Int J Clin Exp Med 2018;11(12):13904-13912
www.ijcem.com /ISSN:1940-5901/IJCEM0070799

Case Report

Postoperative evaluation of single-stage surgery for multiligament injured knee dislocation in elderly patients

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Received December 12, 2017; Accepted August 1, 2018; Epub December 15, 2018; Published December 30, 2018

Abstract: Aim: Limited researches involving the multi-ligament injured knee dislocation have been reported in elderly patients due to its relatively low incidence rate. The purpose of this study was to present the clinical outcomes after surgery of the multi-ligament injured knee dislocation and to analyze the value of surgical timing and comorbid injury treated by early single-stage surgery in aged patients. Methods: Totally 13 elderly patients with multi-ligament injured knee dislocation were collected in this retrospective study. All patients were treated with single-stage surgery. The preoperative and postoperative knee function was evaluated by the Lysholm score and the International Knee Documentation Committee (IKDC) 2000 Subjective Knee Form. Visual Analogue Scale (VAS) pain score and the satisfaction score were also analyzed for assessing postoperative outcome. Results: Mean Lysholm score, average IKDC score before operation and at the final follow-up were 98.0 ± 2.2 and 89.9 ± 4.1; 95.9 ± 1.5 and 81.8 ± 4.5 respectively. VAS pain score decreased significantly from 4.9 ± 0.6 preoperatively to 0.5 ± 0.9 at the final follow-up ($P < 0.01$). According to the grading of Lysholm and IKDC subjective scores, 11 (84.6%) patients were reported as a 'good' postoperative knee function, and 12 (92.3%) patients were regarded as a 'successful' prognosis. However, patients with comorbid meniscus tear showed a clear trend towards a lower postoperative Lysholm score. Conclusions: Early single-stage surgery for multi-ligament injured knee dislocation is clinically feasible in aged patients. Moreover, a more optimized treatment protocol is necessary to the patients with additional meniscus injury.

Keywords: Single-stage surgery, multiligament injured, knee dislocation, elderly patients

Introduction

Traumatic knee dislocation is one of the most catastrophic orthopedic emergencies, characterized by a comprehensive damage to surrounding ligamentous, cartilaginous and neurovascular structures [1]. Traumatic knee dislocation is uncommon but may induce serious long-term disability. The leading causes of traumatic knee dislocation are high-velocity impact injuries such as motor vehicle accident and falling from a height in younger patients [2]. The incidence of traumatic knee dislocation peaks at 10-20 years and falls off along with the growth of the age [3]. In elderly population, knee pain has become the primary reason of social isolation and disability which basically due to osteoarthritis [4]. Meanwhile, evidence showed that the quadriceps muscle-tendon, plays an important role on knee joint function, was displayed less stiffness in elderly people [5]. Also the neuromuscular function has a significant impact on the post-injury rehabilitation. In terms of the therapy to multi-ligament injured knee dislocation, acute single-stage surgery, both of ligament repair and reconstruction, yields satisfactory outcomes and more than half of the patients operated in the acute phase reported an excellent or acceptable postoperative knee function [6]. A long-term follow-up investigation showed that the acute single-stage surgery obtained a mean Lysholm score of 91 points at the second year postoperatively [7]. Of note, the average age of the recruited patients in those studies ranged from 20 to 40 years [3, 8-13]. However, there is

largely insufficient attention has been paid to the elderly patients with traumatic knee dislocations, partially because of its relative low-incidence in the elderly population. Therefore, it remains unclear that whether the single-stage surgery could obtain similarly favorable outcomes in aged patients as the younger counterparts. Besides, there is still lack of studies referring to the prognostic value of the patient characteristics, such as surgical timing and comorbidities in elders.

The purpose of this study was to present the clinical outcome of single-stage surgery in a batch of elderly patients with multi-ligament injured knee dislocations. Meanwhile, another novelty of this research is the investigation on the influence of comorbid knee injuries and surgical timing as prognostic predictors.

Material and methods

Patients

A retrospective study was performed under the approval of the Hospital Ethical Committee of the First Affiliated Hospital of Anhui Medical University (No. 20160103). The clinical database was reviewed in all cases with multi-ligament injured knee dislocation, diagnosed and received the single-stage surgery between May 2011 and May 2016. Written informed consent forms were obtained from all recruitment patients.

Inclusion criteria include: (1) documented multidirectional knee instability at presentation, (2) tears in anterior and/or posterior cruciate ligaments (ACL/PCL) showed in Magnetic Resonance Imaging (MRI) and at least one collateral ligament complex, (3) patients who received a single-stage surgery by the same senior surgeon (B.X.) and undertook a standardized postoperative rehabilitation protocol, and (4) patients aged over 60 years.

Exclusion criteria include: (1) patients who have open or chronic knee dislocations (> 4 weeks after injury), (2) patients received conservative therapies, and (3) patients lost to follow-up.

Based on the aforementioned criteria, 13 patients were finally recruited in this research and the general characteristics of patients were summarized in the Results part.

Surgical technique

The specific operation time was listed in **Table 2** for individual patient. Patients were placed in the supine position on the operating table under general anesthesia.

For preparation of arthroscopy, an approximately 3-cm long longitudinal incision located at the anteromedial portion of the tibia below the tibial tuberosity was made on the injured knee. Then the routine arthroscopy was performed through standard anterolateral and anteromedial portals. All compartments were checked for evaluating associated lesions and additional allografts were prepared as well. A tendon stripper was used to harvest hamstring through the incision. Different types of ligament rupture repair would be introduced as follows:

1. For ruptured cruciate ligaments, ruptured part was removed using basket forceps and the stump was preserved. With the use of an arthroscopic shaver and coagulator, the medial walls of both medial and lateral femoral condyle were prepared. Then femoral tunnels of both ACL and PCL were created on the footprints of the preserved stump. Similarly, tibial tunnels were created through tibial footprints.

After that, the grafts for both ligaments were introduced to the tibial and femoral drill hole and the Endobutton (15-35 mm, Smith & Nephew, MA, USA) was flipped and fixed on the femoral cortical surface. Both grafts in the tibial tunnels were fixed with bioabsorbable interference screws (8-10 mm, Smith & Nephew, MA, USA) at 30° flexion for ACL and 90° flexion for PCL. A metal anchor (5.0 mm, Smith & Nephew, MA, USA) was used to strengthen the grafts out of tibial tunnels.

2. For ruptured medial patellofemoral ligament (MPFL), suture anchors (3.5 mm, Smith & Nephew, MA, USA) fixation on the medial patellar edge and interference screw (6-7 mm, Smith & Nephew, MA, USA) fixation on the Schottle's point of femoral insertion using allograft were performed.

3. As to the ruptured collateral ligament, open surgical approach was performed after arthroscopy to allow for improved soft tissue visualization and to limit fluid extravasation into the sur-

Table 1. Demographic data and injury characteristics of the 13 elderly patients with multi-ligament knee injury

Patientnumber	Gender	Age	Mechanism of injury	Side	Main structure Injury	Comorbid Injuries			Schenck Classification
						MPFL	Meniscus	Other Injuries	
1	M	60	Vehicle accident	R	ACL+PCL+MCL	No	No	Rib fracture	KD-III
2	F	63	Vehicle accident	R	ACL+PCL+MCL+PLC	Yes	Yes	Tibialplateau fracture Fibular head fracture Peroneal nerve injury	KD-V†
3	M	68	Vehicle accident	R	ACL+PCL+MCL	Yes	No	No	KD-III
4	M	69	Vehicle accident	R	ACL+PCL+MCL	No	Yes	No	KD-III
5	M	72	Vehicle accident	R	ACL+PCL+MCL	No	Yes	Distal radius fracture	KD-III
6	M	64	Vehicle accident	L	ACL+PCL+MCL	Yes	No	No	KD-III
7	F	62	Vehicle accident	R	ACL+PCL+MCL	No	Yes	Lumbar vertebra fracture Rib fracture	KD-III
8	M	65	Vehicle accident	L	ACL+PCL+MCL	Yes	No	No	KD-III
9	M	67	Vehicle accident	R	ACL+PCL+MCL	No	No	No	KD-III
10	M	63	Fall from height	R	ACL+PCL+MCL+PLC	No	Yes	No	KD-IV
11	F	62	Vehicle accident	L	ACL+PCL+MCL	No	No	No	KD-III
12	M	70	Vehicle accident	L	ACL+PCL+MCL+PLC	No	Yes	Lateral malleolus fracture	KD-IV
13	M	65	Vehicle accident	R	ACL+PCL+MCL	Yes	No	No	KD-III

Notes: †indicates associated nerve injury; ACL, anterior cruciate ligament; MCL, medial collateral ligament; MPFL, medial patellofemoral ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner.

gical site. Rupture site was identified carefully and repaired at insertion site using a suture anchor (5 mm, Smith & Nephew, MA, USA).

4. Repair of the posterolateral corner (PLC) was conducted in avulsion of popliteus and fibular collateral ligament. After decorticating bone at the site of insertion, relevent structure was directly repaired using suture anchors (5 mm, Smith & Nephew, MA, USA).

Data collection

Demographic data of each patient was reviewed and recorded, comprised of the mechanism of injury, type of knee dislocation and comorbid injuries. Type of knee dislocation is categorized according to the Wascher modified Schenck classification [14]. Before the implementation of surgery, the pre-injury function of the affected knee was evaluated by the Lysholm score and International Knee Documentation Committee (IKDC) 2000 Subjective Knee Formafter the interview of each patient [15, 16]. The preoperative and postoperative pain was assessed bya Visual Analog Scale (VAS) pain score [17]. In the period of follow-up, the function of the operated knee was evaluated by Lysholm score and IKDC subjective score respectively, and the degree of patient satisfaction of clinical outcomes (0-10; 0: dissatisfaction; 10: fully satisfaction) was recorded.

The Lysholm score is categorized as the following four levels: excellent (95-100), good (84-94), fair (65-83), and poor (≤ 64) [18]. The IKDC normative data obtained by Anderson et al. was regarded as the criterion compared with the IKDC subjective knee score in this research [19]. The IKDC score of the patients was compared with the mean IKDC score of age- and gender-matched population, a higher score is defined as having "successful" treatment while a lower one is defined as "unsuccessful" treatment [20].

Statistical analysis

Continuous variables were described using mean ± standard deviation (SD), median and range. Data distribution was analyzed by D'Agostino & Pearson omnibus normality test. Wilcoxon signed-rank test was used for matched comparisons. Wilcoxon signed-sum test was used to analyze the effects of independent variables. The level of significance was set at 0.05. Statistical analysis was performed with SPSS (IBM SPSS 20, SPSS Inc., Chicago, IL).

Results

Characteristics profiles of patients

13 Patients (male 10, female 3) with multi-ligament injured knee dislocations caused by high-

Table 2. Surgical data and function outcome after single-stage surgery

Patient number	Surgical timing (days after injury)	Surgical procedures		Duration of surgery (minutes)	Lysholm score		IKDC score		VAS score		Satisfaction score
		Reconstruction	Repair		Pre-OP	Final follow-up	Pre-OP	Final follow-up	Pre-OP	Final follow-up	
1	31	ACL+PCL	MCL	85	100	99	97	90	4.3	0	10
2	13	ACL+PCL+MPFL	MCL+PLC	130	100	85	98	74	5.1	2.1	7
3	15	ACL+PCL	MCL+MPFL	90	100	91	97	77	4.5	2	8
4	17	ACL+PCL	MCL	90	95	87	97	87	4.3	0	10
5	14	ACL+PCL	MCL	87	100	89	95	79	5.2	1.5	8
6	17	ACL+PCL+MPFL	MCL	100	100	87	94	80	4.6	0	8
7	28	ACL+PCL	MCL	95	96	89	94	82	5.5	0	8
8	16	ACL+PCL	MCL+MPFL	110	95	92	95	83	5	0	8
9	16	ACL+PCL	MCL	93	95	89	94	78	4.8	1.3	7
10	18	ACL+PCL	MCL+PLC	125	100	92	95	79	5	0	8
11	14	ACL+PCL	MCL	90	98	92	98	84	5.7	0	8
12	19	ACL+PCL	MCL+PLC	100	98	83	97	84	6.2	0	9
13	15	ACL+PCL	MCL+MPFL	95	97	93	95	86	3.9	0	9
Mean ± SD	17.9 ± 5.4	-	-	99.2 ± 14.2	98.0 ± 2.2	89.9 ± 4.1	95.9 ± 1.5	81.8 ± 4.5	4.9 ± 0.6	0.5 ± 0.9	8.3 ± 0.9

Notes: The pre-OP Lyscholm score and IKDC score showed the best functional level of the injured knee before injury after interviewing each patient preoperatively. The pre-OP VAS score showed the pain after injury.

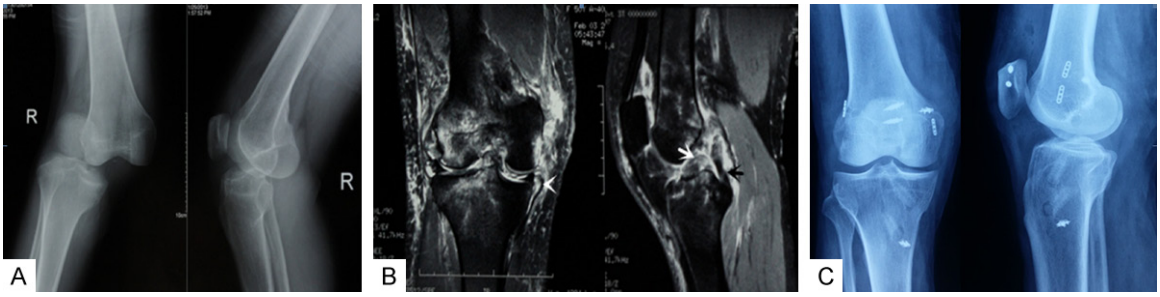

Figure 1. The radiographs of a dislocated knee with multi-ligamentous injuries before (A, B) and after (C) a single-stage surgery. (A) Preoperative anteroposterior (AP) and lateral radiographs indicate lateral dislocation. (B) Magnetic resonance imaging (MRI) of the same knee showing simultaneous rupture of ACL (white arrow), PCL (black arrow) and MCL (white arrowhead); (C) AP and lateral plain radiographs following reconstruction of ACL & PCL using Endobutton and interference screws, reconstruction of medial patellofemoral ligament (MPFL) using suture anchors on the medial patellar edge and interference screw on the Schottle's point of femoral insertion, MCL was repaired using a suture anchor on the femoral side.

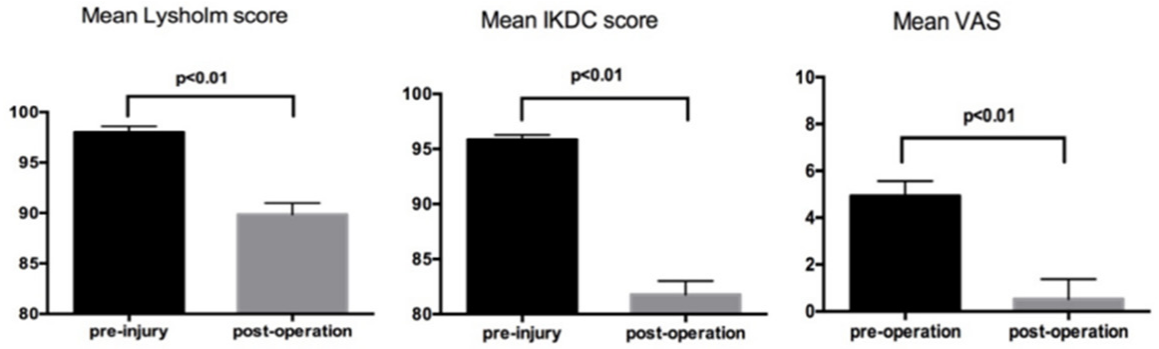

Figure 2. Comparison of average Lysholm score, IKDC subjective score and VAS score before and after the single-stage surgery.

speed impact accidents were enrolled and numbered, with a mean age of 65.3 ± 3.6 years (median 65.0, range 60-73) (**Table 1**). In terms of the keen dislocation position, 9 patients (69.2%) injured on the right knee while 4 cases (30.8%) happened to the left knee. According to the Wascher modified Schenck classification, patterns of injury were classified into KD-III (10 cases), KD-IV (2 cases) and KD-V (1 case). MPFL rupture was detected in 5 cases (38.4%), and meniscus tear was found in 6 cases (46.2%). The injured structures in most participants were the combination of ACL, PCL and medial collateral ligament (MCL), meanwhile, additional posterolateral corner (PLC) injured in 3 cases. The average follow-up time was 17.5 ± 3.2 months (median 17.0, range 12-23). Apart of MPFL and meniscus injured, there are several kinds of injury happened along with the knee dislocation, including rib fracture, tibial plateau fracture, fibular head fracture, distal radius fracture, lumbar vertebra fracture and lateral malleolus fracture. The patient, only one in KD-V pattern, suffered the peroneal nerve injury. There was no patient presented the preoperative vascular injury or any vascular complications during the follow-up.

Surgical treatment

Totally 11 patients (84.6%) were operated in the acute phase (< 3 weeks after injury), but the other 2 patients had to be operated in the fourth and fifth week due to the comorbid thoracic trauma and fractures (28 and 31 days after the injury). Theaverage timing of surgery was 17.9 ± 5.4 days (median 16.0, range 13-31) after injury And the duration time of the surgery was 99.2 ± 14.2 minutes (median 95.0, range 85-130) (**Table 2**). Depending on the specific scenario, injured ligaments were either repaired or reconstructed with hamstring autograft or allograft and the specific surgical procedures and corresponding structure were

Table 3. Comparison of average Lysholm score, IKDC subjective score, and VAS score at the final follow-up

	MPFL injury		*P* value	Meniscus injury		*P* value
	Yes	No		Yes	No	
Lysholm score	89.6 ± 3.4	90.0 ± 4.6	0.97	87.5 ± 3.2	91.9 ± 3.8	0.05
IKDC score	80.0 ± 4.7	82.9 ± 4.2	0.33	80.8 ± 4.5	82.6 ± 4.6	0.66
VAS score	0.8 ± 1.1	0.4 ± 0.7	0.38	0.6 ± 0.9	0.5 ± 0.8	0.70

listed in **Table 2**. **Figure 1** illustrates the radiographs and MRI image of one specific case before and after the single-stage surgery with the visual reconstruction and repair outcomes.

Outcome evaluation

Mean Lysholm score before injury and at the final follow-up were 98.0 ± 2.2 (median 98.0, range 95-100) and 89.9 ± 4.1 (median 89.0, range 83-99), respectively. According to the grading of Lysholmscore, the postoperative knee function of 11 patients (84.6%) was reported as 'good' and 1 patient (7.7%) could be classified as 'excellent'. The rest patient with the lowest score (83) was classified as 'satisfied' (**Table 2** and **Figure 2**). Average IKDC subjective score before injury and at the final follow-up were 95.9 ± 1.5 (median 95.0, range 94-98) and 81.8 ± 4.5 (median 82.0, range 74-90) respectively. The normative IKDC subjective score of population over 51 years is 77.4 ± 23.3 for men and 70.9 ± 22.0 for women [17]. Compared with this 'normal' control, 12 (92.3%) patients were regarded as having "successful" outcomes, and only 1 patient (No. 3) was classified as "unsuccessful". Despite that both postoperative Lysholm and IKDC subjective score didn't reach pre-injury level (both $P < 0.01$), the final outcome was fairly satisfactory after the grading. Mean VAS score significantly decreased ($P < 0.01$) from 4.9 ± 0.6 (median 5.0, range 3.9-6.2) preoperatively to 0.5 ± 0.9 (median 0, range 0-2.1) at the final follow-up. The patient subjective satisfaction score at the final follow-up was 8.3 ± 0.9 (median 8.0, range 7-10). Besides, 11 patients who were operated within 3 weeks yielded an average of 89.1 in Lysholm score, 81.0 in IKDC subjective score, and 0.6 in VAS score. The rest 2 patients operated in the fourth and fifth week after injury obtained an average Lysholm score of 94.0 and IKDC subjective score of 86.0. The comparison of average Lysholm score, IKDC subjective score and VAS score before and after the single-stage surgery was analyzed in **Figure 2** which all have statistic difference ($P < 0.01$).

Depending on the comorbid MPFL injury and meniscus tear, the enrolled patients were divided into separate subgroups (**Table 3**). No significant difference of final knee function was detected between the patients with and without a comorbid MPFL injury (all $P > 0.05$). Regarding to the meniscal comorbidity, 6 patients with a comorbid meniscus tear (46.2%) showed a clear trend towards a lower postoperative Lysholm score ($P = 0.05$). However, the postoperative mean IKDC subjective score and VAS score were comparable irrespective to the occurrence of a meniscal injury ($P = 0.66$ and 0.71, respectively).

Discussion

The most significant finding of this study was that the single-stage surgery yielded a satisfactory outcome in elderly patients with multiligament injured knee dislocations. MPFL and meniscus injuries were the two main types of comorbidities, meanwhile the patients with the comorbid meniscus tear indicated a coincident lower Lysholm score compared to other comorbifities.

Injury pattern

Injury pattern is related to the prognosis of traumatic knee dislocation. Previous studies with a relatively large sample size found that KD-III dislocation involved 60-80% of the total population with knee dislocation, and KD-IV patients had significantly lower IKDC scores than KD-II and KD-III patients [21, 22]. In this research, KD-III dislocation was also the predominant type (76.9%) in our patients which highly consists with those studies. However, the limited sample size of other subtypes needs the further comparison of the results among different KD types.

Operative to conservative treatment

Operative treatment is superior to conservative treatment in general knee dislocations, as

showing by improved postoperative range of motion, a smaller range of degree of flexion contracture [23]. Peskun et al. collected both operative and non-operative treatment outcomes of multi-ligament knee injuries from previous studies in an evidence-based review [24] and it summarized that the average Lysholm score of the operated (mean age 30.5 years) and non-operated (mean age 29.1 years) cohorts was 84.3 and 67.2, respectively. Another study from Levy et al. obtained an average IKDC subjective score of 78 in the operated patients [25] Compared with these data in younger population, the final results of postoperative knee function was even better in our elderly patients in this research. Besides, postoperative knee function of 11 (84.6%) patients was reported as 'good' according to the Lysholm score, and 12 (92.3%) patients in our cohorts were reported as 'successful' with a higher IKDC subjective score compared with normative data. Therefore, surgical intervention in elderly traumatic knee dislocation could achieve a reasonable and satisfactory outcome.

Single-stage surgery to multistage surgery

Controversy still existed on the optimal stage management of knee dislocations. Advocators for multistage surgery declared that the single-stage surgery resulted in extensive damage to the joint capsule and the periarticular soft tissue, which could further lead to difficulties in rehabilitation and limited range of motion [26]. A systematic review of evidence level IV studies from Jiang et al. reported an excellent or good function score in 54.5% single-stage treated patients and 79.1% multistage treated patients [6]. Notably, this review only enrolled KD-III type dislocation, hence the result could not give the sufficient evidence to the merit of multistage treatment. In contrast, a large amount of evidence demonstrated that the single-stage surgery could also produce an excellent postoperative knee function [11, 13, 27]. Hirschmann et al. performed an average 12 years follow-up in 74 multi-ligament injured patients treated with a single-stage reconstruction/repair, in which 80% patients got the ability to return to their previous work and 60% patients showed a good or excellent function assessment [27]. Similarly, all elder patients in this study received single-stage surgery and the overall outcome was excellent at final follow-up. Throughout the current research findings, it is hardly can reach a consensus of the optimal stage management of knee dislocation, more convincing studies are necessitated to construct stage management algorithm of knee dislocation in younger and elder population.

Surgical timing

Early intervention can achieve a positive result on the immediate recovery of the range of motion and prevents the formation of scar tissue that may compromise the long-term outcome of the operated knee [28]. Chhabra and his colleagues reported that patients operated within 3 weeks after injury yielded a better knee function than the patients who operated later than 3 weeks after injury [11]. In this study, most elder patients (84.6%) were operated within 3 weeks after injury, and the overall reasonable outcome indicated the feasibility of the early single-stage surgery in elderly patients.

Comorbidities

MPFL lesion and meniscus injury are the two most common comorbidities in this study, involving 38.5% and 46.2% incidence of all patients. The varus mechanism of dominant injury pattern KD-III can easily lead to the rupture of MPFL and patellar dislocation. Engebretsen L et al. pointed out that 6% dislocated knees had an associated patellar dislocation which the corresponding incidence (38.4%) was much higher in our study [21]. No significant difference was found in aspect of postoperative Lyshlom score, IKDC subjective score, and VAS pain score between the patients with and without MPFL lesion. The probable explanation is that the overwhelming multi-ligamentous ruptures presumably covered the impairment of patellar dislocation, and the evaluation scores here didn't involve the assessment to patellar function and maybe not sensitive enough to detect this divergence. A more systematic knee dislocation classification and score including assessment of patella or MPFL could be analyzed in further researches. Furthermore, meniscus tear is the other common comorbidity during knee dislocations which also showed in this study [29]. A mid-term follow-up study showed that meniscus tear was presented in 56% patients with an inferior IKDC subjective score [30]. This is consistent with

the decreased postoperative Lysholm score in our patients with a comorbid meniscus injury. Therefore, an in-depth evaluation and treatment is warranted for a better prognosis of patients with the multi-ligament injured knee dislocation with a comorbid meniscus tear.

There are also several limitations in this study. Firstly, no KD-I and KD-II dislocation cases were enrolled in this study due to the limited sample size which might represent the natural stage distribution of this disease. Secondly, the source of graft (allograft or autograft) and the type of procedure (repair or reconstruction) were not the focus of our study, therefore no further subgroup analyses were performed regarding to these issues. Thirdly, no control group of younger patients was presented in this study. Instead, sufficient historical control data of younger knee dislocations were taken into comparison with our patients.

This study firstly provides insight into the prognostic predictors and surgical treatment of knee dislocations in elderly patients. It displayed a series of aged knee dislocations with detailed information about the surgery and prognosis, and analyzed the influence of two common comorbidities and surgical timing, which are lacking in previous reports.

Conclusions

Single-stage surgery for multi-ligament injured knee dislocation is clinically feasible for elderly patients with an acceptable clinical outcome. Relatively low postoperative Lysholm score was showed in the patients with both ligament and meniscus injuries which indicates that an in-depth evaluation and treatment protocol might be necessary for this type of patients for better curative effect.

Acknowledgements

A retrospective study was performed under the approval of the Hospital Ethical Committee of the First Affiliated Hospital of Anhui Medical University (No. 20160103). Written informed consent forms were obtained from all recruitment patients.

Disclosure of conflict of interest

None.

Abbreviations

IKDC, the International Knee Documentation Committee; VAS, Visual Analogue Scale; ACL/PCL, anterior and/or posterior cruciate ligaments; MRI, Magnetic Resonance Imaging; MPFL, medial patellofemoral ligament; PLC, the posterolateral corner; SD, standard deviation; MCL, medial collateral ligament.

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