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Low Energy Multiligament Knee Injuries Are Associated With Higher Post-Surgical Activity Scores Compared to High Energy Multiligament Knee Injuries: A Systematic Review and Meta-Analysis of the Literature

Running Title: Low Energy MLKIs Have Higher Activity Scores

ABSTRACT

Background: Multiligament knee injuries (MLKIs) can result from high energy injury mechanisms such as motor vehicle accidents or low energy injury mechanisms such as activities of daily living or sports.

Purpose/Hypothesis: To conduct a systematic review on postoperative patient reported outcomes following MLKIs, and to conduct a meta-analysis of comparable outcome variables based upon high versus low energy injury mechanisms. We hypothesized that MLKIs with low energy injury mechanisms would demonstrate significantly improved subjective clinical outcome scores compared to high energy injuries.

Study design: Meta-analysis and systematic review.

Methods: A systematic review was performed with inclusion criteria of postoperative MLKI outcomes based upon high versus low energy mechanisms of injury with a minimum 2-year follow-up. Outcome scores included were the Lysholm knee scoring scale, Tegner activity scale, and the International Knee Documentation Committee (IKDC) score. High energy mechanisms included motor vehicle accidents or falls from a height greater than five feet; low energy mechanisms included sports related injuries, activities of daily living, or falls from less than five feet. A meta-analysis was performed comparing the outcome scores of high versus low energy mechanisms of MLKIs.

Results: Overall, 1214 studies were identified, 15 of which were included in the systematic review and meta-analysis. Thirteen studies performed surgical reconstructions of all injured ligaments. A total of 641 patients with 275 high energy and 366 low energy injuries were grouped for comparisons in the meta-analysis. No significant differences in Lysholm scale (78.6 vs. 78.0) or IKDC scores (69.0 vs. 68.4) were found between high and low energy groups at a

minimum of 2 years (range, 2-10 years) postoperatively (p>0.05). The low energy injury group demonstrated significantly higher Tegner activity scale scores (3.9 vs 5.0, p=0.03). There was no significant difference in failure rates between groups (2.0% vs 3.5%, p>0.05).

Conclusion:

We found in this systematic review and meta-analysis that patients with low energy mechanisms of MLKI surgery had improved postoperative Tegner activity scores compared to those patients with high energy mechanisms following MLKI surgery. However, there were no differences in Lysholm score, IKDC score, or failure rates between high and low energy MLKI patients at an average of 5.3 years postoperatively.

Key words: multi-ligament knee injury, outcomes, knee trauma, knee dislocation

FOR PEER REVIEW:

What is known about the current topic: Multiligament knee injuries can be debilitating injuries with poor subjective patient outcomes scores pre-operatively and for those patients managed non-surgically. Surgical management of MLKI's is associated with improved subjective and objective clinical outcomes. Patient demographic variables and complexity of injury pattern likely play a significant role in the surgical outcomes of MLKIs. To date, there has not been a well-defined distinction between outcomes and activity levels between high and low velocity MLKIs.

What this study adds to the existing literature: This study reported that low energy mechanisms of MLKI are associated with higher Tegner activity scale scores than high energy mechanisms of MLKI, but that Lysholm score, IKDC score, patient reported outcomes and failure rates were similar.

Introduction

With devastating consequences and variable treatment recommendations, multiligament knee injuries (MLKI) are challenging conditions to manage.[2,7,8,30,34] Recent literature has demonstrated encouraging short to mid-term patient reported outcomes and objective radiographic results following single-stage surgical intervention of sports related MLKIs.[16] Patients have reported average Tegner activity scale scores of 6 and Lysholm scale scores of 90, with 90% of patients reported to be satisfied with their outcomes.[16] Although, other studies looking at sports related MLKIs in elite athletes have demonstrated low rates of return to play in comparison to other orthopedic surgeries.[3] Despite these studies, prognostic indicators for treatment success for MLKIs remain poorly understood.

Systematic reviews on the treatment of MLKIs have demonstrated that surgical intervention is favored over conservative management,[20,27] ligament reconstruction is superior to repair,[19,9] arthroscopic intervention is favored over open procedures,[25] and single-stage procedures are superior to staged surgeries.[10] Further, studies have demonstrated that early surgery leads to more favorable outcomes than delayed surgery,[13,29]and that early post-operative range of motion can help prevent arthrofibrosis and improve patient function.[17,22]

The etiology of MLKIs can be classified into either high energy injury mechanisms, such as motor vehicle accidents or falls from a substantial height, or low energy injury mechanisms, such as activities of daily living, injury during sport, and fall from lesser height. Based upon the current literature, the clinical significance of a high versus low velocity injury mechanism for MLKIs is not clearly defined. As such, the purpose of this study was to conduct a systematic review of literature on postoperative outcomes following MLKIs, and to conduct a meta-analysis of comparable outcome variables based upon high versus low energy injury mechanisms. We

hypothesized that low energy MLKI mechanisms would demonstrate significantly improved subjective clinical outcomes and activity scores compared to high energy MLKIs.

Methods:

A systematic review of articles was completed using the PRISMA (Preferred Reporting Items for Systemic Meta-Analyses)[28] guidelines on the outcomes following surgical management of multiligament knee injuries using PubMed (2000-2019); the query was performed in July 2019 (Figure 1). Registration of this systematic review was performed in August 2019 using PROSPERO international prospective register of systematic reviews (ID#: 145707). The specific search terms utilized were “knee dislocation outcome” OR “multiligament knee injury” AND “outcome” OR “surgery”.

The inclusion criteria for studies in both the systematic review and meta-analysis consisted of the following: English language studies, studies that either describe the mechanisms of injury or categorize patients into high and low energy mechanisms of injury. Studies that treated injuries operatively, included patient reported outcomes data with a minimum two-year follow-up, had two or more knee ligaments treated operatively and studies that were published during or after the year 2000 were included in the current analysis. Exclusion criteria were no discernable mechanism of injury, study published before 2000, case studies (level V evidence), failure to report outcomes scores at a minimum 2-year follow-up, open dislocations, and concomitant lower extremity fracture. Two investigators (*R.S.D.*, *D.H.K.*) independently reviewed the abstracts from all identified articles. If necessary, full-text articles were obtained for review to allow further application of the established inclusion and exclusion criteria. Additionally, reference lists from the included studies were reviewed and reconciled to verify that all eligible articles were considered. Studies that failed to list the specific mechanisms of

injury, or failed to group patients by the energy of mechanism of injury, were contacted for the details regarding this information. All studies that responded to this inquiry were included in the final analysis.[11,16,19]

Data Extraction for Meta-analysis

The variables of interest that were extracted from each study included descriptive article information, patient demographics, mechanism of injury, surgical technique, chronicity of surgical intervention, concomitant injuries, patient reported outcome variables (Lysholm knee scale, Tegner activity score, and International Knee Documentation Committee (IKDC) score, follow-up duration, and complications.

Patients were grouped into high and low energy mechanism of injury cohorts. This grouping was extracted from each study when provided,[2,16,34,35] or by the current authors when a single study contained patients that fell into both cohorts.[4,7,11,14,15,18,19,24,26,32,33] When the current authors were forced to categorize the studies, high energy mechanisms were defined as motor vehicle accidents, fall from height greater than 5 feet, and industrial accidents. Low energy mechanisms included injury from sports, fall from heights less than 5 feet, or activities of daily living. Surgical technique was grouped into either repair or reconstruction cohorts. Demographic variables, concomitant injuries, and perioperative complications were not evaluated in the meta-analysis aspect of the current study because few studies separated these variables based upon injury mechanism, but rather previous studies reported these variables based on their study populations as a collective unit.

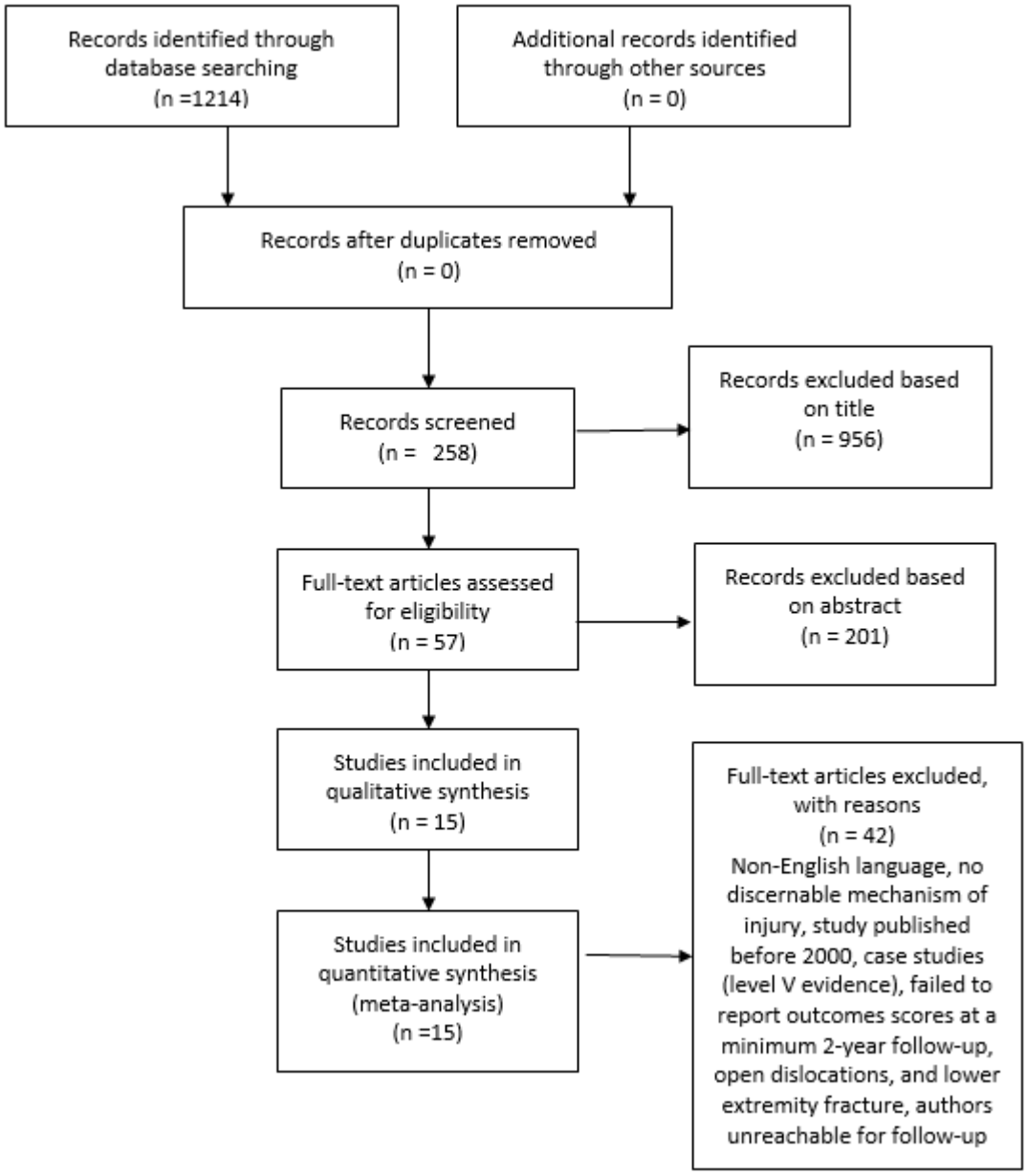
Statistical Analysis

We extracted and pooled outcomes of interest and related standard error using DerSimonian & Laird random effect models.[6] The difference between HE and LE was conducted using the Altman interaction test.[1] Two tailed p-values < 0.05 were determined as statistically significant. All statistical analyses were conducted using Stata version 15.1 (Stata Corp LLP, College Station, TX).

Risk of Bias Evaluation

The Methodological Index for Non-Randomized Studies (MINORS) checklist was used to evaluate the non-randomized surgical studies included (Table I)[31] The index includes 12 questions to assess quality, 4 of which are only applicable for those studies that are comparative. These 4 questions were utilized for the comparative studies included in this analysis. Each of the 12 items was scored 0 to 2; 0, not reported; 1, was reported but reported or performed poorly or inadequately; 2, reported accurately and well described. Higher scores are associated with a lower risk of bias. For non-comparative studies the maximum score was 16, while the maximum score for comparative studies was 24. Two independent reviewers (*R.S.D., D.H.K.*) assessed each study for the risk of bias and discussed when discrepancies were found.

Figure 1. PRISMA flowchart demonstrating article selection process.



Results:

The literature search identified 1214 studies, of which 15 were included in the systematic review and final meta-analysis (Table 1).Three studies reported on patients who suffered only low energy injuries,[2,16,34] one study reported on patients who suffered only high energy injuries,[35] and eleven studies reported on a combination of both cohorts.[4,7,11,14,15,19,21,24,26,32,33] In total, the studies included 641 patients, 275 with high energy injuries and 366 with low energy injury mechanisms. The average age range of included patients was 17.7 to 47 years. All but one study[33] reported on concomitant peroneal nerve injuries. The most common mechanisms of injury in the low energy injury group were sports related activities (n=291, 79.5%) and activities of daily living (n=35, 9.6%). The most common mechanisms of injury in the high energy injury group were motor vehicle accidents (n=187, 68%) and falls from height greater than 5 feet (n=5, 1.8%) (Table 1). All but two studies performed surgical reconstructions of all injured ligaments.[2,4,7,11,15,16,19,21,25,26,32–35]

In fourteen studies, the overall range of reported common peroneal nerve injury incidence was 0 – 22%.[2,4,7,11,15,16,19,21,24,26,32–35] One study[14] reported that 12 out of 17 patients (70.5%) displayed common peroneal nerve injuries—7 patients had partial sensory loss, 5 patients had both partial sensory and motor loss, and 1 patient had complete sensory and motor loss. Nine studies reported on concomitant meniscal pathology identified intraoperatively.[4,7,11,14,16,21,32,33,35] Eight of these nine studies reported a prevalence that ranged from 28.2 to 66.7%. One study reported meniscal tears in 15 of 17 (88%) patients.[14]

Thirteen studies reported to have performed a reconstruction of all torn ligaments, while one study reported on ligament repairs of all injured ligaments[13] and another reported on repair versus reconstruction of the FCL and PLC.[19]

Table 1: Demographics and Injury Details of Included Studies													
Authors (Year)	HE/LE	Number of Subjects	Mechanism Details and number of patients	Avg. age (SD)	Gender	Surgery Technique	Concomitant Injury			Time between injury and surgery	Average time (in years) between surgery and final follow-up (SD) or range	Post-op Complications
							Peroneal Nerve Injury	Vascular Injury	Other			
Woodmass et al. (2018)[35]	HE	31	MVA = 28 Horse trampling = 1 FFH = 1 Industrial accident= 1	34 (range 18-52)	M = 21 F = 10	Reconstruction (n = 20 single staged, n = 11 staged)	4	4	11 meniscus (6 Lat, 2 Med, 3 both), MPFL x 2, chondral lesions 9	n = 6, < 3 weeks, n = 25 ≥ 3 weeks	5.58 (range 2-18.3)	3 infections, 4 cases of arthrofibrosis, 1 failed surgery requiring revision,
Engebretsen et al. (2009)[7]	HE	43	MVA = 27 Other = 18	38 (11)	M = 48 F = 37 (2 patients were lost to follow-up)	Reconstruction	18	5	22 Chondral lesion, 24 Meniscus tears (13Med, 7Lat, 4 both), 5 patellar dislocations, 2 patellar tendon ruptures, 12 fractures of either tibia or fibula	14 months (SD = 37)	5 (2)	5 cases of arthrofibrosis, 4 cases of infection, 3 DVT
	LE	40	Sport related = 27 Other = 13	47 (14)								
Hua et al (2016).[14]	HE	16 (17 knees)	MVA = 14 FFH = 2	40.06 (10.03)	M = 9 F = 7	Single stage in-situ repair	12	Excluded vascular injuries requiring acute OR fix	15 meniscus tears, 2 tibial plateau fractures,	5-10 days	4.74 (1.18)	1 infection, 1 case of fat liquefaction, 3 cases of arthrofibrosis, 2 cases of heterotopic bone formation
	LE	1	Football = 1	19	M = 1						6.3	0
Bin et al. (2007)[4]	HE	12 (13 knees)	MVA = 12	31.583 (10.77)	M = 10 F = 2	2-staged reconstruction	0	Excluded vascular injuries requiring acute OR fix	5 meniscus tears, 1 sacral fracture, 1 C6 fracture	<2 weeks	7.41 (1.82)	3 patients required arthroscopic LOA
	LE	2	FFS = 1 Sport = 1	29 (1)	M = 2						6.625 (1.29)	

LE: Low Energy Mechanism of Injury
HE: High Energy Mechanism of Injury
MVA: Motor Vehicle Accident
FFH: Fall from height >5 feet
LOA: Lysis of Adhesions
DVT: Deep Vein Thrombosis, PE: Pulmonary Embolism
LARS: Ligament Advanced Reinforcement System
FFS: Fall from standing, height <5 feet
M: Male, F: Female
OR: Operating Room
Med: Medial Meniscus, Lat: Lateral Meniscus
OA: Osteoarthritis
DNR: Does Not Report
FCL: Fibular Collateral Ligament, PLC: Posterolateral Corner

Helito et al. (2019)[24]	HE	4	MVA = 3, FFH=1	31.5 (7.30)	M = 4	Medical opening-wedge osteotomy combined with PLC reconstruction-single stage	1	0	DNR	44 months (7.04)	2.44 (.56)	1 post-operative infection
	LE	1	Sports related = 1	23 (0)	F = 1					40 months (0)	2.5 (0)	
Godin et al. (2017)[11]	HE	2	MVA = 2	17.7 (14-19)	M = 14 F=6	Reconstruction	1	0	7 chondral defects, 10 meniscus injuries (2 Med, 6Lat, 2 both)	34.6 weeks (1 day – 3 years)	3.09 (2-5.58)	2 graft failures
	LE	18	Sport related = 18									
Tao et al. (2013)[33]	HE	4	MVA = 4	39.5 (4.15)	M = 2 F=2	Single stage reconstruction using ligament advanced reinforcement system (LARS)	Nerve injury was exclusion criteria	Vascular injury was exclusion criteria	3 meniscus tears (1Med , 1Lat, 1 both)	15 days (4.41)	2.42 (.87)	0
	LE	5	Sport related = 4, FFS = 1	26.2 (5.49)	M = 4, F = 1				3 meniscus tears (1Med, 1Lat, 1 both)	8.6 days (1.62)	2.7 (0.36)	1 superficial post-operative infection
Khakha et al. (2013)[15]	HE	23	MVA = 23	36.5	M = 33 F=3	Reconstruction	4	3	DNR	11.39 days (6.45)	10.1 (7-19)	1 patient developed mild arthrofibrosis
	LE	13	Sport related = 11, Assault = 1, FFS=1				4	1	DNR	11.08 days (6.62)		
Sundararajan et al. (2018)[32]	HE	36	MVA = 33, high impact collision during sports = 3	39 (17-74)	M = 39 F=6	Single stage reconstruction	2	Vascular injuries were exclusion criteria	15 meniscus injuries, 6 MPFL injuries, 2 patella dislocations, 7 cartilage injuries	35 patients $\leq$ 6 weeks, 5 patients between 6-12 weeks, 5 patients $\geq$ 12 weeks.	3 (2-6)	2 patients had post-operative stiffness, 1 patient developed infection
	LE	9	FFS = 2, Fall from stairs= 7									
Ranger et al. (2011)[26]	HE	48	DNR	38.5 (13.4)	M=57 F=14	LARS reconstruction	13	9	DNR	10.8 days (8)	4.5 (1.66)	14 cases of arthrolysis, 15 cases of heterotopic bone formation, 2 ACL revisions, 1 screw removal, 1 infection
	LE	23										
Moatshe et al. (2017)[21]	HE	34	MVA = 20, Other= 14	36 (13.4)	M = 36 F=29	Reconstruction	15	5	25 meniscus injuries, 25 articular cartilage injuries	For patients with acute injuries	13.1 (10-18.8)	27 developed OA

Moatshe et al. (2017)[21]	LE	31	Sports related = 31							= 10 days, Chronic injuries = 279 days		
Werner et al. (2014)[34]	LE	17	FFS = 17	35.7	M = 7 F= 16 6 lost to follow-up	Reconstruction	9	6	DNR	9.4 days	5.8 (2-12)	2 converted to total knee arthroplasty, 5 cases of stiffness, 2 DVT, 1 PE, 4 infections, 2 graft failures
Azar et al. (2011)[2]	LE	6	FFS = 6	23.8 (6.33)	M = 2 F= 4	Reconstruction	2	1	None	DNR	1.98 (1.30)	1 graft failure
LaPrade et al. (2019)[16]	LE	194	Sports related activity = 194	34.5 (13.6 – 69.6)	M = 111 F = 83	Single stage reconstruction	4	0	59 chondral defects, 107 meniscus injuries	15 days (1-522)	3.5 (1.3, range 2-8)	9 graft failures, 18 cases of arthrofibrosis, 3 DVT, 3 hardware migration, 2 hardware pain, 1 infection, 1 pneumonia
Levy et al. (2010)[19]	HE	22	MVA: 21 FFH: 1	35.0 (10.7)	M=18 F=4	10 FCL/PLC repairs, 12 FCL/PLC reconstructions; all cruciate reconstructions	0	0	0	77 ± 88 days	2.83 (range, 2-4.1)	5 graft failure, 1 arthrofibrosis
	LE	6	Sport= 5 Altercation= 1	25.8 (4.36)	M=5 F=1					157 ± 282.2 days		

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M: Male, F: Female
OR: Operating Room
Med: Medial Meniscus, Lat: Lateral Meniscus
OA: Osteoarthritis
DNR: Does Not Report
FCL: Fibular Collateral Ligament, PLC: Posterolateral Corner

Outcomes:

All studies included in the current analysis reported patient outcomes data at a minimum of 2 years post-operation (mean 5.32 years; range, 2.0-10.1 years). The post-operative outcome scores considered were IKDC (range, 40.2-81.8), Lysholm scale score (range, 42.2-90.0), and Tegner activity scale (range, 2.83-6.00). Seventeen patients (n=1 study)[14] underwent ligament repairs for all torn ligaments, 10 patients had lateral collateral ligament repairs with cruciate reconstructions (n=1 study)[18], and the remaining 614 patients (n=14 studies)[2,4,7,11,15,16,19,21,24,26,32–35] underwent ligament reconstructions of all torn ligaments. The average age of the low energy cohort ranged from 19-47 years,[7,14], and the average age of the high energy cohort ranged from 31.5-40.1 years.[14,24] There were 199 (72.5%) males in the low energy cohort and 221 (60.4%) males in the high energy population.

The meta-analysis concluded that low energy (n=366) injury mechanisms were associated with significantly improved Tegner activity scale scores (mean: 5.0, 95% CI: 4.18-5.82) compared to high energy (n=275) injury mechanisms (mean: 3.9, 95% CI: 3.3-4.5) (p=0.03). The two cohorts were not significantly different in either the Lysholm scale (low energy: 77.9, 95% CI: 66.6-89.3; high energy: 78.6, 95% CI: 69.2-87.3; p=0.93) or IKDC (low energy: 68.4, 95% CI: 58.0-78.7; high energy: 69.0, 95% CI 63.0-74.9; p=0.92) patient reported outcome scores. Failure rates between the two mechanism of energy cohorts was not significantly different (low energy, 3.5%; high energy, 2.0%; p=0.23).

Complications:

All but one study[2] reported on complications. The average complication rate ranged from 2.7-46.5% in all but one study.[4,7,11,14,15,16,19,21,24,26,32,33,35] Ranges of the following knee related complication rates were reported: arthrofibrosis (0-19.7%)[26], superficial infection (0-20.0%)[24],

heterotrophic bone formation (0-21.1%)[26], graft failure (0-17.9%)[19], deep vein thrombosis (0-3.6%)[7], and hardware complications (0-2.78%)[16]. However, in one study which considered ultra-low velocity MLKIs, a 73.9% complication rate was reported, 29.4% of patients developed arthrofibrosis, 23.5% developed a superficial infection, 11.8% suffered graft failure, and 11% required a total knee arthroplasty.[34] Additionally, one study reported that 42% of patients developed osteoarthritis at 10-year follow-up.[21]

Risk of Bias

The results of the risk of bias assessment using MINORS checklist can be found in Table 3.

There were 12 non-comparative studies and 3 comparative studies.

1

Table 3: Quality Assessment Using Methodological Index for Non-Randomized Studies (MINORS)													
	Clearly Stated Aim	Consecutive Patients	Prospective Data Collection	End Points Appropriate to Aim of Study	Unbiased Assessment of End Points	Follow-Up Appropriate to Aim	<5% Lost to Follow-Up	Prospective Calculation of Study Size	Adequate Control Group	Contemporary Groups	Baseline Equivalence of Groups	Adequate Statistical Analysis	Total
Woodmass et al. (2018)[35]	2	2	2	2	2	2	2	2	2	2	1	2	23 (95.8%)
Sundarajan et al. (2018)[32]	2	1	2	2	2	2	1	1	1	2	1	2	19 (79.2%)
Levy et al. (2010)[19]	2	2	2	2	2	2	2	1	1	2	1	2	21 (87.5%)
Engebretsen et al. (2009)[7]	2	2	2	2	2	2	2	1	N/A	N/A	N/A	N/A	15 (93.8%)
Hua et al. (2016)[14]	2	2	2	2	2	2	0	1	N/A	N/A	N/A	N/A	13 (81.3%)
Bin et al. (2007)[3]	2	1	2	2	2	2	2	1	N/A	N/A	N/A	N/A	14 (87.5%)
Helito et al. (2019)[24]	2	1	2	2	2	2	2	1	N/A	N/A	N/A	N/A	14 (87.5%)
Godin et al. (2017)[11]	2	2	2	2	2	2	2	1	N/A	N/A	N/A	N/A	15 (93.8%)
Tao et al. (2013)[33]	2	2	2	2	2	2	0	1	N/A	N/A	N/A	N/A	13 (81.3%)
Khakha et al. (2013)[15]	2	2	2	2	2	2	0	1	N/A	N/A	N/A	N/A	13 (81.3%)
Ranger et al. (2011)[26]	2	1	0	2	2	2	0	1	N/A	N/A	N/A	N/A	10 (62.5%)
Moatshe et al. (2017)[21]	2	1	2	2	2	2	2	1	N/A	N/A	N/A	N/A	14 (87.5%)
Werner et al. (2014)[35]	2	2	1	2	2	2	0	1	N/A	N/A	N/A	N/A	12 (75.0%)
Azar et al. (2011)[2]	2	1	0	2	2	2	0	1	N/A	N/A	N/A	N/A	10 (62.5%)
LaPrade et al. (2019)[16]	2	2	1	2	2	2	2	1	N/A	N/A	N/A	N/A	14 (87.5%)

N/A: Not applicable. Studies were not comparative studies.
0: not reported
1: reported, but inadequate
2: reported and adequate

2

Discussion

The most important finding of this systematic review and meta-analysis was that patients with low energy mechanisms of MLKI surgery were associated with significantly higher postoperative Tegner activity scale scores compared to high energy mechanisms following MLKI surgery. Contrary to our hypothesis, there was no significant difference in the other subjective clinical outcomes or failure rates between energy mechanism of injury cohorts. In addition, rates of postoperative arthrofibrosis were high. This systematic review and meta-analysis demonstrates that low energy injury mechanisms are associated with return to higher activity levels at an average of 5.3 years following MLKI surgery.

In the current analysis, patients in the low energy injury cohort had significantly greater mid- to long-term post-operative Tegner activity scale scores compared to the high energy injury group (5.0 vs 3.9). Briggs et al.[5] determined that the minimal detectable change in the Tegner activity scale score is 1 point for knee ligament injuries, suggesting that the calculated difference between cohorts within the current analysis (1.1) is clinically significant.[5] This conclusion is different than those provided by smaller independent case series, which had previously suggested that the energy of the mechanism of injury was not clinically significant with respect to subjective clinical outcomes or reported activity levels.[7,26] In the current meta-analysis, 79.5% of subjects in the low energy MLKI cohort had sports related injury mechanisms, ultimately suggesting that sports related knee injuries may be associated with significantly better outcomes when compared to high energy injury mechanisms. However, we acknowledge the patient reported outcome measures and return to play are clearly two different ways to evaluate these individuals. A prior study that considered NFL players that underwent surgery for MLKIs reported a 64% rate of return to play in the NFL and even lower rates of return to prior level of

production.[3] This level was significantly lower than levels seen after ACL reconstruction and was dependent on the specific ligament injury patterns involved.[3] We also acknowledge that it is possible that patients with a low energy MLKI had higher preinjury activity levels or an increased expectation to return to higher levels of activity which may explain the finding of higher postoperative activity levels in low energy MLKI patients. Additionally, many of the included high energy MLKIs were from motor vehicle accidents or workplace injuries that may involve pending litigation or workers compensation claims. These types of injuries have historically been associated with a greater number of unsatisfactory outcomes and relatively worse clinical outcomes.[12,23]

It was surprising that there were no differences in Lysholm and IKDC scores between groups of high and low energy MLKIs. We theorize that multiple factors could contribute to this. First, it seems that the additional trauma to the soft tissue envelop surrounding the knee from a high velocity injury may not have had consequences on the patient reported subjective outcomes. If this is true, it is encouraging that in the treatment of these complex pathologies the additional soft tissue injury has no discernable long-term complications. In addition, it is possible that the additional trauma from a MLKI surgery supersedes the original mechanism of injury trauma-no matter if it was a high or low velocity MLKI. This latter point would imply that further refinements and less invasive surgical techniques may be worth pursuing. Finally, it is possible that the patient reported subjective outcome scores considered in the current analysis are not representative of MLKI outcomes. Future studies should be conducted to evaluate the representative value of IKDC, Lysholm, and Tegner activity scale scores at evaluating MLKI outcomes, specifically.

We acknowledge that this systematic review has some limitations. First, several of the studies included in the final analysis did not delineate individual demographic factors (i.e. gender, BMI, age, or preinjury activity levels, workers compensation) into groups based upon injury mechanisms and thus the current analysis was unable to consider these factors. Additionally, many studies available in the literature did not describe the mechanisms of injury for multiligament knee injury outcomes analysis. Thus, it can be difficult to categorize patients into high and low energy mechanism of injury cohorts and some MLKI studies were not included for this reason. Finally, many of the included studies and the current analysis itself excluded significant vascular injuries and open knee dislocations. As these injuries tend to occur more commonly in the high energy injury settings, and also have additional complications associated with poorer outcomes, the conclusions of the current analysis may actually be an underestimation of the true difference in outcomes based upon the energy of the mechanism of injury. The primary strengths of the current analysis are in the relatively consistent reporting of patient reported outcome scores and in the similar reporting of mid- to long-term outcomes that were provided by each study. These factors allowed the included studies to be appropriately combined to develop a reliable and informative, large scale meta-analysis.

Conclusions:

We found in this systematic review and meta-analysis that patients with low energy mechanisms of MLKI surgery had improved postoperative Tegner activity scores compared to those patients with high energy mechanisms following MLKI surgery. However, there were no differences in Lysholm scores, IKDC score, or failure rates between high and low energy MLKI patients at an average of 5.3 years postoperatively.

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