Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-015-3540-9

KNEE

Meniscal tears and articular cartilage damage in the dislocated knee

Aaron J. Krych · Paul L. Sousa · Alexander H. King · William M. Engasser · Michael J. Stuart · Bruce A. Levy

Received: 14 August 2014 / Accepted: 9 February 2015

Abstract
Purpose Knee dislocations can cause significant damage to intra-articular knee structures, but currently there are limited data reporting articular cartilage and meniscal injuries in this setting. The purpose of this study is to (1) report the rate of concomitant intra-articular injuries at the time of multiligament reconstruction for knee dislocation, (2) determine whether the pattern of ligament injury is associated with the presence of chondral and meniscal injuries, and (3) assess the relationship between timing of surgery and incidence of chondral and meniscal injuries.
Methods The records of patients who sustained a knee dislocation between 1992 and 2013 were retrospectively reviewed. Patients included for further review had a PCL-based multiligament knee injury or a minimum of three disrupted ligaments, both indicative of knee dislocation. Patient demographics, ligament injury patterns, meniscal tears and chondral injuries at arthroscopy, and interval from injury to surgery were recorded. Early surgical intervention was defined as <3 months, delayed was between 3 and 12 months, and chronic was >12 months. Data analysis compared ligament injury pattern with chondral and meniscal injuries, as well as the rates of intra-articular injury by timing of surgery.
Results One-hundred and twenty-one patients (122 knees) were included (93 males, 28 females) with a median age at time of surgery of 31 years (range 15–62). Ninety-three knees (76 %) had associated chondral or meniscal injury. Sixty-seven knees (55 %) presented with meniscal tears (26 isolated medial, 27 isolated lateral, and 14 combined medial/lateral), while 52 knees (48 %) had chondral damage, most commonly in the medial compartment. Schenck classification as well as side of injury did not demonstrate consistent relationships with intra-articular injury. A higher incidence of damage to the lateral femoral condyle (20 % vs 3 %; $p = 0.02$), lateral tibial plateau (20 % vs 2 %; $p < 0.01$), and patella (40 % vs 13 %; $p = 0.01$) was found in the chronic group compared to the early group. The chronic group contained significantly more patients with bicompartmental and tricompartmental chondral lesions (25 % vs 6 %; $p = 0.03$ and 10 % vs 0 %; $p = 0.02$, respectively).
Conclusion Meniscal tears and chondral damage occur frequently in patients with a knee dislocation. A longer interval from injury to surgical reconstruction is associated with higher rates of articular cartilage lesions, especially in multiple compartments.
Level of evidence IV.

Keywords Knee dislocation · Multiple ligaments · Cartilage · Meniscus

A. J. Krych · P. L. Sousa · A. H. King · W. M. Engasser · M. J. Stuart · B. A. Levy (✉)
Department of Orthopedic Surgery and Sports Medicine Center, Mayo Clinic, Rochester, MN, USA
e-mail: Levy.Bruce@Mayo.edu
e-mail: Sousa.Paul@Mayo.edu

A. H. King
e-mail: King.Alexander@Mayo.edu

W. M. Engasser
e-mail: WilliamEngasser@Gmail.com

M. J. Stuart
e-mail: Stuart.Michael@Mayo.edu

Introduction

Dislocations of the tibio-femoral articulation are devastating and complex injuries that can lead to severe disability [2].

Published online: 21 February 2015

High-energy mechanisms capable of dislocating a knee have the potential to damage intra-articular structures, including the articular cartilage and menisci [10]. In isolated ACL or PCL injuries, chondral lesions have been correlated with increased pain, loss of function, and development of osteoarthritis [4]. Additionally, meniscal injuries are associated with the development of early arthrosis [1, 12]. The incidence of intra-articular findings in ACL-deficient knees has previously been described [7, 11, 17]; however, the data in multiligament knee dislocations still remain largely unreported [2, 9, 18].

To our knowledge, there is little data on the rate of intra-articular injury with true knee dislocation. Further, the impact of ligament injury pattern and surgical timing on the development of meniscal and chondral injuries is largely unknown. Therefore, the purpose of this study was to (1) report the arthroscopic rate of concomitant intra-articular injuries at the time of multiligament reconstruction for knee dislocation, (2) compare the pattern of ligament injury with the location of associated chondral and meniscal injuries, and (3) determine whether timing of surgery influenced the rate of cartilage injury. It was hypothesized that there would be a high rate of intra-articular damage for patients with knee dislocation, an association between intra-articular injury and pattern of knee dislocation, and a longer period of time between injury and surgery would increase the rate of chondral and meniscal injuries.

Materials and methods

Patients were identified for this retrospective study by the use of a prospectively gathered database at our institution. We included patients with a history of reconstructive surgery for multiligament knee dislocation performed between 1992 and 2013 by the two senior authors using standardized surgical techniques. Patient demographics and operative reports were reviewed and recorded following approval from our institutional review board (Mayo Clinic IRB, study number 07-004018).

Knee dislocation was defined as ligament reconstruction for either a PCL-based multiligament injury or a minimum of three surgically treated ligaments. Patients were excluded for non-operative treatment only ($n = 9$) or prior surgery ($n = 26$) on the affected knee. Groups were then formed based on ligament injury pattern (Table 1). Injury patterns were further grouped using the Schenck classification [15] and side of injury (medial/lateral). Articular cartilage damage and meniscal injuries were identified at the time of diagnostic arthroscopy for each group. Chondral defects were divided into six subsets based on anatomic location: lateral femoral condyle, lateral tibial plateau, medial femoral condyle, medial tibial plateau, patella, and trochlea. Articular

Table 1 Meniscal and chondral injuries for knee dislocations stratified by pattern of ligamentous disruption

	Total *n* (%)	MMT *n* (%)	LMT *n* (%)	LFC *n* (%)	LTP *n* (%)	MFC *n* (%)	MTP *n* (%)	Patella *n* (%)	Trochlea *n* (%)
ACL/MCL/LCL (KD I)	4 (3)	1 (25)	2 (50)	1 (25)	1 (25)	0 (0)	0 (0)	1 (25)	0 (0)
PCL/MCL (KD I)	4 (3)	1 (25)	0 (0)	1 (25)	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)
PCL/LCL (KD I)	13 (11)	6 (46)	1 (8)	0 (0)	0 (0)	4 (31)	4 (31)	5 (38)	2 (15)
PCL/MCL/LCL (KD I)	4 (3)	3 (75)	1 (25)	1 (25)	1 (25)	0 (0)	1 (25)	2 (50)	0 (0)
PCL/ACL (KD II)	9 (8)	4 (44)	4 (44)	0 (0)	0 (0)	0 (0)	1 (11)	1 (11)	0 (0)
PCL/ACL/MCL (KD IIIM)	31 (25)	8 (26)	8 (26)	2 (6)	3 (10)	7 (23)	2 (6)	7 (23)	3 (10)
PCL/ACL/LCL (KD IIIL)	41 (34)	10 (24)	20 (49)	2 (5)	2 (5)	9 (22)	3 (7)	8 (20)	1 (2)
PCL/ACL/MCL/LCL (KD IV)	16 (13)	7 (44)	5 (31)	2 (13)	1 (6)	4 (25)	2 (13)	0 (0)	0 (0)
Total	122 (100)	40 (33)	41 (34)	9 (7)	8 (6)	24 (20)	13 (11)	25 (21)	6 (5)

Percentages represent percent of knees in each injury pattern displaying the specific type of intra-articular pathology. KD represents the Schenck classification for each of the patterns of injury
MMT medial meniscus tear, *LMT* lateral meniscus tear, *LFC* lateral femoral condyle, *LTP* lateral tibial plateau, *MFC* medial femoral condyle, *MTP* medial tibial plateau

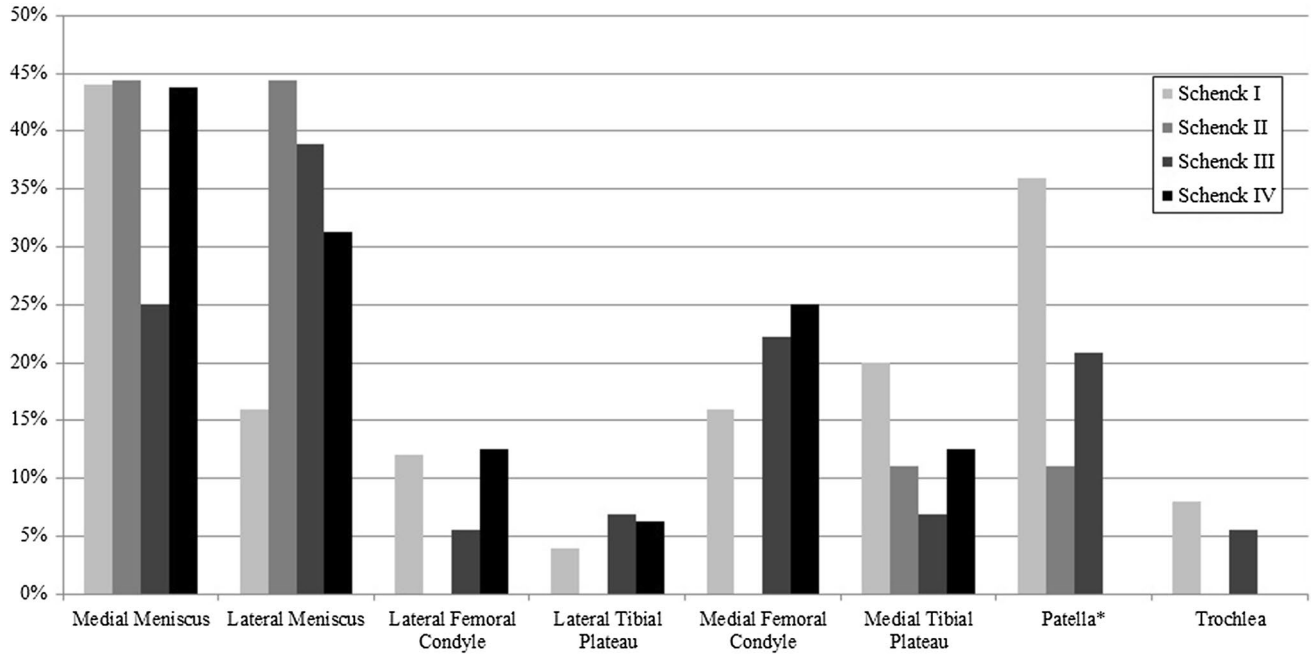

Fig. 1 Rate of meniscal and chondral injuries for patients grouped by Schenck classification. *Asterisk* indicates significant difference at the $p < 0.05$ level of significance, as was the case for patellar chondral injury

cartilage lesions were graded according to a modified outerbridge classification (0 = normal, I = softening, II = superficial fibrillation, III = deep fibrillation down to bone, IV = exposure of subchondral bone) [15]. For this study, chondral damage was defined as grade II involving 50 % or more of the condylar width, or any grade III or IV lesion [9]. Meniscal tears were subclassified into medial or lateral.

Chronicity was evaluated to determine whether the time interval from injury to surgery contributed to meniscus or chondral damage. Early intervention was defined as <3 months between injury and surgery, delayed intervention was between 3 and 12 months after dislocation, and chronic was >12 months after injury.

Statistical analysis

Chi-square testing was used to evaluate the various groups for differences in the rate of meniscal and chondral injuries. Comparisons were made between each ligament injury group (Schenck classification) as well as injury side. Patients with both MCL and LCL disruptions were not included in the analysis of injury side, as their inclusion would introduce dependence between the two groups. Additionally, Chi-square testing was used to compare the incidence of concomitant injuries between the early, delayed, and chronic intervention groups.

Representative comparisons were used to estimate power and sample size. One such example compared the rate of lateral sided articular injury between the early reconstructed group and the chronic reconstruction group. With 62 patients in the early group and 20 patients in the chronic group and an observed rate of injury in the acute group of 3 %, we would be able to detect a significant difference (significance level of 0.05 and a power estimate of 0.80) if the rate of lateral articular injury was at least 25 % for the chronic group. p values <0.05 were considered statistically significant. All analyses were performed with the use of SPSS software (version 18.0; SPSS, Chicago, Illinois).

Results

A total of 121 patients (122 knees) met inclusion criteria for a surgically treated knee dislocation as defined above (93 males, 28 females) with a mean age of 32.1 years (range 15–62) at time of surgery. Overall, 93 knees (76 %) were found to have intra-articular concomitant injuries. Sixty-seven knees (55 %) had meniscal tears, while 52 knees (43 %) had associated chondral damage. Of the 67 knees with meniscal tears, there were 26 isolated medial meniscus tears, 27 isolated lateral meniscus tears, and 14 knees with both medial and lateral tears (Table 1).

Ligament injury patterns with associated intra-articular injuries are listed in Table 1. KD IV injuries were associated with significantly less patellar chondral lesions ($p < 0.01$); however, no other differences were found (Fig. 1).

When patients were grouped by injury side, 35 (29 %) patients had a medial sided injury and 54 (44 %) patients

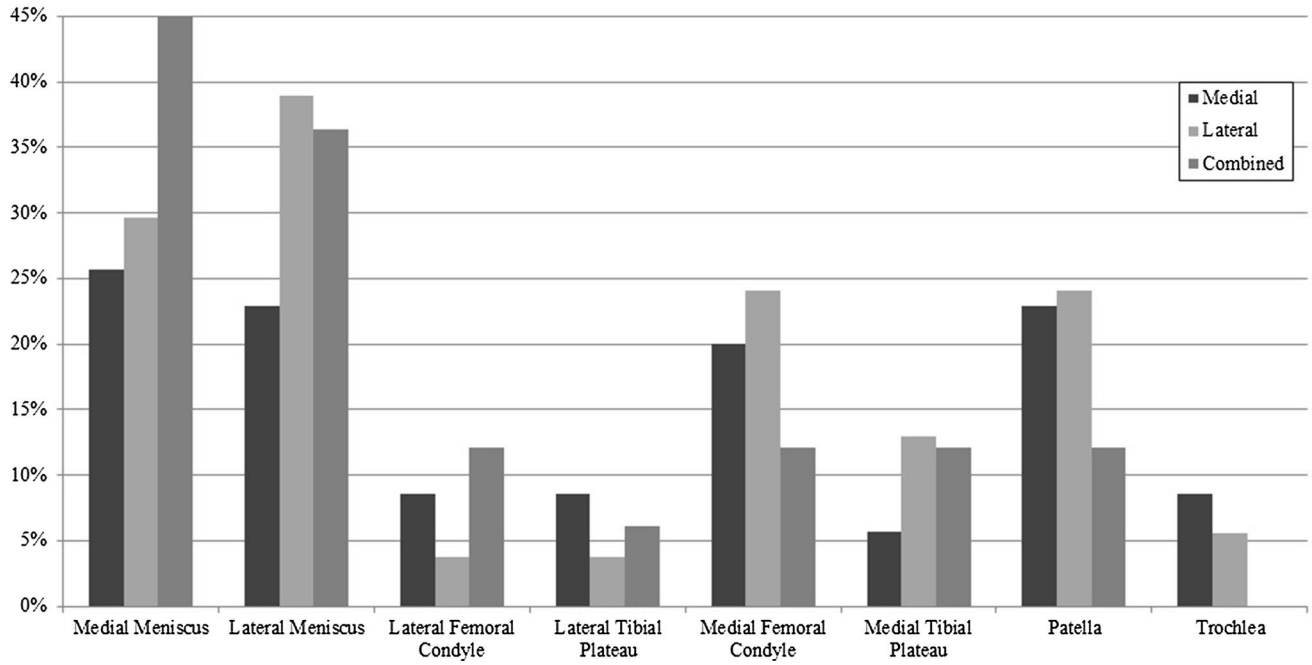

Fig. 2 Rate of meniscal and chondral injuries for medial-based and lateral-based knee dislocations. No significant differences in rate of injury were found at the $p < 0.05$ level of significance

had a lateral sided injury. There were 33 (27 %) patients who had combined medial and lateral injuries, and were not included in the injury side comparison (Fig. 2). Lateral sided injuries had significantly more cartilage and meniscal injuries (80 % vs 59 %; $p = 0.04$). The majority of this difference was attributed to a higher rate of lateral meniscal lesions with lateral sided injuries (37 % vs 17 %; $p = 0.06$), with less significant contributions from medial meniscal lesions (28 % vs 24 %; n.s.) and chondral lesions (50 % vs 31 %; n.s.). All other subgroup comparisons were unable to determine a relationship between injury side and rates of intra-articular injury.

The early group was comprised of 62 knees with a mean interval between injury and surgery of 1.5 months (range 4 days–3 months), the delayed group contained 40 knees with a mean interval of 5.9 months (range 3–12 months), and the chronic group contained 20 patients with a mean interval of 34.0 months (range 14 months–10 years). Chi-square analysis identified a significance difference between the surgical timing groups and chondral injury for both the patellofemoral and lateral articular compartments ($p = 0.02$ and $p = 0.02$, respectively). Further analysis showed higher rates of lateral femoral condyle injury (20 % vs 3 %; $p = 0.04$), lateral tibial plateau injury (20 % vs 0 %; $p = 0.01$), and patellar chondral lesions (40 % vs 11 %; $p = 0.03$) in the chronic group compared to the early group (Fig. 3).

Discussion

The most important finding of the present study was that a longer interval from injury to surgical reconstruction increased rates of articular cartilage lesions and the number of compartments affected. Knee dislocations are devastating injuries, but there remains limited information regarding concomitant intra-articular injuries, including the articular cartilage and menisci [9]. In this study, we sought to define the rate of chondral and meniscus injuries, clarify the relationship between ligament injury pattern and intra-articular damage, and determine whether a prolonged time between dislocation and reconstruction had a higher rate of articular cartilage and meniscus involvement. Our cohort showed a high rate (76 % of patients) of associated intra-articular injuries at the time of surgery. Medial compartment chondral lesions were most common, and meniscus tears were equally distributed between medial and lateral. In addition, patients with chronic reconstruction had significantly more articular cartilage lesions compared to the delayed and early groups, confirming our hypothesis. However, the rate of intra-articular pathology was similar amongst the different patterns of ligamentous injury.

Sixty-seven knees (55 %) had meniscal tears, and 52 knees (43 %) had chondral damage at the time of surgery. Kaeding et al. [9] similarly reported data on intra-articular findings in knees undergoing ligament reconstruction. Although 2265 patients were included in their study, the

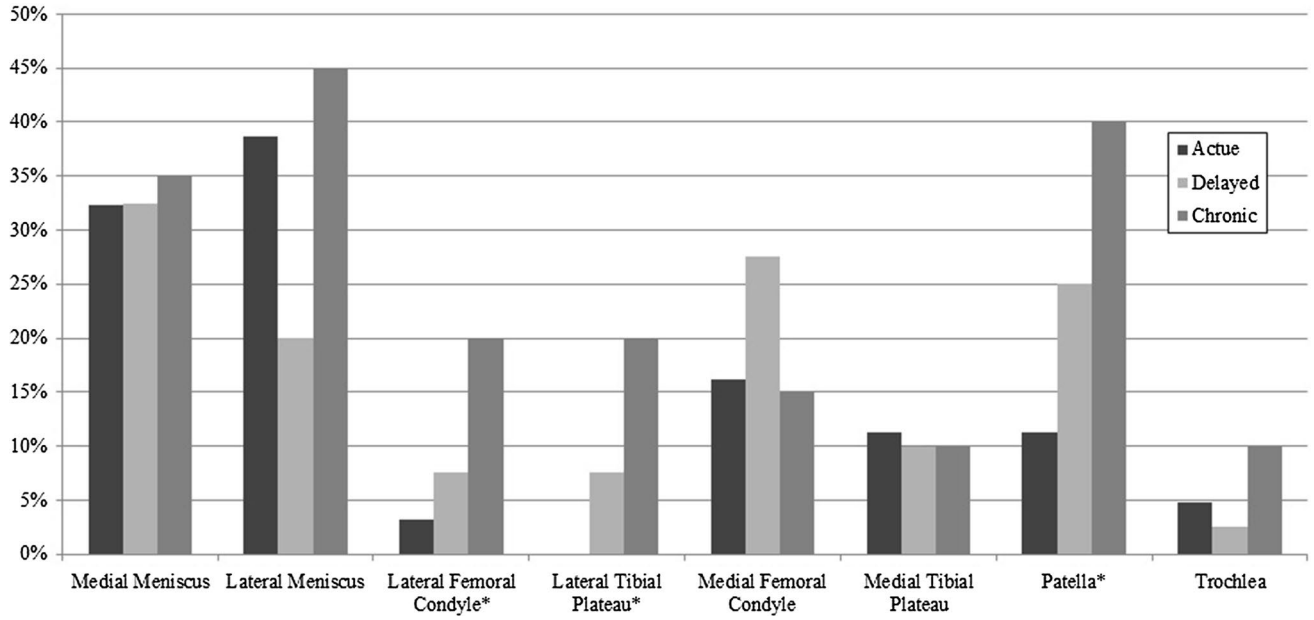

Fig. 3 Rate of meniscal and chondral injuries grouped by timing of surgery for knee dislocations. Early reconstruction occurred within 3 months of injury, delayed between 3 months and 1 year, and chronic >12 months following injury. Lateral femoral condyle, lateral tibial plateau, and patella showed significant differences for rates of chondral injury, as indicated by the *asterisks*. *Significant difference at the $p < 0.05$ level of significance

majority of the multiligament patterns were only two ligament injuries involving either the ACL and MCL or the ACL and LCL. However, the series did include a small number of knees with injury to three or more ligaments. They found the overall incidence of medial meniscal tears was 37 %, while lateral meniscal tears were present in 58 % of patients. Multiple-ligament knee injuries had the following associated chondral damage: lateral femoral condyle (23 %), medial femoral condyle (22 %), patella (13 %), lateral tibial plateau (8 %), trochlea (8 %), and medial tibial plateau (5 %). In the present study, the medial compartment was more commonly affected, which coincides with the majority of patients having PCL-based injuries. Chronic PCL deficiency has been correlated with increased pressure in the medial and patellofemoral compartments, causing increased articular cartilage lesions [16]. Strobel et al. [19] also published data on cartilage lesions in PCL-deficient knees with the majority of the lesions involving the medial femoral condyle (50 %) and patella (33 %), with the fewest at the lateral tibial plateau (8 %). Our results showed injuries to the medial femoral condyle (25 %) and patella (21 %) to be the most common, while lateral tibial plateau injuries (8 %) were the least common, consistent with the injury patterns found in previous studies [16, 19].

There were limited differences amongst the various patterns of injury. Each of the Schenck groups was similar, and comparisons between medial and lateral injuries displayed modest differences; LCL-based dislocations repaired within 1 year of injury may have more intra-articular pathology than MCL-based injuries repaired within 1 year. However, the overall rate of chondral and meniscal injuries was similar for Schenck classification and the side of injury. Patients presenting with an ACL/MCL tear have been found five times more likely to tear their lateral meniscus [5]. This injury type was excluded from our study, possibly leading to our decreased incidence of lateral meniscal tears. Lateral meniscus tears have been associated with bone bruising on the lateral femoral condyle in the setting of acute ACL injuries [18]. Due to the increased rotation after an ACL tear, the lateral meniscus could become lodged between the tibial plateau and lateral femoral condyle [5, 9, 13]. This increased valgus stress and rotation can cause a greater likelihood of a lateral meniscal tear in some patients [9, 13]. The results showed that medial-based knee dislocations repaired within 1 year had significantly more lateral meniscal tears. However, the most likely explanation for the overall limited relationship between pattern of injury and cartilage damage in the present study is that knee dislocations have a variety of complex injury mechanisms, in which different intra-articular structures are damaged [3, 6, 8, 14].

The present study demonstrated increased lateral and patellofemoral damage in the chronic group compared to the early group. As the majority of the knees included in this study had PCL deficiency, it is not surprising that overall, there was more medial and patellofemoral compartment

chondral degeneration. Additionally, exposure to prolonged instability seemed to increase the rate of lateral compartment injury. An MRI review of early posteromedial corner injuries found that the posterior horn of the medial meniscus was most commonly torn, possibly caused by the severe disruption of the deep meniscofemoral and meniscotibial ligaments in these injuries [2]. Chronic instability may represent an accumulation of this damage seen in the acute injury. While both early and chronic medial injuries displayed high rates of medial compartment pathology, the chronic setting provided longer exposure to instability, which negatively affected the patellofemoral and lateral compartments. Lastly, 12 months seemed to mark an important distinction in the development of chondral damage. While limited relationships were established between the chronic group and the delayed group, as well as the delayed and the early group, there were more significant differences between the chronic group and the early group.

This retrospective cohort study had several limitations. First, although arthroscopic confirmation is an accurate method to diagnose cartilage damage, injury noted at the time of surgery may or may not be directly related to the knee dislocation. Pre-existing cartilage injury would be difficult to distinguish from a new injury. Second, the experience of a single institution may not provide a true incidence of chondral and meniscal injuries. Third, this cohort included only knee dislocations that received surgical reconstruction with concomitant intra-articular injuries noted at the time of surgery. Non-operative knees did not meet the inclusion criteria, as this study used arthroscopically confirmed cartilage injury instead of radiographic diagnosis. Lastly, there is no consensus in the literature for the definition of early, delayed, and chronic reconstruction. After a review of previous studies, 12 months seemed an appropriate distinction for chronic reconstruction, allowing ample opportunity for instability episodes to affect the articular cartilage and menisci [9, 19].

The findings presented in the current study have several clinical implications. Primarily, in deciding the ideal time for surgical reconstruction, the potential for increased cartilage damage in prolonged delay between injury and surgery must be taken into account. Additionally, these findings will significantly improve understanding of the risk for osteoarthritis following these devastating injuries.

Conclusion

Meniscal tears and chondral damage occur frequently in patients presenting with a knee dislocation. A longer interval from injury to surgical reconstruction is associated with higher rates of articular cartilage lesions, with an increase in compartments affected. Further research using multicenter data would provide a better representation of the true incidence of meniscus and articular cartilage damage in this patient population and also help to determine whether these injuries negatively affect outcome.

References

1. Badlani JT, Borrero C, Golla S, Harner CD, Irrgang JJ (2013) The effects of meniscus injury on the development of knee osteoarthritis: data from the osteoarthritis initiative. Am J Sports Med 41(6):1238–1244
2. Chahal J, Al-Taki M, Pearce D, Leibenberg A, Whelan D (2010) Injury patterns to the posteromedial corner of the knee in high-grade multiligament knee injuries: a MRI study. Knee Surg Sports Traumatol Arthrosc 18(8):1098–1104
3. Cole BJ, Harner CD (1999) The multiple ligament injured knee. Clin Sports Med 18(1):241–262
4. D'Anchise R, Manta N, Prospero E, Bevilacqua C, Gigante A (2005) Autologous implantation of chondrocytes on a solid collagen scaffold: clinical and histological outcomes after two years of follow-up. J Orthop Traumatol 6(1):36–43
5. Duncan JB, Hunter R, Purnell M, Freeman J (1995) Meniscal injuries associated with acute anterior cruciate ligament tears in alpine skiers. Am J Sports Med 23(2):170–172
6. Fanelli GC, Orcutt DR, Edson CJ (2005) The multiple-ligament injured knee: evaluation, treatment, and results. Arthroscopy 21(4):471–486
7. Fok AM, Yau WP (2013) Delay in ACL reconstruction is associated with more severe and painful meniscal and chondral injuries. Knee Surg Sports Traumatol Arthrosc 21(4):928–933
8. Frassica FJ, Sim FH, Staeheli JW, Pairolero PC (1991) Dislocation of the Knee. Clin Orthop Relat Res 263:200–205
9. Kaeding CC, Pedroza AD, Parker RD, Spindler KP, McCarty EC, Andrish JT (2005) Intra-articular findings in the reconstructed multiligament-injured knee. Arthroscopy 21(4):424–430
10. Levy BA, Dajani KA, Whelan DB, Stannard JP, Fanelli GC, Stuart MJ, Boyd JL, MacDonald PA, Marx RG (2009) Decision making in the multiligament-injured knee: an evidence-based systematic review. Arthroscopy 25(4):430–438
11. Lind M, Menhert F, Pedersen A (2009) The first results from the Danish ACL reconstruction registry: epidemiologic and 2 year follow-up results from 5818 knee ligament reconstructions. Knee Surg Sports Traumatol Arthrosc 17(2):117–124
12. Liow RYL, McNicholas MJ, Keating JF, Nutton RW (2003) Ligament repair and reconstruction in traumatic dislocation of the knee. J Bone Joint Surg Br 85(6):845–851
13. Matsumoto H, Suda Y, Otani T, Niki Y, Seedhom BB, Fujikawa K (2001) Roles of the anterior cruciate ligament and the medial collateral ligament in preventing valgus instability. J Orthop Sci 6(1):28–32
14. Rihn JA, Groff YJ, Harner CD, Cha PS (2004) The acutely dislocated knee: evaluation and management. J Am Acad Orthop Surg 12(5):334–346
15. Schenck RC Jr (1994) The dislocated knee. Instr Course Lect 43:127–136
16. Skyhar M (1993) The effects of sectioning of the posterior cruciate ligament and the posterolateral complex on the articular contact pressures within the knee. J Bone Joint Surg Am 75(5):694–699
17. Smith JP, Barrett GR (2001) Medial and lateral meniscal tear patterns in anterior cruciate ligament-deficient knees. A prospective analysis of 575 tears. Am J Sports Med 29(4):415–419

18. Spindler KP, Schils JP, Bergfeld JA, Andrish JT, Weiker GG, Anderson TE, Piraino DW, Richmond BJ, Medendorp SV (1993) Prospective study of osseous, articular, and meniscal lesions in recent anterior cruciate ligament tears by magnetic resonance imaging and arthroscopy. Am J Sports Med 21(4):551–557

19. Strobel MJ, Weiler A, Schulz MS, Russe K, Eichhorn HJ (2003) Arthroscopic evaluation of articular cartilage lesions in posterior cruciate ligament—deficient knees. Arthroscopy 19(3):262–268