Review Article

Management of the multi-ligamentous injured knee: an evidence-based review

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Abstract: Multi-ligamentous knee injury (MLKI) can be a devastating injury, resulting in long-term knee instability and loss of function. For patients with MLKI, areas of controversy persist on how to best optimize outcomes. These areas of contention are often centered operative timing and technique with the aims of restoring patient function, knee range of motion, and stability. Currently, a paucity of studies exists that can be used to direct orthopedists on how to manage MLKI patients. This review critically analyzes literature in attempts to equip readers with best options for managing patients with MLKI.

Keywords: Multi-ligamentous knee injury (MLKI); knee dislocation; management

Received: 15 December 2018; Accepted: 22 February 2019; Published: 21 March 2019.
doi: 10.21037/aoj.2019.02.06
View this article at: http://dx.doi.org/10.21037/aoj.2019.02.06

Introduction

Multi-ligamentous knee injury (MLKI) is a rare but serious injury of the knee and is defined as involving at least two of the four main knee ligaments: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), posteromedial corner (PMC) including the medial collateral ligament (MCL), and posterolateral corner (PLC) including the lateral collateral ligament (LCL). Mechanisms of injury often involve acute knee dislocation secondary to high velocity trauma (i.e., motor vehicle accident) but can also be secondary to low -velocity injury that arise from sporting events (1). Early care management involves critical assessment of soft tissue integrity and patient neurovascular status as both peroneal nerve and popliteal artery are at risk. Early knee reduction is important as to best relieve tension stress on neurovascular structures.

Subacute management options for MLKIs vary and are often based on severity of injury with considerations given to patient expectation (2). Earlier treatment modalities hinged on non-operative management with immobilization and casting. However, this modality quickly fell out of favor as multiple reports demonstrated poor functional outcomes (3,4). As such, non-operative indications are limited, with most patients requiring and undergoing operation. However, areas of contention exist amongst sports and trauma orthopedists on how best optimize these patient groups. Current areas of contention include pre-operative and operative management, and post-operative rehabilitation as to best restore function and articular mobility and strength (4).

The purpose of this review is to explore these current areas of contention and help facilitate the decision-making process for orthopedists caring for patients with MLKI. More specifically, this review will examine current literature on areas associated with operative management of patients

suffering from MLKI.

Conservative management

The indications for non-operative management are few, as most patients will require surgical management barring comorbidities that preclude surgery. Current indications are patients with low-functional demand, severe polytrauma, significant head injury, and extensive soft tissue damage above the knee (5). Nonetheless, outcomes can be optimized for patients undergoing conservative management, although this is not expected to mirror results obtained from surgery. Important points to consider are an expeditious closed reduction after knee dislocation with care taken to avoid the popliteal fossa as to not compromise arterial flow. After reduction, the knee should be immobilized in 15 to 20 degrees of flexion with a subsequent arteriogram conducted to assess vascular compromise. It is important to note that the use of doppler ultrasound has been controversial due to occult intimal thrombosis in the presence of normal pulses (6). Magnetic resonance imaging can be conducted one week after initial injury to assess for ligamentous damage. Rehabilitation should entail range of motion exercises that emphasizes extension (7). Isometric exercises should be conducted to strengthen quadriceps and hamstring muscles.

Still, the literature demonstrates inferior outcomes with non-operative management when compared to operative management. Dedmond and Almekinders 2001 performed a meta-analysis encompassing treatment of 206 knee dislocations, 132 treated operatively and 74 conservatively. The analysis supported superiority of operative treatment with statistically higher Lysholm scores and ROM relative to conservative management. However there was no statistical difference found in ability to return to sport or pre-injury employment (8). A systematic review by Levy *et al.* 2009 which included the meta-analysis of Dedmond and Almekinders in addition to three retrospective cohort analyses comparing operative and conservative management of MLKI also lends support to the former. It was found that patients receiving operative treatment did return to work (72% *vs.* 52%) and sport (29% *vs.* 10%) at higher rates. Operative treatment additionally yielded higher Lysholm scores (80 *vs.* 57) and International Knee Documentation Committee (IKDC) scores (58 *vs.* 20). However difference in postoperative ROM between the groups was negligible (1). Peskun and Whelan 2011 performed an evidence-based review of 31 studies (916 patients) evaluating operative or non-operative management of MLKI. The authors found that patients treated operatively showed significantly higher Lysholm scores, and rate of return to work and sport. However no statistically significant differences were found between IKDC and Tenger scores, and in ROM (2). It should be noted that the methodological quality of studies included in this review were poor overall. Only 4 studies directly compared operative and conservative management, and only 61 patients out of the 916 were treated operatively. More recently Everhart *et al.* 2018 performed a systematic review of 21 studies (524 patients) to investigate rates of return to work and sport after MLKI. Rate of return to work and sport was practically and statistically more significant in patients treated operatively. In studies where all patients were treated operatively 59% returned to sport and 79% returned to work with minimal restriction, while in studies including a mix of operative and non-operative treatment only 46% returned to sport and 65% returned to work with minimal restriction (9).

In conclusion, indications for non-operative management are few as most patients who are able to endure surgery and rehabilitation should undergo operative treatment. Early reduction, followed by rehabilitation focused on optimizing range of motion and muscle strength yields the best outcomes.

Optimal operative management

Most orthopaedic surgeons would recommend surgical treatment of MLKI in absence of significant contraindications, and, as discussed, the literature lends some support to this (10). The optimal course of operative management however is another source of controversy. There are a variety of surgical techniques and protocols employed to treat MLKI. Broadly they can be categorized as either suture repair, or reconstruction using autograft, allograft, or synthetic ligament. Ligamentous repair is usually performed during the acute injury phase, typically defined as <3 weeks after injury, since tissue planes are more easily identified and are of sufficient integrity to allow re-approximation without retraction and holding of sutures (11). Reconstruction is performed during either the acute phase or the chronic phase, which is usually defined as any time point after the 3-week acute period. Different structures in a given MLKI may be treated with repair or reconstruction, or with different timing, using a staged surgical protocol. Surgeons may also elect to treat some

structures conservatively performing neither a repair nor a reconstruction. There are additionally different techniques for ligamentous reconstruction varying, among other qualities, in choice of graft, and method of graft fixation.

This heterogeneity in operative strategies combined with rapid evolution of surgical technique, and rarity and heterogeneity of MLKI, makes it exceedingly difficult to systematically study and develop an evidence-based standard of operative care for MLKI. There are indeed conflicting reports of, and a lack of high-quality studies investigating optimal operative strategy. Despite paucity of evidence however it would be logical to assume that there is no "one-size-fits-all" approach to the surgical management of MLKI. Each strategy—acute repair, acute reconstruction, chronic reconstruction, and conservative management—may have utility in a certain context.

Utility of acute repair

Several studies have evaluated outcomes after acute ligamentous repair in MLKI. In retrospective analyses both Owens *et al.* and more recently Hua *et al.* reported satisfactory outcomes with direct repair of all structures in MLKI (5,12). Most studies evaluating surgical treatments for MLKI vary in which structures were treated by repair or reconstruction. In general, it appears that most surgeons strongly prefer reconstruction to repair for cruciate injuries. While repair is more often used for the corners and the collateral ligaments, opinions seem mixed as to whether this is superior to reconstruction. Of note it appears that some variety of acute repair is consistently used for avulsion fractures.

Although repair of mid-substance tears of the cruciate in MLKI appears uncommon, it has been reported to produce successful outcomes, as aforementioned by both Owens *et al.* and Hua *et al.* However, these studies are not comparative. Mariani *et al.* retrospectively compared three surgical procedures for acute knee dislocation in 23 patients which included (I) direct repair of both cruciate ligaments, (II) ACL reconstruction and PCL reattachment, and (III) reconstruction of both cruciates. It was found that reconstruction of both cruciates resulted in better stability, ROM, and return to pre-injury activity levels. However no significant differences were found in Lysholm score and IKDC score (13).

Historically repair of the corners and collateral ligaments has been advocated as they are thought to have high healing capacity (1). Several studies have reported success with acute repair of these structures (5,12,14-24). Comparative studies however suggest that reconstruction may be a superior approach for lateral structures. In a prospective cohort study Stannard *et al.* found a statistically significantly higher rate of failure for repair compared to reconstruction of the PLC [37% (13/35) *vs.* 9% (2/22)] (25). A retrospective cohort study by Levy *et al.* also found that repair of the LCL and PLC failed at a statistically significant greater rate compared to reconstruction [40% (4/10) *vs.* 6% (1/18)] (26). Two systematic reviews have also been published evaluating outcomes after surgical treatment in combined injury to the PLC and at least one of the cruciates. Both found some evidence that combined reconstruction of the cruciates with the PLC resulted in superior outcomes compared to when the PLC was repaired (27,28). More recent comparative studies however have not found strong superiority of reconstruction of the PLC. A retrospective cohort study McCarthy *et al.* found no statistically significant difference in outcomes when the PLC was treated with repair or reconstruction, with low rates of failure in both groups (29). A prospective cohort study by Westermann *et al.* similarly found no significant difference for PLC repair or reconstruction (30).

There are conflicting reports as to whether repair or reconstruction is optimal for MCL and PMC injuries in MLKI. A retrospective cohort study by Stannard *et al.* found that repairs of the PMC had a statistically significant greater rate of failure [20% (5/25) *vs.* 4% (2/48)] (31). More recently, in a retrospective cohort study King *et al.* found that reconstruction of all medial side structures resulted in significantly improved outcomes relative to repair (32). Conversely a recent systematic review by DeLong *et al.* found evidence that repair was an effective strategy for both the PMC and MCL (33). Other reports have focused on MCL injury only in the context of MLKI, including a systematic review by Kovachevich *et al.* which found no substantial difference in outcomes between MCL repair and reconstruction (34). Similarly a retrospective study by Dong *et al.* found no difference between MCL repair and reconstruction in patients who had a concomitant ACL tear reconstruction (35). In another retrospective analysis Hanley *et al.* found that MCL repair in MLKI actually resulted in higher patient reported outcomes relative to MCL reconstruction (15).

Timing of reconstruction

Reconstructive techniques for ligamentous injury have

become popular in recent years, and there are a number of reports of good outcomes when reconstructive techniques are at least partially used to treat MLKI (3,17-19,21,22,25,26,31,32,36-46). However, the optimal timing of reconstruction is controversial, whether early within 3 weeks of injury, delayed, or with a staged surgical protocol. Proponents of early reconstruction report better clinical and functional outcomes, and reduced risk of deformity, and future chondral and meniscal injuries (10,47). Others advocate for delayed reconstruction to allow for resolution of swelling and natural healing of capsular and ligamentous structures, which may reduce risk of stiffness and arthrofibrosis (47).

Hohmann *et al.* performed a meta-analysis of 8 studies (260 patients) published between 1999 and 2014, similarly finding that early intervention produced significantly superior outcomes (47). Other reviews have reported alternative findings however. Mook *et al.* performed a systematic review of the literature up to 2008 and analyzed the results of 24 retrospective studies (396 knees) evaluating outcomes after either early, delayed, or staged surgery for MLKI. It was found that early surgery was associated greater stiffness and equivalent stability compared to delayed surgery, and that staged surgery yielded the best patient reported outcomes (48). Jiang *et al.* systematically reviewed the literature up to 2014 and selected 12 studies which evaluated various operative timing protocols. Uniquely they attempted to account for the heterogeneity of MLKI by only analyzing outcomes after surgery for KD-III injuries (153 knees). It was found that staged treatment yielded the best outcomes in these patients, with no significant differences found between acute and chronically treated groups. It should be noted that most of the studies included in these reviews employed some form of repair in surgeries that included an early intervention (49). Not included in these aforementioned reviews was a recent retrospective study by Tardy *et al.*, which compared one-stage early and delayed interventions for MLKI in 39 patients. It was found that early surgery yielded superior outcomes, regardless of injury characteristics (24).

Developing evidence-based guidelines

The most confident conclusion that can be made after careful analysis of the literature is that optimal operative strategy is most likely closely dependent on injury characteristics. It appears that acute repair has utility in treating avulsion fractures. Acute repair may also be a suitable strategy for injuries to the corners and collateral ligaments, however this not certain considering higher rates of failure of repair *vs.* reconstruction found for both the PLC and PMC in comparative studies (25,26,31). Although it appears that reconstruction may be optimal for cruciate injury, and is certainly preferred in practice, no high-level evidence exists to conclude this with certainty. It should also be noted that the literature may underestimate the efficacy of modern reconstructive techniques as they have rapidly evolved in recent years. Comparisons of repair *vs.* reconstruction are in general complicated by this evolution of reconstructive techniques as well as the variety of different techniques that are now available.

Optimal operative timing also likely depends on injury characteristics however how so is not clear. There appears to be more evidence supporting early or staged intervention. This may reflect the fact that the surgeon has more flexibility in the techniques he can use if an acute intervention is incorporated. In most evaluations of early or staged interventions, repair was utilized in the acute phase, which is suggestive of its utility, and circles back to the debate of which structures if any are more amenable to repair *vs.* reconstruction. There are conflicting reports however with others suggest a superiority of delayed surgery. The benefit of delayed reconstruction may furthermore be underestimated due to selection bias, since surgery is more often delayed in patients with more serious injuries as they cannot tolerate acute surgery (1).

The most notable characteristic of the body of evidence concerning operative management of MLKI is a marked lack of high-quality data. The literature primarily consists of retrospective case series with small sample sizes. Very few prospective and/or comparative studies of different surgical treatments for MLKI have been published. Comparative studies were also characterized by small sample size. Moreover, these were not randomized and most involved a population that was highly heterogeneous in both injury and patient characteristics, creating high potential for selection bias. Both within and across all studies there is a high degree of variability with respect to patient and injury characteristics, operative techniques, rehabilitation protocol, and evaluation of outcomes, which limits the ability to systematically review and draw conclusions from them.

Conclusions

Evidence and experience suggest that operative management or is superior to conservative management

for treatment of MLKI in most cases. However, it should be noted that the evidence basis for this conclusion is not particularly strong, and more work should be done to clarify when conservative management might be a preferable strategy. The optimal course of operative management for MLKI however is not clear. Most likely it closely depends on individual patient and injury characteristics, but how so exactly is not certain. There is evidence that acute repair, acute reconstruction, and delayed reconstruction are useful tools in certain contexts, but it is not clear when exactly each should be used. Substantial work needs to be done to develop evidence-based guidelines for surgical management of MLKI. Most importantly studies need to be carried out on populations that are homogeneous with respect to their patient and injury characteristics. Ideally such studies would also be comparative, prospective, and randomized. However as aforementioned systematically studying MLKI is exceedingly difficult due to its rarity. Retrospective comparative studies on highly homogenous patient populations would perhaps be most feasible and would be a significant step in the right direction. It is also important that outcomes are reported in a more standardized way so that results can be more easily compared. Finally, although not discussed in this review, the importance of rehabilitation and its effect on outcomes should not be underestimated. More work needs to be done to develop evidence-based guidelines for rehabilitation post-surgery for MLKI.

Acknowledgments

Funding: None.

Footnote

Conflict of Interest: CL reports the following: CanSino Biotechnology: Employee; Stock or stock Options. CUG serves as an unpaid editorial board member of *Annals of Joint* from Jul 2018 to Jun 2020. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/aoj.2019.02.06
Cite this article as: Samuel LT, Rabin J, Jinnah A, Rosas S, Chao L, Sullivan R, Gwam CU. Management of the multi-ligamentous injured knee: an evidence-based review. Ann Joint 2019;4:21.

