data and associated lesions in two groups

	Group PMC ($n = 19$)	Group LCL ($n = 20$)
Age (years)	36.3 (16–55)	32 (17–65)
Sex	15 Men/4 women	16 Men/4 women
BMI (kg m^{-2}) ± SD	24.6 ± 3.2	23.9 ± 3.9
Injury mechanism	10 Motorcycle accidents	11 Motorcycle accidents
	9 Sports traumas	8 Sports traumas
		1 Work accident
Knee dislocations	8 Knees (42 %)	4 Knees (20 %)
Associated ACL/PCL injuries	13 ACL + PCL injuries (KD III-M)	8 ACL + PCL injuries (KD III-L)
	5 PCL injuries (KD I)	9 PCL injuries (KD I)
	1 ACL injury (KD I)	3 ACL injury (KD I)
Associated meniscal lesions	7 Medial	4 Medial
	2 Lateral	3 Lateral
Associated lesions	4 Patellar tendon avulsions	1 Patella fracture
	1 Patella fracture	

KD knee dislocation of Schenck classification, *BMI* body mass index

or staples. If a laxity persisted after repair, a PMC anatomic reconstruction was also performed using a hamstring tendon autograft, recreating the superficial MCL and the POL.

In the PLC group, the reconstruction consisted of an anatomic reconstruction technique recreating the lateral collateral ligament, the popliteus tendon and the popliteofibular ligament, using autologous hamstring tendons [5, 10, 28]. Overall, in nine cases, an additional hamstring graft had to be taken from the contralateral knee.

Full weight bearing was allowed at 6 weeks post-operatively with crutches. A ligament brace was used for 3 months. Strengthening physiotherapy and progressive knee motion exercises were started on the first post-operative day. Rehabilitation in the prone position was preferred in patients with PCL reconstruction. In the case of persistent post-operative range-of-motion deficits, manipulation under anaesthesia in the first 6 weeks or arthroscopic release after 6 weeks was performed.

Clinical and radiological evaluation

At the final follow-up, objective and subjective International Knee Documentation Committee (IKDC) forms, Lysholm scores and sports activity levels were recorded. Any complications and reoperations were registered. In addition to the numerical score on a scale from 0 to 100, clinical outcomes were also rated as 'excellent', 'good', 'fair' or 'poor' according to IKDC values and to the Lysholm score [7, 19]. Furthermore, clinical outcomes were aggregated to a dichotomous variable classified as 'excellent or good' or 'fair or poor' in order to compare to the literature data.

A complete knee examination was performed with special attention to joint laxity. The ACL was tested using the Lachman and pivot shift tests. The PCL was evaluated using the posterior drawer test at 70° flexion. The MCL and PMC were tested using valgus stress at 30° flexion. The PLC was examined using varus stress at 30° flexion, as well as the recurvatum test and the dial test. All laxity grades were determined in comparison with those of the healthy knee. For frontal and sagittal laxity, the IKDC grade A is a 0- to 2-mm side-to-side difference; grade B, 3–5 mm; grade C, 6–10 mm; and $D > 10$ mm. Range of motion was measured with a goniometer with a measurement accuracy of 5°.

This study was approved by the institutional review board of the hospital and by the scientific committee of the A. Mignot Hospital in Versailles. This study was performed in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki. All patients signed a written informed consent. No patients declined to participate in this study.

Statistical analysis

The Fisher's exact test and Mann–Whitney test were conducted using the GNU GSPP version 3 free software. A p value <0.05 was considered significant.

Results

At a median follow-up of 57 months (range 12–129 months) after knee reconstruction, a total of 39 patients were reviewed (8 women, 31 men). Fifteen patients were lost to follow-up. The median age at the final follow-up was 40 years (range 20–64 years).

The two groups were comparable regarding age, sex, body mass index (BMI), associated ACL/PCL injuries, associated meniscus injuries and injury mechanism (Table 1). Eight patients in the PMC group and four in the PLC group presented initially with a dislocated knee.

All patients in the PMC group were operated on in the acute phase, 17 days, on average, after trauma (7–30). Nine patients in this group had a PMC repair, and ten had a PMC reconstruction. In the PLC group, nine patients had acute reconstructions and 11 had chronic reconstructions later than 3 weeks after the trauma. Operative findings and additional procedures are summarised in Table 2. No post-operative neurovascular complications were recorded.

One patient in each group had mobilisation under anaesthesia 5 weeks after surgery; three patients in the PMC group and two in the PLC group had arthroscopic anterior arthrolysis at a mean of 3 months (1.5–6) after surgery (Table 2).

The clinical results are presented in Table 3. There were significant differences in subjective IKDC and Lysholm scores, with better functional outcomes in the PMC group ($p < 0.05$). None of the patients in either group had residual range-of-motion deficits. Knee laxity tests are presented in Table 4. Most of the patients were IKDC A and B. Four patients with chronic PLC reconstruction were classified as IKDC C because of residual varus laxity of more than 6 mm, and two other patients were classified as having acute PLC reconstruction for a positive dial test with excessive external rotation at 30° and 90°. These two patients also had a positive grade C posterior drawer test. Only one patient in the PMC group was IKDC C because of residual valgus laxity of more than 6 mm.

In the PMC group, no significant difference was found for subjective and objective clinical scores between the subgroups 'repair' and 'reconstruction'. In the PLC group, subjective outcomes tended to be better in the acute reconstruction subgroup (Fig. 1; Table 5).

Table 2 Surgical management of the multiligament injured knees

	Group PMC ($n = 19$)	Group LCL ($n = 20$)
Timing of the surgery	19 Acute	9 Acute
		11 Chronic
Collateral ligament surgery	9 Repairs	20 Anatomic reconstructions
	10 Reconstructions	
Concurrent meniscal surgery	3 Medial meniscectomies	3 Medial meniscectomies
	4 Medial repairs	1 Medial repair
	2 Lateral repairs	3 Lateral repairs
Second-stage operation	1 Mobilisation under anaesthesia	1 Mobilisation under anaesthesia
	3 Arthroscopic arthrolysis	2 Arthroscopic arthrolysis
	1 Arthroscopic debridement for septic arthritis	

Acute surgery was defined as performed in the first 3 weeks after the injury; chronic surgery after 3 weeks

Table 3 Objective and subjective clinical evaluations

	Group PMC ($n = 19$)	Group LCL ($n = 20$)	p value
Follow-up (months) ± SD	75 ± 26	39 ± 22	
Average ROM (°) (recurvatum/flexum/flexion)	6/0/131	5/1/127	n.s.
Objective IKDC	2A, 16B, 1C	1A, 13B, 6C	n.s.
Subjective IKDC	81 ± 15	70 ± 17	<0.05
Lysholm	89 ± 7	79 ± 11	<0.05
Sports	8 At same level 10 Decreased in activity level 1 Stopped sports	4 At same level 10 Decreased in activity level 6 Stopped sports	n.s.

ROM range of motion

Table 4 Results of the clinical tests according categories

	IKDC A		IKDC B		IKDC C	
	Group PMC	Group LCL	Group PMC	Group LCL	Group PMC	Group LCL
Lachman test	15	17	4	3	0	0
Pivot shift	15	16	4	4	0	0
Posterior drawer	15	15	4	3	0	2
Valgus stress	12	19	6	1	1	0
Varus stress	17	9	2	7	0	4
ER 30°	16	12	3	6	0	2
ER 90°	16	12	3	6	0	2

n number of patients, *ER* external rotation

Discussion

The most important finding of the present study is two-fold. Firstly, when operating during the acute phase, PMC sutures/reconstructions gave comparable functional outcomes to PLC reconstructions. Secondly, functional outcomes of PLC reconstructions are slightly better for acute surgery than for chronic surgery. To our knowledge, the present study is the first to compare posteromedial sutures or reconstructions to posterolateral reconstructions in multiligament injured knees.

There is a consensus that surgical treatment of multiligament knee injuries using repair or reconstruction of the injured ligaments, followed by early rehabilitation, provides better results than does conservative treatment [20, 31, 33, 50]. There is still controversy regarding the timing of surgery, one-stage versus two-stage surgery, repair and/or reconstruction, and autograft and/or allograft [34].

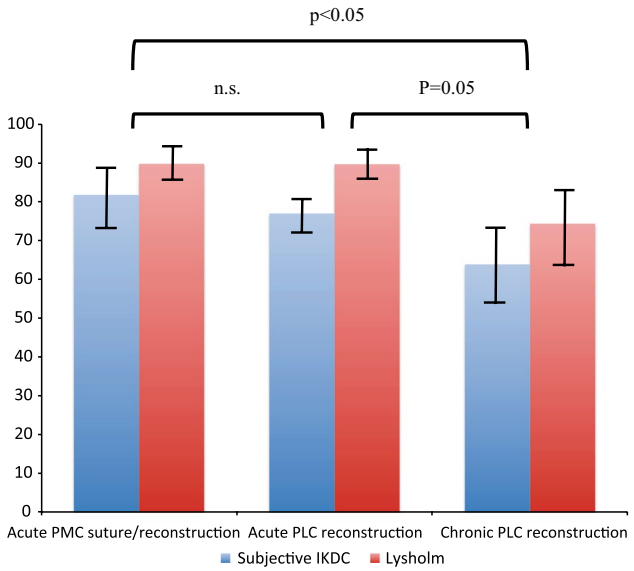

Fig. 1 Knee function scores for the PMC and PLC groups regarding to the timing of surgery

Table 5 Clinical outcomes graded as 'excellent'/'good' and 'fair'/'poor' according to subjective IKDC and Lysholm scores

	Acute PMC repairs/reconstructions (%)	Acute PLC reconstructions (%)	Chronic PLC reconstructions (%)
Excellent/good results	79	72	44
Fair/poor results	21	28	56

Good clinical outcomes were reported by our patients in the PMC group, with a mean Lysholm score of 89 (SD ± 7) and a mean subjective IKDC score of 81 ± 15. This is within the range reported in the literature [9, 43]. Nonetheless, unlike the abundant literature on PLC injuries in KDs [2, 16, 21, 51], the available literature dedicated to the clinical outcomes after medial-sided surgeries in KDs is sparse [24]. The healing potential of the MCL has often tipped the balance in favour of the conservative treatment. A recent focus on medial-sided anatomy and biomechanics [37, 49] has enabled the development of anatomic reconstructions, which seem to give encouraging results [27, 43].

Werner et al. [48] compared clinical outcomes after surgical treatment of bicruciate ligament injuries, including medial-sided involvement, without or with posterolateral corner injuries (Schenck KD III-M and KD IV, respectively). They found significantly better Lysholm scores (88 vs. 67, $p = 0.027$) and Veterans RAND 36-Item Health Survey (VR-36) scores (88 vs. 70, $p = 0.022$) for KD III-M than for KD IV knees. Nonetheless, KD IV knees included patients with both medial and lateral injuries.

DeLong and Waterman [9] recent meta-analysis found 14 level IV retrospective case series reporting clinical outcomes after MCL/PMC reconstructions. A total of 359 patients with a mean age of 33.7 ± 4.7 were identified at an average clinical follow-up time of 34.5 ± 12.4 months. The heterogeneity of the patient population, a variety of concomitant ligament injuries, varying degrees and chronicity of medial-sided injuries and different surgical techniques make it difficult to compare between studies. Nonetheless, in these 359 patients, IKDC valgus stability grades A or B varied from 82.5 to 100 %, and the Lysholm score ranged from 87 to 94.8. Another recent meta-analysis by Smyth and Koh [43] showed similar results.

In our study, worse but reasonable clinical outcomes were observed after PLC reconstructions than after medial-sided surgeries, with a mean Lysholm score of 79 ± 11 and a mean subjective IKDC score of 70 ± 17 (Table 3, $p < 0.05$). This result is also within the range found in recently published data [3, 46].

Nonetheless, when our results were analysed regarding surgical timing, no significant difference was observed between the acute PMC sutures/reconstructions and the acute PLC reconstructions, with 79 and 72 % receiving excellent or good scores, respectively. Chronic PLC reconstructions had significantly worse clinical results than did acute PLC reconstructions, with only 44 % receiving excellent or good results.

Three recent meta-analyses and systematic reviews reported clinical outcomes after multiligament knee reconstructions with respect to injury pattern, according to Schenck's classification [6, 15, 23]. Only one of these studies, by Jiang et al. [23], compared the results between the KD III-M and KD III-L groups. They reported 69 cases with KD III-M and 84 cases with KD III-L in the 12 eligible studies from 1999 to 2014. Excellent or good results were obtained in 66.7 % of KD III-M cases versus 57.1 % for KD III-L cases, but this difference was not statistically significant. Nonetheless, the timing of the surgery (acute or chronic) was not taken into account.

With regard to surgical timing, there is an increasing consensus that surgical intervention should be performed as early as possible [8, 11, 23, 25, 34, 41]. Three weeks seems to be the critical timing threshold for acute surgery that is widely advocated throughout the literature [13, 32, 34] because tissue flexibility allows for plane identification and dissection. Levy et al.'s [30] systematic review, including five studies comparing early with delayed surgery, found significantly better outcomes for early intervention than for chronic intervention, with 47 % receiving excellent/good IKDC scores versus 31 %, respectively.

With regard to the management strategy for multiligament injured knees, for example the procedures noted by Clark and Engebretsen [6], repair or reconstruction of all of the injured ligaments together was preferred. Indeed, the role of the combination of all knee ligaments towards knee joint kinematics was demonstrated by the biomechanical studies [17, 22]. Moreover, this strategy entails a lower duration of recovery than does staged treatment [23]. Therefore, a one-step procedure was performed instead of a stepwise approach, with arthroscopic reconstruction of the cruciate lesions and simultaneous open repair or reconstruction of the peripheral lesions as early as possible to restore the normal anatomy and enable immediate stability. The main risk of this acute one-step ligament surgery is the development of post-operative knee stiffness [36, 42]. Immediate post-operative knee rehabilitation with early motion protected with a brace and quadriceps awakening prevented arthrofibrosis. In this series of 39 multiligament reconstructed knees, the reoperation rate (18 %) for knee stiffness was comparable to the results found in the literature [8, 18, 39]. Staged treatments are as likely to require additional procedures for joint stiffness as those who undergo acute surgery [1, 44, 45].

For the treatment of MCL/PMC lesions, a femoral- or tibial-sided avulsion of the MCL was considered reparable and was reinserted into the anatomic origin. If this repair was insufficient with residual medial laxity or for intrasubstance tears during intraoperative testing, we performed an additional MCL/PMC reconstruction above the MCL/PMC repair. When comparing the results of PMC repairs versus reconstructions, there was no significant difference for clinical outcomes in this series. Fanelli et al. [14] carried out a literature review from 1978 to 2008 and identified eight studies reporting outcome data on repair or reconstruction of the MCL in multiligament injured knees. This literature review suggests that either repair or reconstruction of the PMC/MCL in knees with multiple ligament injuries yields satisfactory outcomes.

There is more evidence in the literature that PLC reconstructions give better outcomes than does repairing [20, 34]. Black and Stannard [2] and Levy et al.'s [29] recent works indicate that PLC reconstruction is probably better than repair, with a lower failure rate as well as a higher rate of return to sporting activities. Reconstruction of the PLC is therefore recommended, and various surgical techniques have been described [10, 14]. In our series, we always performed an anatomic PLC reconstruction [5, 10, 28].

In this series, combinations of autografts and artificial ligaments were used for complete knee ligament reconstruction to limit the morbidity associated with harvesting the autograft on an already traumatised knee joint. At the time of this study, we did not yet have access to allografts.

For acute PCL reconstruction, a synthetic device (LARS, Arc-sur-Tille, France) was used to guide the natural healing of the PCL. The use of a LARS has recently been described in the literature, with promising midterm results, as an alternative to allografts, but safety and long-term results are needed [21, 39].

The study has some limitations. First, the main limitation is obviously the heterogeneity of initial lesions, especially for injured cruciate ligaments. Nonetheless, multiligament knee injuries are still rare, with many clinical presentations [26]. The advantage of our study was being able to compare two homogeneous groups with collateral ligament injuries. Second, like almost all studies on multiligament injured knees, this study was a retrospective case series with only a small study population, which is considered level IV evidence. Third, acute and chronic patients were combined in the PLC group, but our hospital is a reference centre for traumatic knees and chronic patients with PLC lesions that are referred to our service.

A new finding with clinical relevance in the present work is significantly better clinical outcomes for acute than for chronic multiligament repairs or reconstructions with comparable outcomes between acute PMC and PLC repairs/reconstructions.

Conclusions

Multiligament knee injuries are rare and potentially devastating, but the development of specialised referral centres with experienced surgeons is associated with a better understanding of these complex injuries, leading to better clinical outcomes in the future than in historical studies. This study suggests that a protocol of early surgery rather than delayed reconstruction produces better clinical outcomes without an increased risk of arthrofibrosis, regardless of the injured collateral ligament—medial or lateral.

Compliance with ethical standards

Conflict of interest N. Tardy, P. Teissier, C. Steltzlen declare that they have no conflict of interest. P. Beaufils is occasional educational consultant for Zimmer and Smith and Nephew, and chief editor of Orthopaedics and Traumatology: Surgery and Research. P. Boisrenoult is occasional educational consultant for Smith and Nephew. N. Pujol is occasional educational consultant for Zimmer and Smith and Nephew.

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