



External fixation increases complications following surgical treatment of multiple ligament knee injuries

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Received: 12 January 2021 / Accepted: 14 February 2021 / Published online: 27 February 2021
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Abstract

Purpose The purpose of this study was to review post-operative complications after surgical intervention of MLKIs within the first 6 months to be better able to counsel patients before surgical intervention.

Methods All patients who underwent surgical reconstruction for a MLKI at one institution from 2009 to 2018 were included in this study. A retrospective review was performed of all patients and post-operative complications were recorded, including motion loss (which included > 10 degree flexion loss or > 3 degree extension loss), hematoma formation, infection, iatrogenic vascular or nerve injury, deep vein thrombosis (DVT), pulmonary embolism (PE), skin lesions, symptomatic hardware, recurrent ligamentous laxity, and need for additional surgery. Knee ligament injuries were classified based on the Schenck Knee Dislocation (KD) Classification.

Results A total of 136 patients were included in this study, 83 with KD I injuries, 40 with KD III injuries, 9 with KD IV injuries, and 4 with KD V injuries. Of these total patients, 48 (35.5%) sustained a post-operative complication: 11 out of 133 (8.3%) from 0 to 1 week, 46 out of 132 (34.8%) from 1 week to 1 month, 28 out of 124 (22.6%) from 1 to 3 months, and 26 out of 121 (21.5%) from 3 to 6 months. Out of the total complications, 99 (78.5%) occurred at 1 week–3 months post-operation. Patients who had an external fixator placed at initial injury were more likely to sustain a post-operative complication. The most common complication was motion loss in 39 (28.6%) patients. There was a significant difference in mean number of complications between the KD I and KD III groups, as well as the KD III and KD IV–V groups. There was no significant difference in the overall prevalence of post-operative complications or occurrence of motion loss with KD grade.

Conclusion The main finding of this study was 48 (35.5%) patients sustained a complication after surgical treatment of MLKIs, with 99 (78.5% of all complications) complications occurring at 1 week–3 months post-operation. Patients who had an external fixator placed at initial injury were more likely to sustain a post-operative complication. The most common post-operative complication was motion loss in 39 (28.6%) patients. The KD grade was not associated with post-operative development of motion loss, but KD III had a significantly greater mean number of complications than KD I or KD IV–V grades.

Level of evidence IV.

Keywords Multiple ligament knee injuries · Postoperative · Complications · Motion loss

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Abbreviations

MLKIs	Multiple ligament knee injuries
DVT	Deep vein thrombosis
PE	Pulmonary embolism
MUA	Manipulation under anaesthesia
LOA	Lysis of adhesions
KD	Knee Dislocation Classification

Introduction

Multiple ligament knee injuries (MLKIs) are devastating and are associated with severe injury to multiple structures of the knee. Due to the extensive nature of injury, treatment for MLKIs creates multiple complex problems fraught with complications [2, 3, 9, 11, 12]. While controversies exist for timing of surgery and rehabilitation after MLKI, recent studies have demonstrated that operative management is superior to non-operative management [7, 8, 13, 14, 16, 18]. Patients treated with operative management were significantly more likely to return to work and sports [5, 12].

MLKIs are classified based on the Schenck classification, with each knee dislocation (KD) grade based on number of ligaments injured [15]. Operative complications are common following MLKIs, especially those with higher KD grades, and include iatrogenic nerve and vascular injury, motion loss, delayed wound healing, post-operative compartment syndrome, deep vein thrombosis (DVT), pulmonary embolism (PE), and persistent laxity [1, 3, 9–12, 17, 19]. A recent retrospective review demonstrated acute surgical intervention in patients with more than two ligaments ruptured had a higher rate of motion loss requiring manipulation under anaesthesia (MUA) [3]. Additionally, patients who sustained knee injuries involving all four ligaments were more likely to undergo revision surgery [3]. However, in the current literature there is lack of consensus on common complications after MLKIs in the immediate post-operative period. This information may provide valuable insight into potential complications in the post-operative period, allowing the treating surgeon to plan accordingly and counsel patients on common complications. It may also change the treatment approach for certain post-operative complications, such as need for external fixation pre-operatively or aggressive rehabilitation post-operatively for patients with motion loss.

Therefore, the purpose of this retrospective study was to establish the rate of post-operative complications after surgical intervention for MLKIs within the first 6 months after surgery. A thorough understanding of early post-operative complications can improve future reporting of complications in clinical trials and improve patient education about risks before surgical intervention. It was hypothesized that patients with higher KD-grade injuries would experience more frequent complications.

Materials and methods

The Institutional Review Board at the University of Pittsburgh provided a waiver of informed consent for retrospective review of existing clinical data. Approval from

the Institutional Review Board at the University of Pittsburgh for the chart review was obtained prior to initiation (PRO12020619). The medical records for individuals who underwent surgical treatment for a MLKI from 2009 to 2018 at one institution were reviewed. Inclusion criteria included age 15–55 years of age at time of injury, complete injury to two or more knee ligaments, and MLKI surgery performed by an orthopaedic sports medicine surgeon at one institution. Exclusion criteria included revision surgery, index surgery performed at an outside facility, prior infection to the ipsilateral knee, inadequate follow-up, and non-operative management of the MLKI.

An initial search of the electronic medical record identified 167 potentially eligible patients, of which 136 patients met the inclusion criteria and were included in the study. Of the 31 ineligible patients, 9 had an isolated anterior cruciate ligament injury, 7 had no follow-up data, 5 had MLKI surgery performed before 2009, 3 were revisions, 2 had the index surgery performed at an outside hospital, 2 were greater than 55 years old, 2 were treated non-operatively, and 1 had prior external fixator placed as definitive treatment with concomitant fasciotomy. A medical records review was performed to document demographic data, type and classification of injury (Schenck Knee Dislocation (KD) Classification) [15], timing of surgery, timing of first post-operative visit, and occurrence of post-operative complications. Complications recorded included motion loss (which included > 10 degree flexion loss or > 3 degree extension



Fig. 1 Post-operative motion loss. The patient above underwent an anterior cruciate ligament reconstruction, posterior cruciate ligament reconstruction, and medial collateral ligament reconstruction of the right knee (KD III-M injury). Post-operatively, the patient developed motion loss requiring a manipulation under anaesthesia and lysis of adhesions. Note the disuse osteopenia in the operative extremity. *KD* Knee Dislocation Grade

loss) (Fig. 1), hematoma formation, infection, iatrogenic vascular or nerve injury, deep vein thrombosis (DVT), pulmonary embolism (PE), skin lesions, symptomatic hardware, recurrent ligamentous laxity, and need for additional surgery. Patients with motion loss at 1-week follow-up were not considered complications, but data reported for completeness.

Statistical analysis

Demographic and injury characteristics were compared between patients who had vs. did not have a complication using the chi-square or Fisher's exact test for categorical outcomes and a two-sample *t* test for continuous outcomes.

The KD grades were combined for the purpose of statistical analysis. Three KD classification groups were created to examine the relationships between severity of injury and frequency of complications. These levels were KD I,

KD III, and KD IV–V. The chi-square test was employed to compare motion loss and presence of complication between these three levels. To compare the number of complications among the three collapsed KD levels a zero-inflated negative binomial regression was employed. All tests were two-sided and alpha was 0.05. All analyses were performed in SAS version 9.4. A post hoc power analysis was performed; if the KD grades were dichotomized to I vs III + then this study would only have 0.14 power to detect a difference in complication rate between the two KD groups.

Results

A total of 136 patients were identified and included in this study. Demographic data are listed in Table 1. Of the 136 patients included, 133 (97.8%) were seen for 1 week

Table 1 Patient and injury characteristics

	Total (<i>n</i> = 136)	Complication (<i>n</i> = 67)	No complication (<i>n</i> = 69)	<i>p</i> value
Age (years, mean ± SD)	28.3 ± 11.9	28.6 ± 12.0	28.0 ± 11.9	n.s
BMI (mean ± SD) ^a	25.9 ± 11.1	27.1 ± 9.9	24.7 ± 12.1	n.s
Female (%)	42 (30.9)	22 (32.8)	20 (29.0)	n.s
Time from Injury to Surgery (days, median (IQR, Q1, Q3))	51 (99, 21, 122)	47 (109, 19, 128)	51 (75, 26, 101)	n.s
Staged procedures <i>n</i> (%)	9 (6.7)	–	–	–
Smoker <i>n</i> (%)	27 (19.9)	13 (19.4)	14 (20.3)	n.s
Hypertension <i>n</i> (%)	12 (8.8)	7 (10.5)	5 (7.3)	n.s
Diabetes <i>n</i> (%)	4 (2.9)	2 (3.0)	2 (2.9)	n.s
Cardiovascular disease <i>n</i> (%)	1 (0.7)	1 (1.5)	0 (0)	n.s
Peripheral vascular disease <i>n</i> (%)	3 (2.2)	2 (3.0)	1 (1.5)	n.s
Neurovascular disease <i>n</i> (%)	3 (2.2)	1 (1.5)	2 (2.9)	n.s
Depression <i>n</i> (%)	9 (6.6)	5 (7.5)	4 (5.8)	n.s
Anxiety <i>n</i> (%)	10 (7.4)	6 (9.0)	4 (5.8)	n.s
Prescribed opioids for > 6 months prior to injury <i>n</i> (%)	6 (4.4)	5 (7.5)	1 (1.5)	n.s
KD classification <i>n</i> (%)				
KD I-L	8 (5.9)	2 (3.0)	6 (8.7)	n.s
KD I-M	75 (55.2)	36 (53.7)	39 (56.5)	
KD II	0 (0)	0 (0)	0 (0)	
KD III-L	11 (8.1)	7 (10.5)	4 (5.8)	
KD III-M	29 (21.3)	14 (20.9)	15 (21.7)	
KD IV	9 (6.6)	5 (7.5)	4 (5.8)	
KD V	4 (2.9)	3 (4.5)	1 (1.5)	
Completed preoperative physical therapy <i>n</i> (%)	53 (39.0)	26 (38.8)	27 (39.1)	n.s
External fixator placed <i>n</i> (%)	17 (12.5)	14 (20.9)	3 (4.4)	0.004
Neurological injury at time of presentation <i>n</i> (%)	5 (3.7)	2 (3.0)	3 (4.4)	n.s
Vascular injury at time of presentation <i>n</i> (%)	8 (5.9)	4 (6.0)	4 (5.8)	n.s
Patellar or quadriceps tendon rupture (%)	2 (1.5)	2 (3.0)	0 (0)	n.s

n number of patients, *SD* standard deviation, *IQR* interquartile range, *Q* quartile, *BMI* body mass index, *KD* Knee Dislocation Classification; *n.s* not statistically significant

p value < 0.05 considered significant

^aData were only available on 123 patients

follow-up, 132 (97%) were seen for 1-month follow-up, 124 (91%) were seen for 3-month follow-up, and 121 (89%) were seen for 6-month follow-up.

Of the 136 individuals that underwent surgical treatment for a MLKI, 48 (35.5%) sustained at least one postoperative complication. Eleven out of 133 (8%) patients had complications at 0–1 week, 46 out of 132 (34.8%) at 1 week–1 month, 28 out of 124 (22.6%) at 1–3 months, and 26 out of 121 (21.5%) at 3–6 months. Out of the total complications, 99 (78.5%) occurred at 1 week–3 months post-operation. Patients who had an external fixator placed at initial injury were more likely to sustain a post-operative complication (Table 1). Motion loss was the most common complication, with 39 (28.6%) of all 136 patients being diagnosed with motion loss at one or more follow-up time points. At 1 week, 1 patient had motion loss in both flexion and extension; at 1 week–1 month, 11 patients had motion loss in flexion and 14 patients in both flexion and extension;

at 1–3 months, 7 patients had motion loss in flexion and 8 in both flexion and extension; and at 3–6 months, 2 patients had motion loss in flexion and 2 patients in both flexion and extension. All the patients that required an MUA/LOA at 1 week–1 month had > 25 degrees motion loss in flexion. Four out of the 14 patients that did not undergo MUA/LOA at 1 week–1 month ultimately required MUA/LOA at 1–3 months or 3–6 months. One patient required multiple MUA/LOA for persistent motion loss. The average time to MUA/LOA from primary surgery was 96 days. A complete list of complications is presented in Table 2.

Knee injuries were classified based on the Schenck classification, with the majority being either KD I-M or KD III-M [15] (Table 1). There were no significant differences in the prevalence of total post-operative complications among the KD grades (Table 3). When looking specifically at motion loss, there was no significant difference in the occurrence of motion loss among the KD grades (Table 3).

Table 2 Postoperative complications

Complication	1 week postop (133 pts) <i>n</i> (%)	1 month postop (132 pts) <i>n</i> (%)	3 months postop (124 pts) <i>n</i> (%)	6 months postop (121 pts) <i>n</i> (%)	Total (136 pts) <i>n</i> (%)
Motion loss	1 (0.8) ^a	25 (18.9)	15 (12.1)	4 (3.3)	39 (28.6) ^e
Patients undergoing MUA/LOA	0 (0)	11 (44.0)	15 (100.0)	4 (100.0)	30 (22.0)
Hematoma	3 (2.2)	0 (0)	0 (0)	0 (0)	3 (2.2)
Superficial infection	0 (0)	2 (1.5)	1 (0.8)	0 (0)	3 (2.2)
Vascular injury as a result of surgery	0 (0)	1 (0.8)	0 (0)	0 (0)	1 (0.7)
Deep vein thrombosis	0 (0)	2 (1.5)	0 (0)	0 (0)	2 (1.5)
Pulmonary embolism	0 (0)	1 (0.8)	0 (0)	0 (0)	1 (0.7)
Skin lesion	1 (0.8)	1 (0.8)	0 (0)	0 (0)	2 (1.5)
Symptomatic hardware ^b	0 (0)	1 (0.8)	1 (0.8)	4 (3.3)	6 (4.4)
Recurrent laxity	0 (0)	7 (5.3)	8 (6.4)	9 (7.4)	24 (17.6)
Requiring revision surgery	0 (0)	2 (28.5)	1 (0.8)	1 (11.1)	4 (2.9)
Additional surgery ^c	1 (0.8)	19 (14.4)	13 (10.5)	8 (6.6)	41 (30.1)
Other ^d	6 (4.5)	8 (6.1)	4 (3.2)	9 (7.4)	27 (20.0)

n number of patients who sustained the complication, *postop* postoperative, *pts* patients, *MUA* manipulation under anaesthesia, *LOA* lysis of adhesions

^aNot considered a true complication, but reported for completeness

^bOne patient at 1 month postop required removal of hardware

^cMUA, LOA, hematoma evacuation, irrigation and debridement, removal of symptomatic hardware

^dKnee effusion requiring aspiration, persistent swelling, wound complication, ganglion cyst on incision, re-injury, medical emergency unrelated

^eNote that 5 patients were diagnosed with motion loss at multiple time points

Table 3 Postoperative complications and Schenck classification

	KD I (<i>n</i> = 83)	KD III (<i>n</i> = 40)	KD IV–V (<i>n</i> = 13)	<i>p</i> value
Experienced any postoperative complication <i>n</i> (%)	38 (45.8)	21 (52.5)	8 (62.5)	<i>n.s</i>
Motion loss <i>n</i> (%)	21 (25.3)	12 (30.0)	6 (46.2)	<i>n.s</i>

KD Knee Dislocation Classification; *n* number of patients; *n.s* not statistically significant
p value < 0.05 considered significant

When comparing the total number of complications between the groups, the KD III group had a higher average number of complications per patient than the KD I group and KD IV–V group (Table 4). There was no difference in the mean number of complications per patient between the KD I and KD IV–V groups (Table 4).

Discussion

The main finding of this study was the high rate of post-operative complications after surgical treatment of MLKIs, with over one-third of patients experiencing at least one complication in the first 6 months after surgery. The majority of complications (78.5%) presented and were recognized between 1 week and 3 months after surgery. Patients who had an external fixator placed at initial injury were more likely to sustain a post-operative complication. Over a quarter (28.6%) of patients experienced motion loss, with 68% of those patients requiring a manipulation under anaesthesia (MUA) and lysis of adhesions (LOA) Only 4 out of 14 (28.5%) patients who experienced motion loss at 1 month and underwent formal physical therapy required MUA/LOA at 3 months or 6 months, while at 3-month and 6-month follow-up visits, all patients with motion loss required a MUA/LOA, highlighting the importance of early and aggressive physical therapy if motion loss is encountered within the first 3 months post-operation. All patients presenting with motion loss were referred to physical therapy for treatment that focussed on increasing range of motion that included cyclic and sustained range of motion and stretching exercises, patellar mobilization and quadriceps activation exercises for 6 weeks. If the patient could not sustain the increases in range of motion after a physical therapy session, a serial drop out cast was considered. If there was no improvement in range of motion after 6 weeks, individuals underwent an MUA/LOA.

Table 4 Number and mean number of postoperative complications and Schenck KD classification

	<i>n</i>	Mean number of complications	Std Dev	Min	Max
KD I	83	0.8	1.0	0	5
KD III	40	1.3	1.5	0	5
KD IV–V	13	0.7	1.0	0	2

The KD III group had a higher average number of complications per patient than the KD I group ($p=0.01$) and KD IV–V group ($p=0.02$). There was no difference in the mean number of complications per patient between the KD I and KD IV–V groups ($p=n.s$)

KD Knee Dislocation Classification; *n* number of patients, *Std Dev* standard deviation; *n.s* not statistically significant

p value < 0.05 considered significant

In the current study, KD grade did not correlate with the overall prevalence of complications or rate of motion loss, but KD III injuries had a higher mean number of complications per patient than KD I and KD IV–V injuries. Prior literature has indicated more frequent complications in patients with more ligaments injured [1, 3–6], which is not in agreement with the findings of this study. However, while not statistically significant, this study found that 52% of patients with a KD III injury and 62% of patients with a KD IV–V injury sustained a complication, while only 46% of patients with a KD I injury had a complication. The present retrospective review was underpowered to determine if a true difference between KD grades exists. It should be noted that there were few patients in this cohort with more severe injuries, and hence the reason patients with a classification of KD IV and KD V were grouped together. Further investigation with a larger number of patients among all severity levels is warranted to augment the current findings and determine whether severity of injury is associated with complications.

The findings of this study provide valuable insight into potential complications in the post-operative period, allowing the treating surgeon to plan accordingly and counsel patients on common complications. It may also change the treatment approach for certain post-operative complications, such as avoiding external fixation pre-operatively if possible or pursuing aggressive rehabilitation post-operatively for patients with motion loss.

This study is not without limitations. The present retrospective review was underpowered to determine if a true difference between KD grades exists. This study was unable to detect any associations with complications and this may be due to the small sample size; if the KD grades were dichotomized to I vs III+ then this study would only have 0.14 power to detect a difference in complication rate between the two KD groups. Although immediate post-operative complications are reported, the effects on patient reported outcome measures or return to activity rates were not possible to determine. There is a paucity of literature that directly discusses the timing and frequency of immediate and delayed post-operative complications in a comprehensive manner. This study details the experience of multiple surgeons at one institution and discusses the prevalence of post-operative complications. Further prospective studies with larger numbers are warranted to evaluate post-operative complications after surgical treatment for a MLKI.

Conclusion

The main finding of this study was 48 (35.3%) patients sustained a complication after surgical treatment of MLKIs, with 99 (78.5% of all complications) complications

occurring at 1 week–3 months post-operation. Patients who had an external fixator placed at initial injury were more likely to sustain a post-operative complication. The most common post-operative complication was motion loss in 39 (28.6%) patients. The KD grade was not associated with overall prevalence of post-operative complications or post-operative development of motion loss. Additionally, all patients with post-operative motion loss at 3- and 6-month follow-up required MUA/LOA, highlighting that particular attention should be paid to range of motion if early motion loss is suspected. These findings allow the treating surgeon to counsel a patient regarding common immediate and delayed complications after surgical intervention for MLKI, irrespective of the KD grade.

Author contributions JDH: research design, data acquisition, processing, and interpretation; ADL: research design, data acquisition, processing, and interpretation; CNS: data analysis and interpretation; VM: research design and data interpretation; JJI: research design and interpretation of data. The paper was drafted by JDH, ADL, and CNS and critically revised by VM and JJI. All authors approve of the submitted manuscript.

Funding There is no funding source.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The Institutional Review Board provided a waiver of informed consent for retrospective review of existing clinical data.

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