Original Article

External Fixator Application, 2-Stage Procedures, and Postoperative Infection Risk Are Higher in Multiligamentous Knee Injuries After Frank Knee Dislocations

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Purpose: To examine outcomes after surgical treatment of multiligamentous knee injuries (MLKIs) in patients with dislocated versus non-dislocated knees. **Methods:** Patients who were surgically treated for MLKIs between 2008 and 2021 were included in this study. Patients were divided into 2 groups: those with a frank knee dislocation (KD), diagnosed by radiographs or reduction notes in the emergency department, and those without a frank KD (non-KD). The following patient-reported outcome measures were collected: visual analog scale for pain, International Knee Documentation Committee subjective score, and Lysholm knee scoring scale. Additional procedures such as revision ligamentous reconstruction and complications such as infection and arthrofibrosis were also obtained. **Results:** A total of 88 patients (88 knees; 36 KD vs 52 non-KD) were included in the final analysis. This study included 30 female and 58 male patients, and the mean age was 34.3 ± 12.7 years (range, 10-61 years). The mean follow-up period for the patients who did not receive revision surgery was 9.2 years (range, 3.4-15.3 years). There were no differences in age, sex, mechanism of injury, meniscal/chondral injury, or neurovascular status between the groups. Furthermore, there were no differences in visual analog scale, International Knee Documentation Committee, or Lysholm scores. Significantly more patients in the KD group showed higher KD grades (KD III—KD V, 29 [81%] vs 21 [40%]; $P < .001$), and significantly more KD I injuries were observed in the non-KD group (48.1% vs 11.1%, $P < .001$). More patients in the KD group underwent staged procedures (69.4% vs 28.8%, $P < .001$) and had external fixators applied (50% vs 5.8%, $P < .001$). The overall complication rate was comparable between groups, with no differences in revision surgery or arthrofibrosis; however, the KD group had a higher postoperative infection rate (16.7% vs 1.9%, $P = .017$). **Conclusions:** Patients who experienced frank KDs showed an increased odds of receiving external fixation, showed an increased odds of undergoing a staged procedure, had higher grades of injury, and had a higher risk of postoperative infection compared with those without KDs. At final follow-up, no differences in patient-reported outcomes were noted between the 2 groups. **Level of Evidence:** Level III, retrospective cohort study.

Multiligamentous knee injuries (MLKIs) are complex knee injuries that make up 0.02% to 0.20% of all orthopaedic injuries.[1,2] MLKIs can be described as complete grade III ruptures of 2 or more knee ligaments, which may occur in the setting of a frank knee dislocation (KD).[3-5] The most common MLKIs typically involve injury to only 2 ligaments (i.e., anterior cruciate ligament and medial collateral ligament), which often does not occur in the setting of a frank KD.[6-9] Injury to more than 2 ligaments is understood to increase the risk of a frank dislocation.[10]

In a multicenter retrospective cohort study, Hughes et al.[11] found that at a mean follow-up of 6.5 years, KD III patients with frank dislocations reported significantly lower patient-reported outcomes (PROs) and lower activity levels than patients without documented KDs. Furthermore, patients with documented KDs often have neurovascular injuries, open injuries, and associated fractures at the time of presentation; additionally, these injuries are often associated with higher-energy traumas.[12,13] Nonetheless, there is still a paucity of

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literature describing direct comparisons between frank KDs and MLKIs without a documented dislocation at mid- to long-term follow-up.

The purpose of this study was to examine outcomes after surgical treatment of MLKIs in patients with dislocated versus non-dislocated knees. We hypothesized that patients who experienced frank KDs would show a higher degree of knee injury than patients who did not have a documented dislocation and that patients with frank KDs would show lower postoperative PROs and a higher postoperative complication rate.

Methods

Study Design

This study was initiated after institutional review board approval (No. 22.043.03). This was a single-center retrospective cohort study involving patients who were surgically treated for MLKIs by the senior author (S.J.K.). All patients who received primary multiligamentous surgery and had a minimum follow-up period of 2 years were included in this study. Patients were excluded if they received a revision surgical procedure as their initial procedure within the study timeline (2008-2021), received conservative treatment or underwent a total knee arthroplasty on initial presentation, or received a below-knee amputation in the months after surgical treatment of their MLKI.

Data Collection

A retrospective chart review was performed, and patients were identified using Current Procedural Terminology codes for cruciate and collateral knee ligament procedures. After patient identification, patients who underwent isolated single cruciate surgery or isolated collateral surgery were excluded. Once the list of MLKI patients was gathered, the electronic medical record was queried for demographic information, intraoperative data, and postoperative complications. Demographic information included patient age at the time of surgery, body mass index (BMI), sex, mechanism of injury (high- vs low-energy trauma), and time from injury to surgery. Intraoperative and injury data included concomitant meniscal/chondral injury, ligamentous injury pattern using the modified Schenck classification,[14,15] documentation of a frank KD via radiographs and/or post-reduction notes in the emergency department, concurrent neurovascular injury, and polytrauma status.

Patients were then contacted via telephone to provide an updated orthopaedic history. Patients did not return to the clinic for an updated physical examination or follow-up imaging. Additionally, the following validated PROs were collected: visual analog scale (VAS) for pain,[16] International Knee Documentation Committee (IKDC) subjective knee evaluation,[17] and Lysholm knee scoring scale.[18]

Final follow-up was determined by the date on which patients completed their PROs and once an updated orthopaedic history was obtained. Patients were deemed lost to follow-up if it was found that the contact information was outdated, after consecutive failed attempts to contact them via telephone, or if they were noted to be deceased in their medical records. The patients were placed into 2 groups: a dislocation group (KD) and a non-dislocation group (non-KD). Patients who may have experienced an undocumented frank KD that spontaneously reduced were placed in the non-KD group.

Surgical Techniques

The senior surgeon (S.J.K.) used allografts for all ligamentous reconstructions. Patients received external fixation after definitive ligamentous surgery if they experienced a KD V injury that was associated with a frank dislocation, had a concomitant vascular injury, had an open knee injury, or had a frank dislocation in which reduction was unable to be maintained in a knee immobilizer or brace.

Ligamentous structures were surgically addressed in a single procedure in patients who sustained a KD I, KD II, or KD V injury in which only 2 ligamentous structures were ruptured. If a patient was found to have grade III injuries to more than 2 ligaments, then the procedures were staged. The initial procedure included addressing injury to the posterior cruciate ligament and to either the medial collateral ligament with or without posterior oblique ligament (KD IIIM or KD IV) or the lateral collateral ligament with or without posterolateral corner (KD IIIL). The staged procedure included addressing injury to the anterior cruciate ligament (ACL) with or without the lateral collateral ligament or posterolateral corner in the setting of a KD IV injury pattern. KD V injuries were treated in the same manner dependent on the injury pattern after definitive osseous treatment.

Statistical Analysis

Patients were grouped based on dislocation status. Continuous variables were defined as mean ± standard deviation (range), and categorical variables were defined as number (percentage). The Shapiro-Wilk test was used to assess the normality of the distribution for continuous variables. For continuous variables, either the Student t test or Mann-Whitney U test was used, depending on the normality of the distribution. For categorical variables, either the χ^2 test or Fisher exact test was used. Statistical analyses were performed using SPSS software (version 27; IBM, Armonk, NY).

Table 1. Patient Demographic Characteristics

Parameter	KD Group (n = 36)	Non-KD Group (n = 52)	*P* Value
Age, yr	35.1 ± 13.4 (10-60)	34.7 ± 13.2 (16-63)	.91
Follow-up,* yr	8.1 ± 4.0 (3.4-14.3)	9.7 ± 4.7 (3.4-15.3)	.48
BMI	31.4 ± 7.5 (21.6-52.9)	30.3 ± 7.6 (18.2-48.7)	.53
Male sex	22 (62)	36 (69)	.43
Time from injury to surgery, d	51.4 ± 103 (1-623)	85.7 ± 133 (0-687)	.18
Injury mechanism			.67
MVC	10 (28)	19 (37)	
MCA	7 (19)	10 (19)	
AvP	5 (14)	8 (15)	
AvB	1 (2.8)	1 (1.9)	
Fall	6 (17)	10 (19)	
Sports	4 (11)	2 (3.8)	
Crush	2 (5.6)	0 (0)	
Assault	1 (2.8)	2 (3.8)	
High velocity	24 (67)	38 (73)	.52

NOTE. Data are presented as mean ± standard deviation (range) or absolute frequency (percentage).

AvB, automobile versus bicycle; AvP, automobile versus pedestrian; BMI, body mass index; KD, knee dislocation; MCA, motorcycle accident; MVC, motor vehicle collision.

*Follow-up in patients who did not undergo revision ligamentous procedures.

Results

After application of the exclusion criteria, there were a total of 188 patients whose treatment fell within the study timeline. Of these patients, 66 (35.1%) had outdated information in their medical records and were unable to be contacted. There were 29 patients (15.4%) who were unable to be contacted after multiple attempts. Moreover, 2 patients (1.06%) did not have any available operative data, and 3 patients (1.60%) were deceased.

A total of 88 patients were included in the final data analysis; of these patients, 36 (40.9%) were found to have documentation of frank KDs. Demographic characteristics are summarized in Table 1. The mean patient age was 34.9 years (range, 10-63 years). The mean BMI was 30.8 (range, 18.2-52.9). The mean follow-up period in patients who did not undergo revision ligamentous procedures was 9.1 years (range, 3.4-15.3 years). Both groups were demographically comparable.

Intraoperative characteristics are summarized in Table 2. Significantly more patients in the KD group showed higher KD grades (KD III–KD V, 29 [81%] vs 21 [40%]; $P < .001$), and significantly more KD I injuries were observed in the non-KD group (48.1% vs 11.1%, $P < .001$). More patients in the KD group underwent staged procedures (69.4% vs 28.8%, $P < .001$) and had external fixators applied (50% vs 5.8%, $P < .001$). No significant differences in neurovascular

Table 2. Intraoperative Characteristics

Parameter	KD Group (n = 36)	Non-KD Group (n = 52)	*P* Value
Peroneal nerve injury	4 (11)	4 (7.7)	.71
Vascular injury	6 (17)	3 (5.8)	.15
Meniscal injury	14 (39)	13 (25)	.22
Medial	5 (14)	8 (15)	
Lateral	5 (14)	4 (7.7)	
Bilateral	4 (11)	1 (1.9)	
Cartilage lesion	9 (25)	15 (29)	.81
Skin integrity: open	3 (8.3)	3 (5.8)	.79
Schenck classification			<.001
KD I	4 (11)	25 (48)	
KD II	3 (8.3)	6 (12)	
KD IIIM	12 (33)	6 (12)	
KD IIIL	7 (19)	10 (19)	
KD IV	3 (8.3)	0 (0)	
KD V	7 (19)	5 (10)	
External fixation	18 (50)	3 (5.8)	<.001
Staged	25 (69)	15 (29)	<.001
Polytrauma	27 (75)	29 (56)	.06

NOTE. Data are presented as absolute frequency (percentage).

KD, knee dislocation.

Table 3. Postoperative Complications

	KD Group (n = 36)	Non-KD Group (n = 52)	*P* Value
Complications	15 (42)	15 (29)	.21
Infection	6 (17)	1 (1.9)	.02
Arthrofibrosis	5 (14)	3 (5.8)	.26
Ligament failure	8 (22)	9 (17)	.57

NOTE. Data are presented as absolute frequency (percentage).
KD, knee dislocation.

injuries, meniscal injuries, cartilage lesions, open versus closed injuries, or polytrauma status were found between the groups.

Postoperative complications are summarized in Table 3. Patients in the KD group showed a higher rate of infection after their procedures (6 [17%] vs 1 [1.9%], $P = .02$). There were no differences in revision ligamentous procedures or the development of arthrofibrosis in the postoperative period between the groups.

Subjective PROs are summarized in Table 4 for patients who did not necessitate revision surgery. There were no differences observed at final follow-up between the KD and non-KD groups regarding VAS pain levels (3.6 vs 2.8, not significant), IKDC subjective scores (61.8 vs 66.4, not significant), or Lysholm scores (66.9 vs 75.3, not significant).

Regression analyses were performed on possible variables that may have affected outcomes. It was determined that increasing BMI was associated with lower IKDC subjective and Lysholm scores, as well as higher VAS pain levels ($P < .05$). Furthermore, increasing age was associated with decreased IKDC subjective scores at final follow-up. Other parameters such as meniscal/chondral injury, Schenck classification, neurovascular injury, staged procedures, external fixation application, and mechanism of injury did not appear to affect patient outcomes.

Discussion

The most important finding of this study was that patients who had documented dislocations via radiographs or reduction notes showed a higher postoperative infection rate. Additionally, patients with KDs were likely to have higher Schenck classification grades, were more likely to receive an external fixator, and were more likely to undergo a staged procedure. Furthermore, although patients in the KD group showed more severe pathology on presentation, subjective outcomes at a mean of more than 8 years were comparable.

There is a paucity of literature describing an increased risk of infection in patients undergoing MLKI surgery, particularly those with KDs versus those without KDs. In a prospective cohort study examining 315 patients who were admitted to a critical care unit, Cole et al.[19] found that 52% of the patients showed the development of at least 1 type of infection. Compared with the KD group, the non-KD group showed a postoperative infection rate of 1.9% in our study, which was comparable to the rate reported by Poploski et al.[6] in their examination of 773 Surgical Timing and Rehabilitation (STaR) trial patients (3.5%).

Significantly more patients in the KD group showed a higher-grade ligamentous injury pattern compared with the non-KD group. Conversely, nearly half of the patients in the non-KD group sustained a KD I injury. It is well documented that most MLKIs are KD I injuries.[6-9] In a cross-sectional study of 303 patients with KDs, Moatshe et al.[10] did not describe a single patient who showed a KD I injury after a frank KD. Furthermore, only 5.3% of patients in their study showed a KD II injury.

We found that patients in the KD group were more likely to undergo a staged procedure. In a retrospective review of 134 MLKIs that underwent reconstruction, Patel et al.[20] found that a planned staged procedure was a risk factor for a higher complication rate after surgery. There are many reasons for the necessitation of external fixation after MLKIs, such as vascular injury, fracture-dislocation, or the inability to maintain reduction.[21-24] This explains why significantly more patients in the KD group underwent external fixation prior to definitive surgical management of their MLKIs.

Meniscal injury is common after MLKIs.[25-28] King et al.[25] noted concomitant meniscal injuries in 56% of patients after KD. Unfortunately, we were not able to elicit similar findings in either group because only 39% of the patients in the KD group and 25% of those in the non-KD group had concomitant meniscal injuries. These percentages both fall at the lower end of what is to be expected after MLKIs. However, because of the loss of follow-up, our percentages may be underrepresentations of the actual numbers of meniscal injuries encountered at our institution after such injuries.

Table 4. Patient-Reported Outcomes at Final Follow-Up

Outcome	KD Group (n = 25)	Non-KD Group (n = 41)	*P* Value
VAS pain score	3.6 ± 2.8 (0-8)	2.8 ± 2.9 (0-10)	.27
IKDC subjective score	61.8 ± 25.9 (3.45-94.3)	66.4 ± 26.6 (20.7-100)	.49
Lysholm score	66.9 ± 27.8 (4-100)	75.3 ± 26.2 (11-100)	.22

NOTE. Data are presented as mean ± standard deviation (range).
IKDC, International Knee Documentation Committee; KD, knee dislocation; VAS, visual analog scale.

Neurovascular comorbidity has been seen to be higher in patients with frank KDs compared with those with no documentation of a dislocation.[6,8] Furthermore, it is well documented that vascular injury has been shown to be associated with inferior patient outcomes and higher complication rates.[29,30] Nonetheless, we were unable to find a significant difference in our cohort. A possible explanation is that we did not have adequate power to determine a difference in this study.

Overall, surgically treated MLKIs after frank KDs have been shown to result in modest postoperative PROs with the following ranges at final follow-up previously described for the VAS pain scale, IKDC subjective score, and Lysholm score: 2.8 to 4.5, 56.0 to 83.8, and 62.5 to 86.4, respectively.[11,25,27,29,31,32] The scores in both of our cohorts fall within these documented ranges. There is evidence that KD patients show worse subjective outcomes than non-dislocators.[6] Despite this, PROs were comparable in both of our groups. On regression analysis, it was found that patient outcomes decreased as patients aged. Levy et al.[31] observed that patients aged 30 years or older showed inferior postoperative PROs after operative treatment of MLKIs, which is supported by our study.

Limitations

This study is not without limitations. Because of the retrospective nature of this study, there is always a possibility of selection bias. A large percentage of patients were lost to follow-up because of inaccurate contact information. Thus, even though we attempted to include as many patients as possible, the outcomes may an over- or under-represented. Because PROs were collected via telephone, recall bias may also be a limiting factor. Another limitation was that preoperative PROs were not collected for any of the patients, therefore the difference between preoperative and postoperative subjective outcomes was unable to be determined. Furthermore, clinical follow-up data, including range of motion and ligamentous physical examination testing, was not available for analysis. This is a major limitation because it would be important to understand whether patients with frank KDs are objectively as ligamentously stable and have range-of-motion arcs similar to patients without documented KDs. Moreover, radiographs were not obtained at final follow-up, so we are unable to determine the degree of osteoarthritis in our patient population and how this may have played a role in patient outcomes. Finally, the procedures were performed by a single surgeon; therefore, there may have been an unrecognized treatment bias, and these results may not be generalizable.

Conclusions

Patients who experienced frank KDs showed an increased odds of receiving external fixation, showed an increased odds of undergoing a staged procedure, had higher grades of injury, and had a higher risk of postoperative infection compared with those without KDs. At final follow-up, no differences in PROs were noted between the 2 groups.

Disclosures

All authors (A.V.D., T.A.J., K.F.D., W.A.W., D.M., S.J.K.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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