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Original Article

Single-stage versus two-stage reconstruction in chronic multi ligament knee injury

Mohammad Jesan Khan, Naiyer Asif, Anubhav Sharma, Yasir Salam Siddiqui, Abdul Qayyum Khan

Department of Orthopaedic Surgery, J. N. Medical College, Faculty of Medicine, A.M.U., Aligarh 202002, Uttar Pradesh, India

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Abstract: Background: Multi ligament knee injury (MLKI) refers to the disruption of at least 2 of the 4 major knee ligaments. These injuries are managed in single and two-stage surgeries however, treatment guidelines for best practice are unsettled. There is no study in the literature that compares single and two-stage surgery for the management of chronic multiligament knee injury. Therefore, the aim of this study was to compare the functional outcome between single-stage and two-stage surgical fixation in chronic multi-ligament knee injury. Methods: Twenty seven patients with chronic MLKI with at least 2 years of follow up were included. Fourteen patients underwent reconstruction of torn ligaments in a single-stage operation (Group I) and 13 patients underwent reconstruction of torn ligaments in two stages (Group II). Assessment of clinical outcome was done with IKDC knee score, TEGNER LYSHOLM knee score, range of movement and laxity tests (Anterior drawer test, Lachman, Posterior drawer test, pivot shift test, dial test, varus and valgus stress test). Results: At final follow up, there was no significant difference in post-operative IKDC knee scores in group I and group II (84.7±7.1 and 81.4±8.4 respectively, p=0.3) and Lysholm scores (85.8±8.3 and 80.9±8.3 respectively, p=0.1), range of movement (133.2±5.7 and 131.5±6.6 respectively, p=0.5) and all the patients regained full extension. At the final follow up 12/14 patients (85.7%) in group I and 11/13 patients (84.6%) in group II had a negative/grade 1 anterior drawer test (p=0.6), 14/14 (100%) in group I and 13/13 (100%) patients had negative/grade 1 lachman test (p=0.6), 13/14 patients (92.8%) in group I and 13/13 patients (100%) patients in group II had negative/grade 1 pivot shift test (p=0.4), 9/10 patients (90%) in group I and 12/13 patients (92.3%) in group II had negative/grade 1 posterior drawer (p=0.6), 6/6 patients (100%) in group I and 6/7 patients (85.7%) in group II had negative/grade 1 dial test (p=0.3), 5/6 patients (83.3%) in group I and 5/7 patients (71.4%) in group II had negative/grade 1 varus stress test (p=0.4), 6/7 patients (85.7%) in group I and 7/7 patients (100%) in group II had negative/grade 1 valgus stress test (p=0.1). Conclusion: Chronic MLKI managed by single stage and two stage reconstruction provides similar functional outcomes. Level of Evidence: Level III Retrospective Cohort Study.

Keywords: Multi ligament knee injury, single-stage, two-stage

Introduction

Multi ligament knee injury (MLKI) is a complex and challenging orthopaedic entity that usually follows traumatic knee dislocation. It causes significant loss of function and leads to pain and instability in the long term. The MLKI is referred to as the disruption of at least two of the four major knee ligaments, including anterior cruciate ligament (ACL), posteromedial corner including the medial collateral ligament (MCL), posterior cruciate ligament (PCL), and posterolateral corner (PLC) including the lateral collateral ligament [1]. Current treatment involves arthroscopic anatomic reconstruction of cruciate ligaments, anatomic MCL reconstruction and fibula sling based anatomic reconstruction for PLC.

Treatment protocol for the multi ligament knee injuries is continuously evolving. The concomitant approach has been favoured for decreasing the overall number and period of surgery and its benefits of early intervention and rehabilitation using knee brace [2-5]; however, it exposes patients to long hours of invasive surgery which increases the chance of postoperative complications such as knee joint stiffness

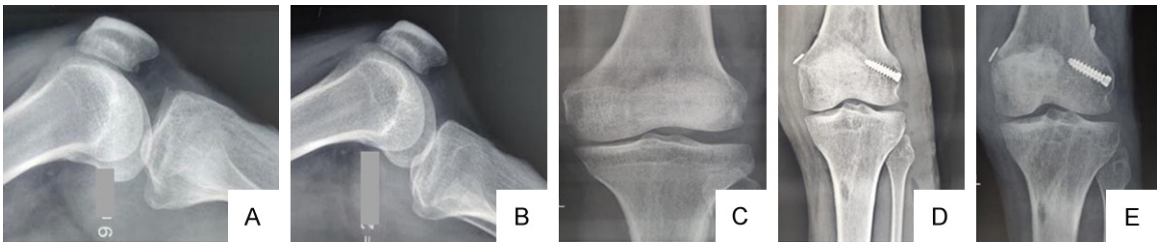

Figure 1. It shows anterior translation of tibia (A), posterior translation of tibia (B), lateral opening of joint line on varus stress test (C), PCL and LCL reconstruction in one stage (D) and ACL reconstruction at second stage (E) in KDIV injury.

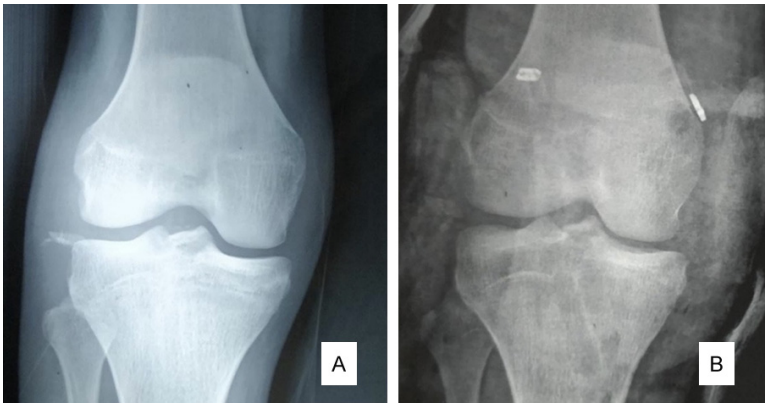

Figure 2. It shows preoperative radiograph of KDIIIL injury (A) and ACL, PCL and LCL reconstruction in single stage (B).

and infection [2, 6, 7]. Conversely, a staged procedure improves clinical outcomes after repair of multiple ligament injuries with no decrease in range of motion (ROM) of the knee [2, 3]. Bin et al. [8] have reported good functional outcomes in patients managed through two stage surgery. Subbiah et al. [9] found a satisfactory outcome in terms of stability and range of motion with two-stage surgery. On the contrary, Godin et al. [10] recommended single-stage surgery as a reliable worthy procedure. Similarly, Bagherifard et al. [1] and Billieres et al. [11] considered single-stage reconstruction as an effective and useful method of treating such patients.

To the best of our knowledge, no study has been published on the comparison of single-stage versus two-stage surgery for the management of chronic MLKI [12, 13]. So, there is a dearth of high-level evidence on the appropriate surgical management of this rare, but crippling entity. Formulation of cohort studies on difficult problems and studying their outcome is a useful approach in designing the best treatment protocols. With this perspective, this retrospective study was conducted to compare single-stage (**Figure 1**) versus two-stage reconstruction (**Figure 2**) in chronic MLKI.

Material and methods

A total of 41 patients with chronic MLKI were identified between May 2015 to May 2018, out of which 27 patients [14 patients in single-stage (Group I) and 13 patients in two-stage (Group II)] were included in the study. This study got approval from the institutional ethical committee (D. No. 1835/FM/IEC).

Inclusion and exclusion criteria

Patients with MLKI with age between 20-50 years, knee flexion of at least 90°, no prior knee ligament reconstruction and patients with a minimum 2 years of postoperative follow up were included. Exclusion criteria were patients with previous knee surgery, mal-alignment and severe osteoarthritis of knee (IKDC grade D).

Decision for two-stage surgery was made on the basis of duration of surgery and hemodynamic stability. All those surgeries were converted into two stages where tourniquet time exceeded three hours, and patients were hemodynamically not stable.

Radiographs of injured knees were done to delineate any associated bony injury and confirmation of our diagnosis by stress views in all cases. MRI knee was done to document the status of injured ligaments, associated meniscus and chondral injuries.

Measurement tools

The observation indicators were range of motion, knee stability and functional outcome. Assessment of flexion and extension (range of motion) of knee was done using the standard goniometric technique [14]. Knee Stability was assessed thorough manual examination of the ligaments (anterior drawer, lachman, pivot shift, posterior drawer, varus and valgus stress test), and functional Outcome was assessed by IKDC knee score and Tegner Lysholm knee score [14].

Surgical technique

The surgery was done by a senior orthopaedic surgeon. After spinal anaesthesia, the uninvolved limb was placed in full extension. After tourniquet application, the patient was kept in the supine position. The ligamentous injuries were reassessed under anaesthesia. Diagnostic arthroscopy was performed through the standard anteromedial and anterolateral portals. ICRS grade 1 and grade 2 chondral lesions were managed conservatively. For grade 3 chondral lesion debridement was done only for unstable fragments. Only 2 patients had grade 4 chondral lesions where micro fracture was done. As all patients presented late, partial meniscectomy was done to address meniscus lesions.

In group I patients, the reconstruction was done in the following order: PCL, LCL/PLC, MCL and ACL.

Anatomic single bundle arthroscopic reconstruction of ACL and PCL was performed [15]. Hamstring and peroneus longus grafts were harvested from the same or opposite leg as per methods described by Asif et al. and Khan et al. [16, 17]. For MCL reconstruction, grade I and II tears were managed conservatively. For grade III tear, open reconstruction by modified Bosworth technique using Hamstring graft was done [18]. In the same way, grade I and II LCL tears were managed conservatively and grade III tears were managed by Larson's technique using hamstring graft [19]. The sequence in graft tensioning was PCL, ACL and then collaterals.

In group II patients, PCL and collateral ligaments were addressed first, and when 90-degree knee flexion was achieved during postoperative rehabilitation, ACL was reconstructed at a subsequent stage [20]. Only three doses of antibiotics prophylaxis were given during perioperative period as per our institutional protocol [21].

Rehabilitation protocol

Physiotherapy started from day one with quadriceps muscle building and early progressive passive ROM (range of motion) exercises. For patients with reconstructed PCL, active knee flexion was delayed for 6 weeks. Partial weight-bearing was advised from first post-operative day keeping the knee brace locked in extension which progressed to full weight-bearing walk after 8 weeks. Once a patient developed adequate neuromuscular control without any pain, return to sports specific exercises was allowed. Return to athletic activities was allowed after 12 months [1].

Statistical analysis

Statistical analysis was done with SPSS software (version 20). For quantitative data, unpaired t test and for qualitative data Fisher's exact test was used to compare functional outcome between group I and group II. A *P*-value of <0.05 was considered significant.

Result

A total of 27 patients were included with 14 patients in Group I and 13 patients in Group II. All the patients were males. Group I had 4 KD I, 2 KD II, 4 KD III M, and 4 KD III L while Group II, 2 had KD II, 4 KD III M, 3 KD III L, 3 KD IV and 1 was KD V. The most common pattern of injury was bicruciate with collateral tear (55.5%). One patient in group I had united fracture of the head of the fibula and two patients in group II had united medial tibial condyle fracture and united fracture shaft of tibia and fibula. 7/14 (50%) patients in group I and 7/13 (53.8%) patients in group II had associated chondral lesions out of which in group I, 2 were ICSRS grade 1, 3 were grade 2, 1 was grade 3 and 1 was grade 4 while in group II 3 were ICRS grade 1, 2 were grade 2, 1 was grade 3 and 1 was grade 4. Demographic data is presented in **Table 1**.

All patients presented after 3 weeks from injury. There was no significant difference in Age, time from injury to surgery, side involved, mech-

Table 1. Demographic parameters and pre-operative functional assessment

	Group I	Group II	*p* value[a]
Gender			
Male	14	13	--
Female	0	0	--
Age (Yrs)	36.5±9.7 (22-52)	35.1±10.2 (22-52)	0.7
Time from injury to surgery (months)	5.1±2.9 (1-11)	8.6±5.6 (1-22)	0.5
Side Involved			
Right	8 (57.1%)	6 (42.9%)	0.7
Left	6 (47.9%)	7 (52.1%)	
Mechanism of Injury			
RTA	10 (71.4%)	10 (76.9%)	1.0
Sports Injury	4 (28.6%)	3 (33.1%)	
Medial meniscus			
Normal	9 (64.3%)	7 (53.8%)	0.7
Tear	5 (35.7%)	6 (46.2%)	
Lateral meniscus			
Normal	11 (78.6%)	8 (61.5%)	0.6
Tear	3 (31.4%)	5 (38.5%)	
IKDC (PREOPERATIVE)	43.8±9.4 (29-58)	44.4±7.6 (31-57)	0.9
TEGNER LYSHOLM KNEE SCORE (PREOPERATIVE)	43.9±11.7 (28-65)	43.2±8.2 (33-59)	0.9
Range of movement (Flexion)	[104.6±11.7] (90-130)	[105.8±12.1] (90-125)	0.8

[a]unpaired t test. IKDC: International Knee Documentation Committee.

Table 2. Post-operative clinical and functional outcome assessment

	Group I	Group II	*p* value[a]
IKDC			
6 months	72.2±5.9 (56-79.3)	67.8±5.1 (58-78)	0.04
2 years	84.7±7.1 (63.1-92.3)	81.4±8.4 (61-90.8)	0.3
TEGNER LYSHOLM KNEE SCORE			
6 months	73.5±8.9 (54-90)	66.9±7.7 (56-81)	0.03
2 years	85.8±8.3 (61-95)	80.9±8.3 (64-90)	0.1
Range of Movement			
6 months	118.9±7.6 (110-135)	112.3±9.9 (90-125)	0.1
2 years	133.2±5.7 (125-140)	131.5±6.6 (120-140)	0.5

[a]unpaired t test. IKDC: International knee documentation committee.

anism of injury, associated meniscus injury and preoperative IKDC score, LYSHOLM score, range of movement and laxity tests between group I and II patients (**Table 1**).

Clinical and functional outcome

At 6 months follow up (**Table 2**) mean IKDC knee score was significantly better in group I as compared to group II (72.2±5.9 and 67.8± 5.1 respectively, P=0.04), mean Tegner Lysholm knee score was significantly better in group I with respect to group II (73.5±8.9 and 66.9±7.7 respectively, P=0.03). However, there was no significant difference in mean ROM in group I and group II (118.9±7.60 and 112.3±9.90 respectively, P=0.1).

At the end of 2 years (**Table 2**), there was no significant difference in IKDC score in group I and group II (84.7±7.1 and 81.4±8.4 in group II respectively, P=0.3), Tegner Lysholm knee score (85.8±8.3 and 80.9±8.3 respectively, P=0.1) and range of movement (133.2±5.7 and 131.5±6.6 respectively, P=0.5).

At final follow up (**Table 3**), 12/14 (85.7%) in group I and 11/13 patients (84.1 KD V6%) in

Table 3. Clinical laxity test assessment at preoperative and at final follow up

Test	Preoperative			Postoperative		
	Group I	Group II	*P* value[b]	Group I	Group II	*p* value[b]
Anterior Drawer Test						
GRADE 0	0 (0%)	0 (0%)	0.6	8 (57.1%)	5 (38.5%)	0.6
GRADE 1	0 (0%)	0 (0%)		4 (28.6%)	6 (46.1%)	
GRADE 2	3 (21.4%)	1 (7.7%)		2 (14.2%)	2 (15.3%)	
GRADE 3	11 (78.6%)	12 (92.3%)		0 (0%)	0 (0%)	
Lachman Test						
GRADE 0	0 (0%)	0 (0%)	0.1	10 (71.4%)	8 (61.5%)	0.6
GRADE 1	2 (14.28%)	0 (0%)		4 (28.6%)	5 (38.5%)	
GRADE 2	1 (7.1%)	4 (30.8%)		0 (0%)	0 (0%)	
GRADE 3	11 (78.6%)	9 (69.2%)		0 (0%)	0 (0%)	
Pivot shift test						
GRADE 0	0 (0%)	0 (0%)	0.8	11 (78.6%)	9 (69.2%)	0.4
GRADE 1	2 (14.3%)	1 (7.6%)		2 (14.3%)	4 (30.8%)	
GRADE 2	4 (28.6%)	5 (38.5%)		1 (7.1%)	0 (0%)	
GRADE 3	8 (57.1%)	7 (53.8%)		0 (0%)	0 (0%)	
Posterior Drawer test						
GRADE 0	0 (0%)	0 (0%)	0.3	5 (50%)	9 (69.2%)	0.6
GRADE 1	1 (10%)	0 (0%)		4 (40%)	3 (23.1%)	
GRADE 2	3 (30%)	2 (15.4%)		1 (10%)	1 (7.7%)	
GRADE 3	6 (60%)	11 (84.6%)		0 (0%)	0 (0%)	
Dial test						
NEGATIVE	4 (66.7%)	3 (42.8%)	0.4	6 (100%)	6 (85.7%)	0.3
POSITIVE	2 (33.3%)	4 (57.1%)		0 (0%)	1 (14.3%)	
POSTERIOR SAG						
ABSENT	0 (0%)	0 (0%)	*	9 (90%)	12 (92.3%)	0.8
PRESENT	10 (72.4%)	13 (100%)		1 (10%)	1 (7.7%)	
Varus Stress test						
GRADE 0	0 (0%)	0 (0%)	0.2	1 (16.7%)	3 (42.8%)	0.4
GRADE 1	0 (0%)	1 (14.3%)		4 (66.7%)	2 (28.6%)	
GRADE 2	2 (33.3%)	0 (0%)		1 (16.7%)	1 (14.3%)	
GRADE 3	4 (66.7%)	6 (85.7%)		0 (0%)	1 (14.3%)	
Valgus Stress test						
GRADE 0	0 (0%)	0 (0%)	0.2	3 (42.8%)	0 (0%)	0.1
GRADE 1	2 (28.6%)	1 (14.3%)		3 (42.8%)	7 (100%)	
GRADE 2	0 (0%)	0 (0%)		1 (14.3%)	0 (0%)	
GRADE 3	5 (71.4%)	6 (85.7%)		0 (0%)	0 (0%)	

*b, Fischers exact t test.

group II had a negative/grade 1 anterior drawer test (P=0.6), 14/14 (100%) in group I and 13/13 (100%) patients had negative/grade 1 lachman test (P=0.6), 13/14 (92.8%) in group I and 13/13 (100%) patients in group II had negative/grade 1 pivot shift test (P=0.4), 9/10 (90%) in group I and 12/13 (92.3%) in group II had negative/grade 1 posterior drawer (P=0.6), 6/6 (100%) in group I and 6/7 (85.7%) in group II had negative/grade 1 dial test (P=0.3), 5/6 (83.3%) in group I and 5/7 (71.4%) in group II had negative/grade 1 varus stress test (P= 0.4), 6/7 (85.7%) in group I and 7/7 (100%) in group II had negative/grade 1 valgus stress

test (P=0.1). Laxity assessment between group I and Group II were comparable with no significant difference (P>.05).

Complications

Two patients in group I and one patient in group II developed superficial wound infection, which improved with oral antibiotics and dressing. One patient with KD IV injury in the group I developed common peroneal nerve palsy with foot drop and was managed with ankle-foot orthoses.

Discussion

The principal finding of this study is that both single-stage and two-stage multi-ligament reconstruction achieve comparable functional outcomes at 2 years follow up. Multi ligament knee injury is a rare entity with varied presenting combinations that makes it difficult to assess and compare outcome. Non-operative management in MLKI with prolonged immobilization was a concept in the past, however, recent studies favour the superiority of surgical management [22, 23]. Previous studies have documented a role of primary/delayed repair only in avulsion injuries of cruciate ligaments and have shown conclusively better outcome with reconstruction in mid substance tears involving collateral and cruciate ligaments [24]. Earlier studies have analyzed variables that affect outcome such as conservative versus surgical management, early versus delayed surgery, repair versus reconstruction, one stage versus two stage surgery as well as various aspects of operative management such as graft options, tensioning sequence and rehabilitation protocols, but mostly previous literature has discussed management of acute injury [5, 25-32]. Knowledge pertaining to management of chronic MLKI remains meagre as only a few studies have discussed its outcomes [32-36]. To the best of our knowledge, this is the first study to compare functional outcome in single stage versus two stage reconstruction of chronic MLKI.

Sequence of graft tensioning and fixation in single stage surgery remains controversial with studies advocating restoration of central pivot and tibial step off by PCL reconstruction followed by ACL, PLC and lastly PMC [32] whereas Wentorf et al. advocated for PLC fixation before ACL to avoid tibial external rotation first [37].

In our study in single-stage reconstruction, PCL was tensioned and fixed first at 90-degree flexion then femoral sockets of both PLC and ACL were fixed followed by fixing tibial end of ACL graft on the tibia. The MCL was tensioned last and fixed in 30-degree flexion with varus force. We followed this sequence as PMC, PLC and posterior capsule are the primary restraints to varus-valgus and rotational displacement whereas ACL/PCL becomes the primary restraint to anterior-posterior displacement and secondary restraint to rotational stability [38-40]. PCL maintains sagittal alignment of the knee and prevents posterior sagging of tibia, which adversely affects healing of the reconstructed ligament. Therefore, PCL reconstruction is done at the commencement of the procedure to achieve successful outcome in knee dislocations [41].

Sequence of repair in Staged surgery can be PLC followed by concomitant PCL, ACL or staged PCL and ACL [42] or PCL reconstructed first to reduce posterior sag followed by PLC and ACL reconstruction in staged or concomitant manner as per surgeon preference [20]. In our study, in two stage reconstruction PCL and collateral were reconstructed initially and ACL was reconstructed at a later stage because posterior sagging of tibia prevents healing of the reconstructed ligaments.

Allografts are not easily available, expensive, and have delayed incorporation with increased risk of infection [43, 45, 46]. Autografts are available easily, they incorporate early, but have associated donor site morbidity and require judicial usage in MKLI reconstruction [43, 44]. Autograft options for ligament reconstruction are limited. The patellar bone tendon-bone graft or quadriceps tendon graft have more chances of anterior knee pain or knee stiffness [46] whereas contralateral hamstrings graft yields good results in MLKI [47]. Moreover, peroneus longus can be used for cruciate ligament reconstruction without any donor site morbidity [48-50]. In this study, ipsilateral peroneus longus and ipsilateral and contralateral hamstrings were used as autografts with no residual morbidity. Tzurbakis et al. in their study of 44 patients with multi-ligament knee injury reported a firm end point in 39

(88.6%) patients on the Lachman test and 42 (95.5%) knees had normal/grade 1 posterior drawer laxity [51]. Faneli et al. found stable knees on valgus stress in 100% patients who underwent MCL reconstruction [32]. Standard et al. in their study of 22 patients with multi ligament knee injury observed normal/grade 1 valgus laxity in 20 patients (91%) after PLC reconstruction [52]. Sander TL et al. reported that out of 61 patients with MLKI who underwent single stage LCL reconstruction, 100% patients had normal/grade 1 varus laxity [53]. Fanelli GC et al. in their study of 35 patients with MLKI reported normal Lachman and pivot shift tests in 33/35 (94%) of knees, 100% normal/grade 1 varus and valgus stress test (7/7) of knees. In our study, at final follow up, in single stage reconstruction 12/14 (85.7%) had normal/grade 1 anterior drawer laxity, 14/14 (100%) had normal/grade 1 laxity on lachman's test, and 13/14 (92.9%) had normal/grade 1 laxity on pivot shift, posterior drawer, varus and valgus stress tests. In two stage reconstruction 11/13 (84.6%) had normal/grade 1 laxity on anterior drawer and varus stress test, 13/13 (100%) had normal/grade 1 laxity on lachman, pivot shift and valgus stress tests and 12/13 (92.3%) had normal/grade 1 laxity on posterior drawer test. Findings in our study are comparable to the above-mentioned studies.

Single stage surgery has been favored for decreasing the overall number and period of surgery and its benefits of early intervention and rehabilitation [2-5], however it exposes patients to long hours of invasive surgery which increases the chance of postoperative complications such as knee joint stiffness, infection, recurrent knee joint instability [2, 6, 7]. Godin et al. [10] recommended single stage surgery as a reliable worthy procedure. Similarly, Bagherifard et al. [1] and Billieres et al. [11] consider one stage reconstruction surgeries as an effective and useful method of treating such patients. Hohmann et al. [54] and Levy et al. [26] in their systematic review have shown better outcomes with single stage reconstruction. Conversely, a staged procedure not only shows improved clinical outcomes after repair of multiple ligament injuries, but also prevents any surgery associated with a decrease in range of motion of the knee [2, 3]. Systemic review by other authors has also shown better functional outcomes with staged reconstruction [55, 56].

Functional outcome after chronic multiligament knee reconstruction is discussed in relatively few studies. Fanelli et al. [4] did single-stage multiligament reconstruction in 20 cases and found a mean Lysholm score of 91.3 after a follow up of two years. In another study, Fanelli [33] performed single stage reconstruction in 35 patients with MLKI and observed a mean lysholm score of 91. Bagherifard A et al. [1] did single stage MLKI reconstruction in 41 patients and reported a mean Lysholm and IKDC scores of 86.9±11.5 and 70±18.7 respectively. Karataglis et al. [57] divided 35 patients of MLKI in single stage and two stage reconstruction and found satisfactory and comparable outcomes in both the groups. Subbiah et al. [9] did staged reconstruction in 19 patients with a mean follow up of 22 months. They found a mean Lysholm score of 92. Bin et al. in their study of 15 knees with staged reconstruction had a good functional outcome with a mean postoperative lysholm score of 87.6. Frychet et al. studied 20 single-surgery and 20 staged surgery patients and the mean Lysholm score and IKDC score was 78.7 and 80.8 respectively in the single stage surgery while mean lysholm score and IKDC score was 84.2 and 74.9 respectively in the staged surgery cohort. They found no difference in functional outcome of single versus two stage surgery [13].

In our study, we could not find any significant difference between the two groups at last follow-up, however, at 6 months follow-up results were significantly better in single stage reconstruction (IKDC and Tegner Lysholm knee score). This may be due to early physiotherapy and rehabilitation in Single stage surgery whereas in two staged surgery rehabilitation gets delayed. We advocate single stage surgery in the management of chronic MLKI because patients can be subjected to early physiotherapy. However, two stage surgery remains a viable option if duration of surgery gets prolonged for >3 hours.

There are a few limitations in this study. Firstly, it is a retrospective study with a small cohort population. Secondly, the injury pattern was not homogenous between the two groups, and only few patients had a specific injury pattern.

Finally, patients could not be followed for a prolonged period.

Conclusion

Single-stage and two-stage surgeries give equivalent clinical outcomes in chronic multi ligament knee injuries. Further prospective studies with longer follow up and bigger cohorts are needed to corroborate our findings.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Mohammad Jesan Khan, Department of Orthopaedic Surgery, J. N. Medical College, Faculty of Medicine, A.M.U., Aligarh 202002, Uttar Pradesh, India. Tel: +91-9997453384; E-mail: mzkhan2k1@gmail.com

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