Injury, Int. J. Care Injured 50 (2019) 534–540

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

A new classification of injury patterns of the medial patellofemoral ligament after acute lateral patella dislocation detected using magnetic resonance imaging studies

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ARTICLE INFO

Article history:
Accepted 8 November 2018

Keywords:
Acute lateral patellar dislocation
Injury patterns
Magnetic resonance imaging
Medial patellofemoral ligament

ABSTRACT

Introduction: Acute lateral patellar dislocation is a very common condition in orthopedics, especially among adolescents and physically active patients. To evaluate distinct medial patellofemoral ligament (MPFL) injury patterns and the associated knee pathology after acute lateral patellar dislocation (ALPD) using magnetic resonance imaging (MRI) studies, which is essential for the development of treatment protocols.

Materials and Methods: MRI images of 74 ALPD patients were taken between January 2015 to December 2016. Images were evaluated using standardized protocols.

Results: The prevalence of MPFL injury following ALPD was 97.3% (72/74 patients). Among the 72 patients with MPFL, the prevalence of Type I injury was 26.4% (19/72). Since only bone marrow edema and a partial tear were showed on MRI of these patients, conservative treatment was given. Tear of the MPFL occurred at the patellar attachment (Type IIa) in 16 patients (16/72, 22.2%), at the middle area of the ligament (Type IIb) in 5 patients (5/72, 6.9%), and at the femoral attachment (Type IIc) in 27 patients (27/72, 37.5%). For Type II injuries, all patients had the surgery to reconstruct the MPFL. The prevalence of Type III MPFL injury was 6.9% (5/72) after the surgery.

Conclusion: MPFL injury of is a common sequel following ALPD. We assessed the distinct injury pattern and associated pathology of MPFL using MRI studies. A good understanding of the injury pattern and associated knee pathology of MPFL is essential in managing patients with ALPD, especially if surgical intervention is considered.

Introduction

Acute lateral patellar dislocation is a very common condition in orthopedics, especially among adolescents and physically active patients [1]. Acute lateral patellar dislocations (ALPD) may account for 2% to 3% of all knee injuries [2]. It can be triggered by traumatic or non-traumatic events; in the latter cases, it is associated with significant anatomical alterations of the knee extensor mechanism. There is no consensus regarding the ideal treatment after the first occurrence of dislocation, mainly because only 30% of the patients experience a singular episode [3]. However, starting in the 1990s, a growing number of studies dealing specifically with reconstruction of the medial patellofemoral ligament (MPFL) as a treatment for ALPD appeared in the medical literature [4–6]. MPFL is the primary stabilizer of lateral patellar translation [7]. As the structure most frequently affected by acute lateral patellar dislocation (ALPD), MPFL was reported to contribute 53% of knee mechanics when the knee is flexed between 0° to 30° (Fig. 1) [8]. Rupture of the MPFL has been reported in 95% to 100% of patients with acute patellar dislocation [5]. Accordingly, MPFL dysfunction is deeply related to recurrent, traumatic patellar dislocation [9]. Recently, studies have clarified the anatomy and biomechanics of MPFL function and documented the importance of MPFL reconstruction to improving patellar lateral stability [10]. Injury patterns of the MPFL after acute

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https://doi.org/10.1016/j.injury.2018.11.024
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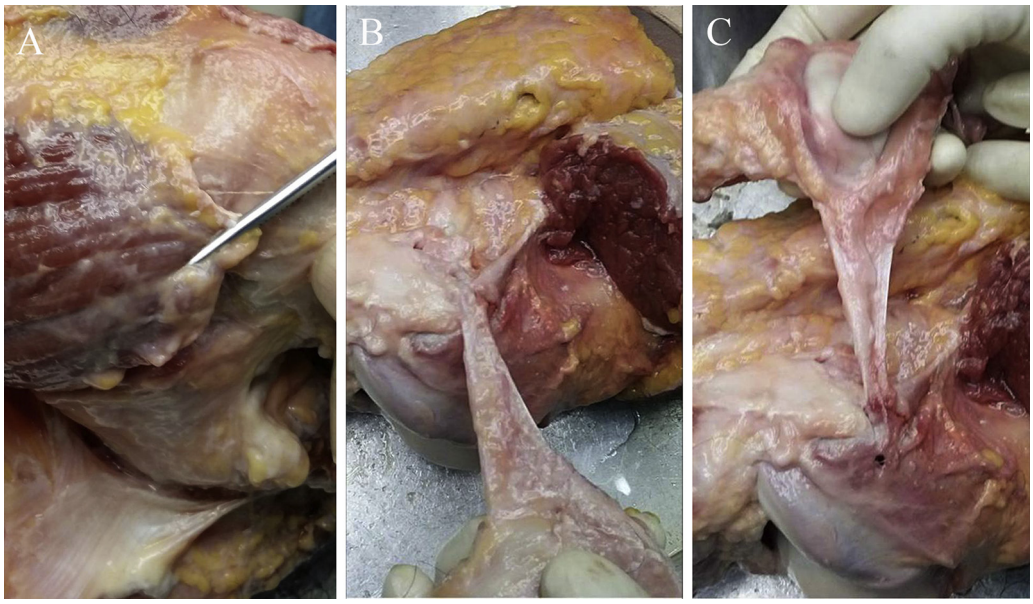

Fig. 1. Morphology and attachments of the medial patellofemoral ligament (MPFL) are shown. (A) MPFL is attached to the medial epicondyle of the femur and runs anteriorly toward the distal part of the vastus medialis. (B) After the removal of distal part of the vastus medialis, MPFL was observed to be fan-like in shape. MPFL fibers have a typical sail-like shape with a narrow femoral insertion that spreads at the patellar insertion. (C) Femoral insertion is located closely to the epicondyle and far away from the adductor tubercle.

lateral patellar dislocation derived from the Zhang et al. study were divided into partial and complete tears [11]. However, this classification of MPFL injury patterns into these categories is too simple to guide clinical treatment. In addition to this injury pattern description, the MPFL was also assessed in three locations—at its patellar insertion, at its mid-substance and at its femoral attachmen [12,13]. However, these patterns do not include the scenario of a medial patellar wing fracture, which has been reported to involve osteochondral fracture. This type of fracture occurs in 25% of traumatic patellar dislocations. More than 100 operative procedures for patellar dislocation have been developed over the past century. These procedures can be classified as two types: soft tissue balancing procedures and bony transfer procedures. Therefore, it appears to be increasingly necessary to develop a new classification of injury patterns of the medial patellofemoral ligament and associated pathology in acute lateral patella dislocation, ideally using Magnetic Resonance Imaging (MRI). This is the first paper to expound on all possible clinical scenarios for acute traumatic patellar dislocation, and this innovative delineation of MPFL injury patterns aims to better guide clinical treatment.

Materials and methods

Patients

This study was approved by the ethics committee and written informed consent was obtained from all patients. A prospective cohort study of patients with ALPD between January 2015 and December 2016 was carried out. All 74 patients were selected according to the following criteria:

Inclusion criteria

1 Presence of primary locked unilateral acute lateral patellar dislocation within 6 h after the injury.
2 Typical clinical findings were found, including: hemarthrosis, medial parapatellar structures and femoral epicondyle that were painful on palpation, apprehension sign (except in locked dislocation).
3 Patient eligible to undergo MRI studies.

Exclusion criteria

1 Recurrent lateral patellar instability.
2 Open dislocation or grossly contaminated wound.
3 Acute lateral patellar dislocation in patients diagnosed with serious neuromuscular disease, peripheral vascular disease, diabetes mellitus or bleeding disorders.
4 Pathological dislocation.

All patients were placed at the single imaging site (1.5 T High Field Open MRI Systems, GE Signa HDXT, MA) with their knees positioned in full extension. Each MRI study was reviewed by two physicians independently: a musculoskeletal radiologist and a chief orthopedic surgeon. Any discrepancy was settled by a consensus between the physicians. The reviewers looked at the patella and MPFL in the axial, coronal and sagittal views in both T1 and T2 weighted images.

Based on the injury mechanism presented in Zheng and Zhang's study discussed previously [2,14, 15]], the following diagnostic classifications were used (Fig. 2):

Type IMPFL injury: When a collision with a smaller force is applied (e.g., a partial MPFL tear), fluid movement and realignment of the macromolecular framework cause the cartilage to deform to avoid injury to the deeper part of cartilage. Consequently, the MRI demonstrates bone marrow edema on the anterolateral femoral condyle and the medial patellar facet without the medial patellofemoral ligament (MPFL) injury or partial MPFL tear.

TypeII MPFL injury: When a collision with a larger force is applied, the manifestations of a complete MPFL tear will be found. This injury can be classified into 3 subtypes based on the 3 locations where the MPFL is disrupted: Type IIa occurs at its patellar insertion, Type IIb at its mid-substance and Type IIc at its femoral attachment. Type IIa and Type IIc also consist of osteochondral avulsion fractures which

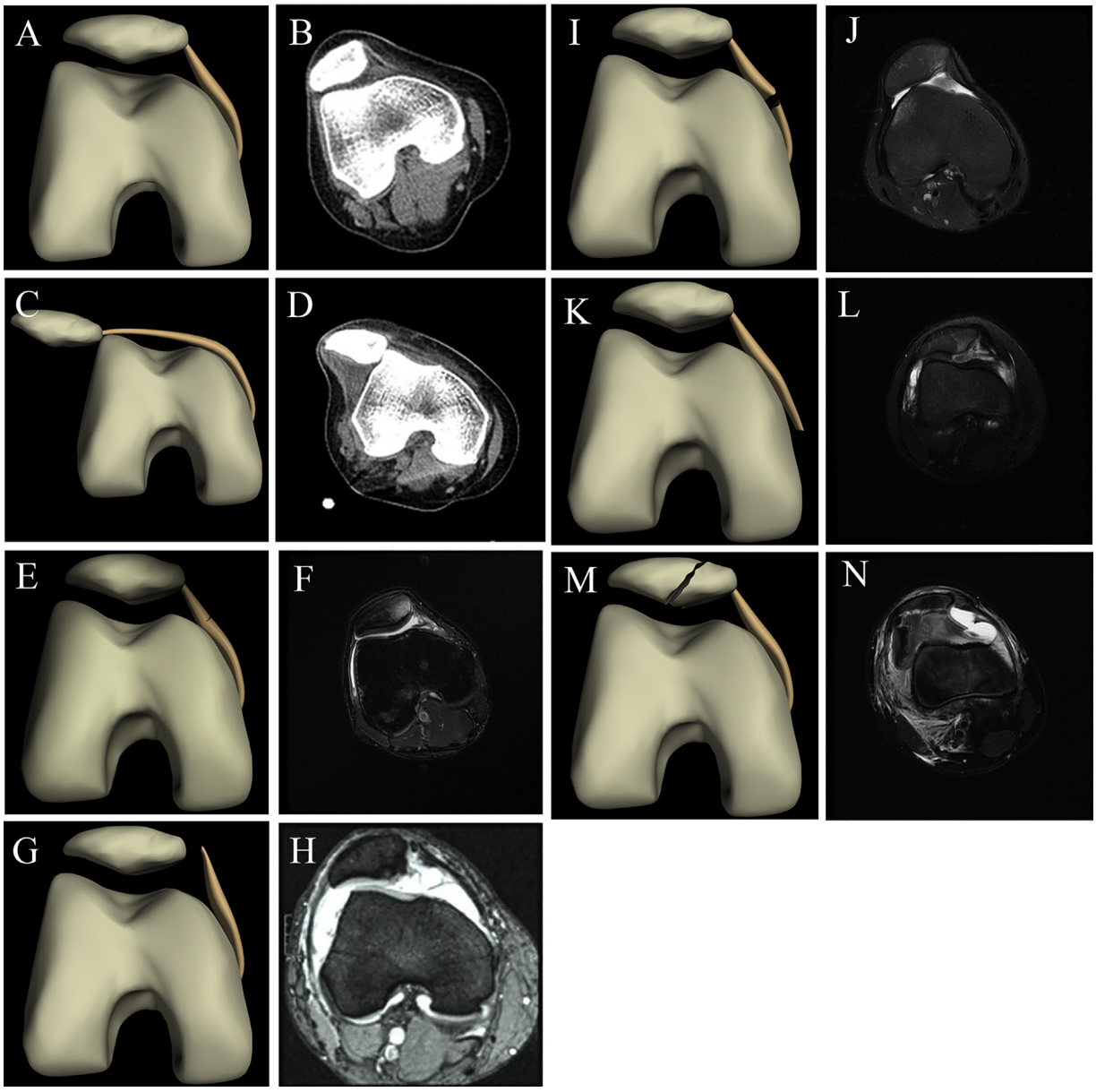

Fig. 2. Three types of MPFL injuries are shown. (A–B) Normal patellofemoral relationship is shown. (C–D) When a collision with force is applied, acute lateral patellar dislocation occurred. (E–F) Type I MPFL injury: bone marrow edema on the anterolateral femoral condyle and the medial patellar facet without the medial patellofemoral ligament (MPFL) injury or partial MPFL tear. TypeII MPFL injury: complete MPFL tear or osteochondral avulsion fractures without involvement of articular cartilage. This type is divided into 3 subtypes based on the 3 locations where the MPFL is disrupted—(G–H) Type IIa at its patellar insertion, (I–J) Type IIb at its mid-substance and (K–L) Type IIc at its femoral attachment. (M–N) Type III MPFL injury: bony fracture occurred from the medial facet of the patella, involving articular cartilage.

without articular cartilage (only bone from medial patellar margin and anterolateral femoral condyle).

Type III MPFL injury: When a collision with more powerful force is applied, the matrix macromolecular framework can rupture, damaging cartilage cells in the deeper part and leaving the underlying subchondral bone unprotected. Hence, more severe injuries to the patella will ensue. The MRI findings associated with this injury demonstrate a bony fracture occurring at the medial facet of the patella, involving articular cartilage.

Results

According to the inclusion and exclusion criteria previously mentioned, there were 74 patients (45 females and 29 males; mean age 21.1 ± 5.2 years, range 9–42 years) enrolled in this study.

After acute lateral patellar dislocation, the prevalence of MPFL injury was high, found in 97.3% of the patients (72/74) based on MRI studies.

The prevalence rate of Type I MPFL was 26.4% (19/72), with only bone marrow edema and partial tear revealed in MRI. Conservative treatment was first considered, including ice compression, knee elevation, and casting or splinting of the knee joint in a functional position for 3–6 weeks (Fig. 3).

Tearing of MPFL occurred at the patellar attachment (Type IIa) in 16 patients (16/72, 22.2%), at mid-substance (Type IIb) in 5 patients (5/72, 6.9%), and at the femoral attachment (Type IIc) in 27 patients (27/72, 37.5%). For Type II injuries, which involve a complete MPFL tear, knee

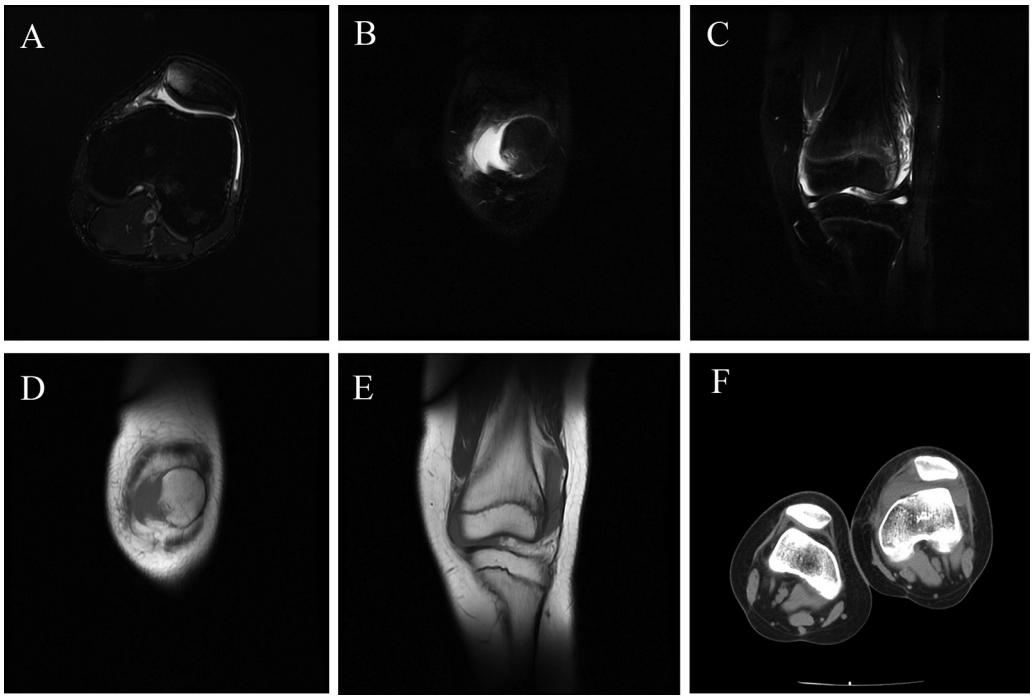

Fig. 3. Typical patterns of Type I MPFL injury are shown. (A) Axial T2 MRI indicates bone marrow edema at the medial patellar facet. (B) Coronal T2 MRI indicates bone marrow edema at the medial patellar facet and (C) the anterolateral femoral condyle. (D) Coronal T1 MRI indicates bone marrow edema at the medial patellar facet and the (E) anterolateral femoral condyle. Computed tomography (CT) showed no fracture at the medial patellar facet or the anterolateral femoral condyle.

ligament reconstruction is an important and effective way to restore knee joint stability. For these patients, arthroscopy was performed initially followed by a minimally invasive operation. If necessary, surgery was implemented for the MPFL reconstruction (Fig. 4).

The prevalence of Type III MPFL injuries was 6.9% (5/72), in which fractures of the patella's medial facet affect the articular surface. In addition to the MPFL reconstruction, open reduction and internal fixation are essential. Therefore, surgery was

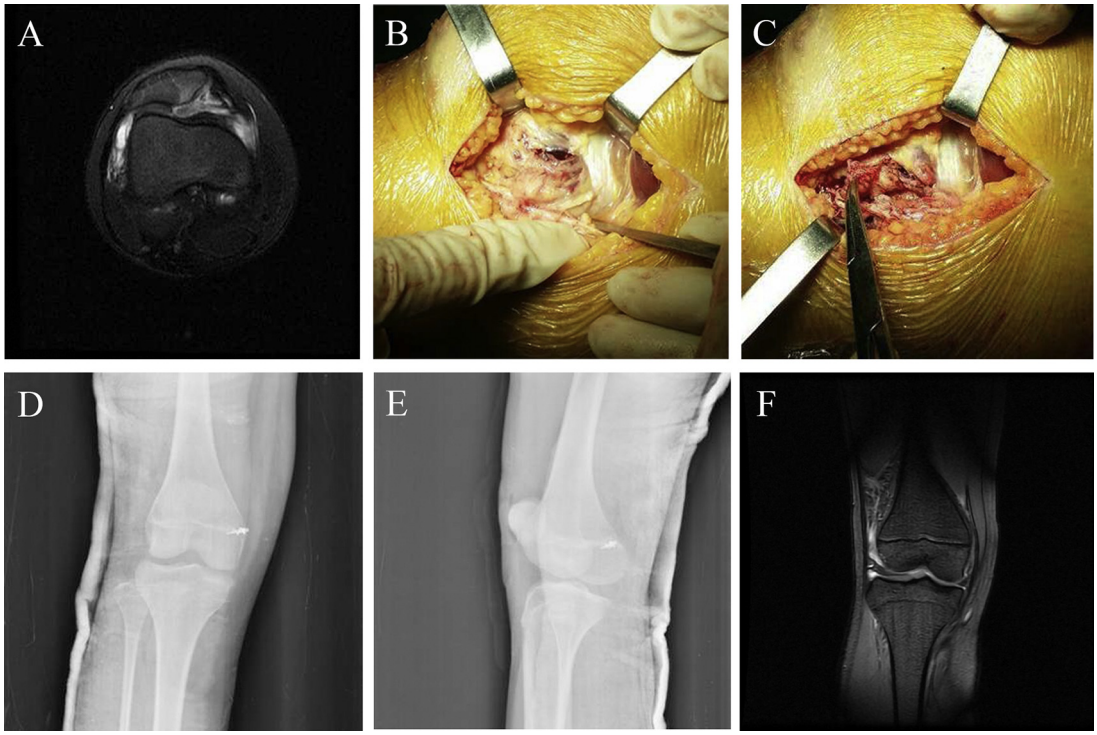

Fig. 4. Typical injury patterns with Type IIc MPFL injury are shown. (A) Axial T2 MRI indicates complete MPFL tear at its femoral attachment. (B–C) During operation, a MPFL tear was found, comply with the performance of MRI. (D–E) A minimally invasive operation was performed, thus operative method was responsible for reconstruction of the MPFL. Post-surgical anteroposterior and lateral radiograph views along with a metal anchor at the femoral attachment and cast are shown. (F) No bone marrow edema was seen at the medial patellar facet or the anterolateral femoral condyle.

performed to regain joint surface smoothness and to avoid the occurrence of traumatic osteoarthritis (Fig. 5, Table1).

Discussion

Acute traumatic patellar dislocation is the second most frequent cause of traumatic hemarthrosis of the knee joint, accounting for 3% of all traumatic knee lesions [16], occurring at a rate of 5.8 per 100,000 individuals [17]. Acute lateral patellar dislocation is associated with sudden trauma, frequently from sporting and physical activities occurring while the knee is in terminal extension with an axial–valgus stress applied during rotation [4]. It has been widely reported that the medial patellofemoral ligament (MPFL) is the primary restrictor against lateral patellar displacement and the most important structure providing resistance against the subluxation of patella [5, 18]. Nomura et al. [10] reported that some MPFL fibers could extend upwards, beyond the upper edge of the patella, directly into the quadriceps tendon. On the other hand, at its patellar end MPFL also capsules a portion of the oblique vastus medialis muscle, approximately 35% of its total length [19]. Tearing of the MPFL is frequently cited as the essential lesion contributing to lateral displacement of the patella. This theory is increasingly accepted, based both on biomechanical and on clinical factors [20]. Imaging techniques such as MRI have improved our understanding of injury mechanics and pathologic changes of cartilage and ligaments, leading to advances in surgical techniques and management. Though the main rupture location of the MPFL in the case of ALPD in children and adolescents remains debatable [14], evidence suggesting that the MPFL is more likely to rupture at the femoral attachment than at the patellar insertion after acute lateral patellar dislocation was supported by Balcarek's and Putney's study [21,22]. Results in this study were consistent with previous findings that the MPFL was more likely to be injured at the patellar, since MPFL tear occurred at the patellar attachment (Type IIa) in 16 patients (16/72, 22.2%) and at the femoral attachment (Type IIc) in 27 patients (27/72, 37.5%).

Injury patterns of the MPFL after acute lateral patellar dislocation derived from the Zhang et al. study were divided into partial and complete tears. A partial MPFL tear was defined as thickening and irregularity of the contour, including discontinuity of normal fibers and intraligamentous or extensive periligamentous edema. A complete MPFL tear was defined as fibers in the expected region of the MPFL being completely discontinuous or appearing absent, with extensive surrounding edema [14,15,23]. However, based on our experience, the classification of MPFL injury patterns into these categories is too simple to guide clinical treatment. In addition to this injury pattern description, the MPFL was also assessed in three locations—at its patellar insertion, at its mid-substance and at its femoral attachment [24,25]. However, these patterns do not include the scenario of a medial patellar wing fracture, which has been reported to involve osteochondral

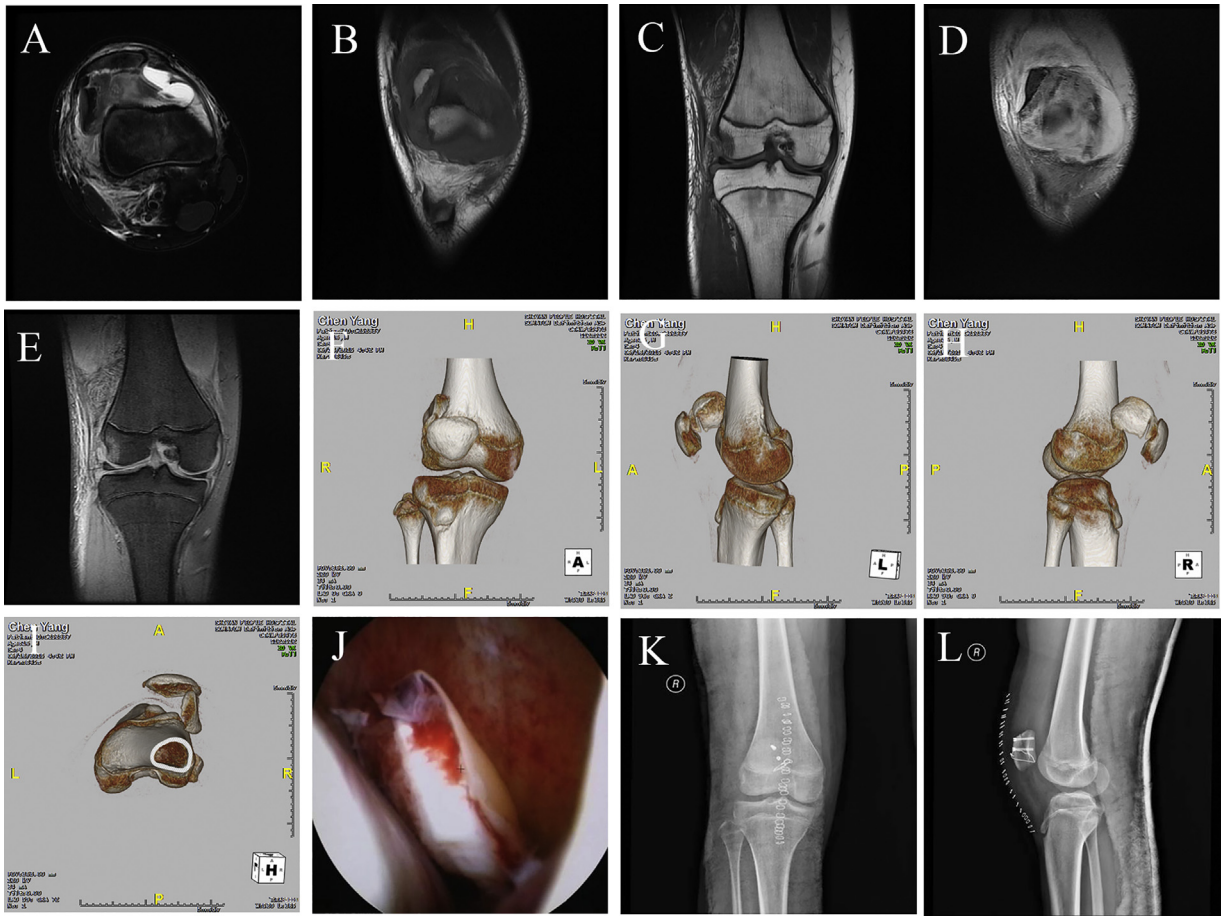

Fig. 5. Typical injury patterns associated with Type III MPFL injury are shown. (A)Axial T2 MRI indicates bony fracture occurred from the medial facet of the patella involving articular cartilage. (B) Coronal T1 MRI indicates bony fracture at the medial patellar facet and (C) bone marrow edema at the anterolateral femoral condyle. (D) Coronal T2 MRI indicates bony fracture at the medial patellar facet and (E) bone marrow edema at the anterolateral femoral condyle. (F–I) Computed tomography (CT) reconstruction showed patellar fracture involving the articular cartilage. (*J*) Arthroscopy was performed initially and an articular fragment of the patella was displayed. (K–L) Besides reconstruction of the MPFL, open reduction and internal fixation were performed along with surgery for the anatomical reduction of the joint surface. On post-surgical anteroposterior and lateral radiographs, cannulated screws, wire and cast are shown.

Table 1
Different treatment for the acute lateral patellar dislocation based on the medial patellofemoral ligament injury patterns.

Type		MRI studies on MPFL	Treatment
Type I		1. Bone marrow edema on the anterolateral femoral condyle and the medial patellar facet 2. Partial tear	Knee joint is casted or splinted in functional position for 3 to 6 weeks
Type II	IIa	1. Complete tear at patellar insertion 2. Osteochondral avulsion fractures from medial patellar margin	Arthroscopy was performed and minimally invasive operation performed if necessary, operative method was responsible for reconstruction of the MPFL
	IIb	Complete tear at mid-substance	
	IIc	1. Complete tear at femoral attachment 2. Osteochondral avulsion fractures from anterolateral femoral condyle	
Type III		Patellar fracture involving articular cartilage	Open reduction and internal fixation, operative method was responsible for anatomical reduction of the joint surface

fracture. This type of fracture occurs in 25% of traumatic patellar dislocations [26]. To our knowledge, this is the first paper to expound on all possible clinical scenarios for acute traumatic patellar dislocation, and this innovative delineation of MPFL injury patterns aims to better guide clinical treatment.

Traditionally, most first-time traumatic patellar dislocations were treated conservatively, except when there was associated patellar dislocation or osteochondral fractures of the lateral femoral condyle. However, with conservative treatment, studies showed a recurrence rate ranging from 17% to 44% with non-surgical treatment [27]. In addition, a history of previous knee pain was later discovered and a recurrent instability rate above 50% after conservative treatment led to an increase in employing surgical repair and reconstruction of the medial patellar stabilizers as the initial treatment [28]. Though some controversy still exists, the key role of medial patellar stabilizers in preventing ALPD is generally accepted worldwide. This view is supported by some studies, which have analyzed two types of approach (reconstruction of the MPFL versus conservative approach) in the treatment of acute lateral patellar dislocation. They found that treatment with reconstruction of the MPFL produced better final results [29]. Furthermore, clear evolutionary trends in treatments and rehabilitation for acute patellar dislocation also been noticed due to MPFL [30].

Arendt et al. concluded that there were three categories of surgical treatments of MPFL. For repair after a primary lateral patellar dislocation, the acutely injured tissue has to be re-attached at the site of the lesion or injury, as measured by MRI and / or direct surgical evaluation [31]. Following this guideline, the recommended treatment for Type II injuries in which a complete MPFL tear occurred (in our study, 66.7% of enrolled patients) was physical examination after anesthesia and arthroscopy. If necessary, surgery is performed to reconstruct MPFL.

The patello-femoral joint is the heaviest loaded joint in human body, therefore, any compromise of the joint surface is likely to lead to degenerative joint disease. Hence, it is highly desirable in treatment of knee fractures to strive for anatomical reduction of the joint surface and stable fixation. As for Type III MPFL injuries (in our study, this type occurred in 5/72 patients, or 6.9%) that involved a fracture of the medial facet of the patella, we insist that open reduction and internal fixation is necessary in addition to reconstruction of the MPFL. Surgical intervention was also employed for the recovery of joint surface smoothness, prevention of traumatic osteoarthritis and restoration of function of the knee extensor mechanism.

In 2008, an interesting find was discovered in a randomized controlled study of non-operative management versus repair undertaken at a mean of 50 days after a primary lateral patellar dislocation. The study showed a 17.5% re-dislocation rate in the operative group compared with 20% in the non-operative group, and lower re-dislocation rates were not achieved by surgery [32]. Subsequently, in 2009, Camanho GL et al. reviewed 33 patients with acute dislocations of the patella. 16 were treated non-operatively, and 17 received operative repair of the MPFL within one month of the injury. At a minimum follow-up of 25 months, 50% (8/16) of patients in the non-operative group had sustained another dislocation and none (0/17) experienced a recurrence of dislocation in the operative group [33]. Hence, besides considering surgery as a treatment, the timing at which the operation should be undertaken is also a worthy consideration.

One limitation of our study is that surgical outcomes were not included since the follow-up was short-term and incomplete. Furthermore, the inability to perform physical knee exams on the patients makes it hard to determine the knee stability. Therefore, it's impossible to determine the after-surgery recurrence rate. An additional limitation of this study is that it involves a small sample size. Nonetheless, the injury patterns in this study consist of almost all types of MPFL injuries at different locations and articular fracture of the patella.

Conclusions

Our results suggested that MPFL injury is a common sequel after acute lateral patellar dislocation. The complete MPFL tear occurs primarily at the femoral attachment and secondarily at its patellar insertion. We developed an innovative assessment of injury patterns of MPFL and the associated intraarticular pathology in acute lateral patella dislocation using MRI studies. A good understanding of injury patterns or tear location of MPFL and the associated knee pathology is essential in managing patients with acute lateral patella dislocation, especially if surgical intervention is planned. Therefore, we highly recommend that a MRI scan of the involved knee should be performed on all patients who have had an acute lateral patellar dislocation.

Conflict of interests

All the authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

This study was supported by the National Natural Science Foundation of China (No. 81602867), Hubei Provincial Department of Education funded projects (No. B2018110), and Hubei Provincial science and Technology Department funded projects (No. 2018CFB524).

References

[1] Sadigursky D, de Melo LM, Nunes M, Caneiro RJ, Colavolpe PO. Reconstruction of the medial patellofemoral ligament by means of the anatomical double-bundle technique using metal anchors. Rev Bras Ortop 2016;51(3):290–7.

[2] Zhang GY, Zheng L, Shi H, Qu SH, Ding HY. Sonography on injury of the medial patellofemoral ligament after acute traumatic lateral patellar dislocation: Injury patterns and correlation analysis with injury of articular cartilage of the inferomedial patella. Injury 2013;44(12):1892–8.

[3] Calapodopulos CJ, Nogueira MC, Eustaquio JM, Calapodopulos JC, Rodrigues OA. Reconstruction of the medial patellofemoral ligament using autologous graft from quadriceps tendon to treat recurrent patellar dislocation. Rev Bras Ortop 2016;51(2):187–93.

[4] Ding DY, Kanevsky R, Strauss EJ, Jazrawi LM. Anteromedialisation tibial tubercle osteotomy for recurrent patellar instability in young active patients: a retrospective case series. Injury 2016;47(3):737–41.

[5] Neri T, Philippot R, Carnesecchi O, Boyer B, Farizon F. Medial patellofemoral ligament reconstruction: clinical and radiographic results in a series of 90 cases. Orthop Traumatol Surg Res 2015;101(1):65–9.

[6] Rouanet T, Gougeon F, Fayard JM, Remy F, Migaud H, Pasquier G. Sulcus deepening trochleoplasty for patellofemoral instability: a series of 34 cases after 15 years postoperative follow-up. Orthop Traumatol Surg Res 2015;101(4):443–7.

[7] Mistry JB, Bonner KF, Gwam CU, Thomas M, Etcheson JI, Delanois RE. Management of injuries to the medial patellofemoral ligament: a review. J Knee Surg 2018;31(5):439–47.

[8] Conlan T, Garth WJ, Lemons JE. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. J Bone Joint Surg Am 1993;75(5):682–93.

[9] Deie M, Ochi M, Sumen Y, Adachi N, Kobayashi K, Yasumoto M. A long-term follow-up study after medial patellofemoral ligament reconstruction using the transferred semitendinosus tendon for patellar dislocation. Knee Surg Sports Traumatol Arthrosc 2005;13(7):522–8.

[10] Nomura E, Inoue M, Osada N. Anatomical analysis of the medial patellofemoral ligament of the knee, especially the femoral attachment. Knee Surg Sports Traumatol Arthrosc 2005;13(7):510–5.

[11] Zhang GY, Zheng L, Feng Y, Shi H, Liu W, Ji BJ, et al. Injury patterns of medial patellofemoral ligament and correlation analysis with articular cartilage lesions of the lateral femoral condyle after acute lateral patellar dislocation in adults: an MRI evaluation. Injury 2015;46(12):2413–21.

[12] Elias DA, White LM, Fithian DC. Acute lateral patellar dislocation at MR imaging: injury patterns of medial patellar soft-tissue restraints and osteochondral injuries of the inferomedial patella. Radiology 2002;225(3):736–43.

[13] Guerrero P, Li X, Patel K, Brown M, Busconi B. Medial patellofemoral ligament injury patterns and associated pathology in lateral patella dislocation: an MRI study. Sports Med Arthrosc Rehabil Ther Technol 2009;1(1):17.

[14] Zheng L, Shi H, Feng Y, Sun BS, Ding HY, Zhang GY. Injury patterns of medial patellofemoral ligament and correlation analysis with articular cartilage lesions of the lateral femoral condyle after acute lateral patellar dislocation in children and adolescents: an MRI evaluation. Injury 2015;46(6):1137–44.

[15] Zhang GY, Zheng L, Feng Y, Shi H, Liu W, Ji BJ, et al. Injury patterns of medial patellofemoral ligament and correlation analysis with articular cartilage lesions of the lateral femoral condyle after acute lateral patellar dislocation in adults: an MRI evaluation. Injury 2015;46(12):2413–21.

[16] Stefancin JJ, Parker RD. First-time traumatic patellar dislocation: a systematic review[J]. Clin Orthop Relat Res 2007;455:93–101.

[17] Colvin AC, West RV. Patellar instability. J Bone Joint Surg Am 2008;90(12):2751–62.

[18] Jeffcote B, Nicholls R, Schirm A, Kuster MS. The variation in medial and lateral collateral ligament strain and tibiofemoral forces following changes in the flexion and extension gaps in total knee replacement. A laboratory experiment using cadaver knees. J Bone Joint Surg Br 2007;89(11):1528–33.

[19] Goncaives MB, Junior LH, Soares LF, Goncaives TJ, Dos SR, Pereira ML. Medial patellofemoral ligment reconstruction to treat recurrent patellar dislocation. Rev Bras Ortop 2011;46(2):160–4.

[20] Netto AS, de Brito MB, Severino FR, Campos LR, Nico MA, de Oliveira VM, et al. Study on the patellofeloral joint using magnetic resonance imaging: morphological variation of the madical patellofemoral ligament. Rev Bras Ortop 2012;47(2):204–9.

[21] Balcarek P, Ammon J, Frosch S, Walde TA, Schuttrumpf JP, Ferlemann KG, et al. Magnetic resonance imaging characteristics of the medial patellofemoral ligament lesion in acute lateral patellar dislocations considering trochlear dysplasia, patella alta, and tibial tuberosity-trochlear groove distance. Arthroscopy 2010;26(7):926–35.

[22] Putney SA, Smith CS, Neal KM. The location of medial patellofemoral ligament injury in adolescents and children. J Pediatr Orthop 2012;32(3):241–4.

[23] Zhang GY, Zheng L, Ding HY, Li EM, Sun BS, Shi H. Evaluation of medial patellofemoral ligament tears after acute lateral patellar dislocation: comparison of high-frequency ultrasound and MR. Eur Radiol 2015;25(1):274–81.

[24] Balcarek P, Walde TA, Frosch S, Schuttrumpf JP, Wachowski MM, Sturmer KM, et al. Patellar dislocations in children, adolescents and adults: a comparative MRI study of medial patellofemoral ligament injury patterns and trochlear groove anatomy. Eur J Radiol 2011;79(3):415–20.

[25] Zhang Z, Xiang L, Bai D, Fu X, Wang W, Li Y, et al. Treatment with Rhizoma Dioscoreae extract has protective effect on osteopenia in ovariectomized rats. ScientificWorldJournal 2014;2014:1–12.

[26] Sillanpaa P, Mattila VM, Iivonen T, Visuri T, Pihlajamaki H. Incidence and risk factors of acute traumatic primary patellar dislocation[J]. Med Sci Sports Exerc 2008;40(4):606–11.

[27] Panagiotopoulos E, Strzelczyk P, Herrmann M, Scuderi G. Cadaveric study on static medial patellar stabilizers: the dynamizing role of the vastus medialis obliquus on medial patellofemoral ligament. Knee Surg Sports Traumatol Arthrosc 2006;14(1):7–12.

[28] Grelsamer RP. Immediate surgical repair of the medial patellar stabilizers for acute patellar dislocation. A review of eight cases. Am J Sports Med 2001;29(3):389–90.

[29] Bitar AC, D'Elia CO, Demange MK, Viegas AC, Camanho GL. Randomized prospective study on traumatic patellar dislocation: conservative treatment versus reconstruction of the medial patellofemoral ligament using the patellar tendon, with a minimum of two years of follow-up. Rev Bras Ortop 2011;46(6):675–83.

[30] Arliani GG, Da SA, Ueda LR, Astur DC, Yazigi JJ, Cohen M. Reconstruction of the medial patellofemoral ligament in cases of acute traumatic dislocation of the patella: current perspectives and trends in Brazil. Rev Bras Ortop 2014;49(5):499–506.

[31] Arendt EA, Moeller A, Agel J. Clinical outcomes of medial patellofemoral ligament repair in recurrent (chronic) lateral patella dislocations. Knee Surg Sports Traumatol Arthrosc 2011;19(11):1909–14.

[32] Christiansen SE, Jakobsen BW, Lund B, Lind M. Isolated repair of the medial patellofemoral ligament in primary dislocation of the patella: a prospective randomized study. Arthroscopy 2008;24(8):881–7.

[33] Camanho GL, Viegas AC, Bitar AC, Demange MK, Hernandez AJ. Conservative versus surgical treatment for repair of the medial patellofemoral ligament in acute dislocations of the patella. Arthroscopy 2009;25(6):620–5.