Original Article

Results of multiple ligament injured knees operated by three different strategies

Lei Sun, Bo Wu, Min Tian, Yong Zhong Luo

Abstract

Background: Multiple ligament injured knee is generally described for a scenario when at least 2 of the 4 major ligaments are ruptured. The most effective treatment for these injuries remains controversial. This study presents the clinical outcome of 3 surgical strategies based on personalized treatment.

Materials and Methods: Thirty two patients with multiple ligament injured knee were treated by 3 surgical strategies in the acute phase. (1) One-stage: Twelve patients treated by repair and reconstruction of all ruptured ligaments in a single operation. (2) Staged: Eleven patients treated by repair or reconstruction of the extraarticular (EA) ligaments and then intraarticular ligaments in 2nd stage. (3) EA ligament repair: Nine patients underwent only EA ligaments repair.

Results: The patients were followed up for an average of 34.7 ± 12.1 months. Significant improvements in knee stabilities ($P < 0.01$), Lysholm score ($P < 0.01$) and International Knee Documentation Committee grade ($P < 0.01$) were noticed in all groups. Of the 32 patients, none had gross mal alignment or gait abnormalities at the latest followup. Comparing the 3 groups, a significant difference in Lysholm score was shown between the one stage group and the EA repair group ($P = 0.040$); additionally, significant differences were found in 2 subscales of knee injury and osteoarthritis outcome score ($P < 0.05$).

Conclusion: Satisfactory clinical and functional outcomes could be achieved adopting the 3 surgical strategies based on personalized treatment. However, a combination of EA repair and intraarticular repair or reconstruction might be more reasonable options for the young and active patients.

Key words: Arthroscopy, knee, multiple ligament injury, surgical management

MeSH terms: Knee joint, arthroscopy, anterior cruciate ligament, ACL reconstruction, arthroscopic surgical procedures, knee dislocation

Introduction

Ligamentous stabilizers of the knee mainly include anterior cruciate ligament (ACL); posterior cruciate ligament (PCL); posterolateral complex (PLC) composed of lateral collateral ligament (LCL), popliteal tendon and popliteofibular ligament; posteromedial complex (PMC) comprised of superficial medial collateral ligament (sMCL), deep medial collateral ligament (dMCL) and posterior oblique ligament (POL).[1-4] Multiple ligament injuries typically involve more than 2 of the main 4 ligamentous structure, arising from an acute knee dislocation caused by violent trauma. However, the ligaments injured vary greatly from one patient to another due to discrepancy in the magnitude of trauma, direction of the violent forces and position of the affected limb at the time of injury.[5,6] Additionally, each patient who suffers from multiple ligament injured knee has his own individual character, including socioeconomic state and general health condition, associated with the distinctive requirement of lower extremity function for daily activity.

We emphasized personalized management of multiple ligament injured knee according to surgeon–patient

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discussion. Surgical strategies could be divided into 3 major categories as follows: (1) All injured structures were repaired or reconstructed in a single stage of operation (the one-stage) (2) Involved ligaments were repaired or reconstructed, respectively, in two stages of surgery (the staged) and (3) Only extraarticular (EA) ligaments were repaired or reconstructed (the EA). We conjectured that personalized surgical treatment for multiple ligament injured knee should attain a rational clinical consequence.

Materials and Methods

32 consecutive patients with multiple ligament injured knee without concomitant neurovascular injuries were surgically treated based on personalized protocols from October 2001 to February 2011. The actual surgical procedure for each patient was selected according to the result of comprehensive surgeon–patient discussion. Of them, 12 patients, who were in good general health condition, excluded local severe contusion of soft tissue, infection and injuries to other parts of the body, associated with a high level of requirement in daily activity, were assigned to the one-stage group. Eleven patients who could not endure a single stage of surgical treatment due to systemic diseases in three cases such as diabetes and hypertension, multiple injuries of the body in three cases and social or financial problems in 5 patients, were enrolled into the staged group. Nine patients who had been planned to the staged surgeries, however, refused the further operation due to satisfaction with the outcome of the primary stage of operation were included into the EA repair group. Information of the patients in each group, including age, gender, interval from injury to the primary surgery, knee laxity and functional scores are documented in detail in Tables 1-3.

Operative procedure

First, a thorough arthroscopic examination of the affected knee was conducted to confirm the exact position and extent of the ligamentous rupture [Figures 1a, b and 2a]. The structures involved and surgical procedures performed in the 32 patients are listed in Table 4. Nonetheless, none of them had concomitant full damage of the 4 major ligaments.

For ligamentous reconstruction, bilateral hamstring tendon autografts in 9 patients and Achilles tendon allograft in 3 patients were used in the one-stage group, while bilateral hamstring tendon in 7, ipsilateral bone patellar tendon bone in 1, ipsilateral hamstring tendon in 1 and Achilles allograft in 2 patients were utilized in the staged group.

In the one-stage group, all ruptured ligaments, including ACL, PCL, PMC, or PLC and posterior capsule were repaired or reconstructed at a single stage of operation. After intraarticular debridement with preserving proper remnants of ACL and PCL near attachment sites, bone tunnels for ACL and PCL on both femoral and tibial sides were, respectively, created outside-in aiming the anatomic insertions [Figure 1c]. The grafts were inserted and routed the bone tunnels individually, PCL first, followed by ACL. Femoral ends of both ACL and PCL grafts were individually fixed with interference screws, whereas the tibial ends of them left unfixed temporarily. Subsequently, a corresponding incision was made to expose injured PMC, or PLC and posterior capsule according to the arthroscopic finding [Figures 1b and 2a]. For posteromedial injuries, the dMCL, sMCLand POL were reattached by transosseous sutures, anchor sutures, or washer screws on their femoral or tibial insertions if avulsed from or ruptured near the insertion [Figure 1d], or repaired by interrupted sutures combined with tensioning suture if midsubstance tear under physiological tension at 30° of knee flexion. For treatment of PLC injuries, PLC reconstruction using free tendon graft or by femoral biceps tenodesis was conducted for midsubstance tear of LCL and popliteofibular ligament [Figure 2b and c], whereas reattachment was performed for the avulsion from the femoral or fibular attachments. At last, the tibial ends of both the ACL and PCL grafts were, respectively, secured with interference screws under constant tension on both of them simultaneously at 10° of knee flexion. After finishing all repairs and reconstructions, a check on femorotibial alignment, passive range of motion (ROM) and knee stabilities, including grafts tension and joint space opening under stress [Figures 1e, f and 2d], was performed with caution.

Table 1: The quantitative data of 32 patients and comparison among groups

Parameters	Mean±SD			*F*	*P*
	One-stage	Staged	EA repair		
Age (years)	31.5±14.4	29.5±7.8	45.3±12.6	5.038	0.013
I-S interval (days)	13.0±5.1	10.4±2.8	10.7±3.3	1.516	0.236
Preoperative					
Lysholm scores	1.5±2.7	1.1±2.4	1.3±2.6	0.071	0.931
Followup (months)	34.0±11.6	36.9±12.8	33.0±13.0	0.279	0.759
At final followup					
ROM (°)	138.3±17.0	140.0±13.4	144.4±10.1	0.497	0.613
Lysholm scores	91.1±7.0	86.3±6.1	84.7±7.1	2.661	0.087

EA repair=Extraarticular repair, I-S interval=Interval from the injuries to the primary surgery, SD=Standard deviation, ROM=Range of motion

Table 2: The enumeration data of 32 patients and comparison among groups

Parameters	One-stage (*n*=12)	Staged (*n*=11)	EA repair (*n*=9)	χ^2	*P*
Gender	Male=8, female=4	Male=7, female=4	Male=3, female=6	2.609	0.271
Preoperative IKDC	D=12	D=11	D=9		NS
IKDC at final followup	A=4, B=6, C=2	A=3, B=5, C=3	A=2, B=4, C=3	0.747	0.688

IKDC=International Knee Documentation Committee, NS=Not significant, EA repair=Extraarticular repair, A=Normal, B=Nearly normal, C=Abnormal

Table 3: The ranked data of knee laxity in 32 patients and comparison among groups

Parameters	One-stage (*n*=12)	Staged (*n*=11)	EA repair (*n*=9)	χ^2	*P*
Preoperative					
0° A-P	2+=1, 3+=11	2+=1, 3+=10	2+=1, 3+=8	0.047	0.977
90° A-P	2+=1, 3+=11	3+=11	3+=9	1.667	0.435
0° M-L	2+=1, 3+=11	3+=11	2+=1, 3+=8	1.148	0.563
30° M-L	3+=12	3+=11	3+=9		NS
Final followup					
0° A-P	0+=8, 1+=3, 2+=1	0+=6, 1+=4, 2+=1	0+=3, 1+=4, 2+=2	2.405	0.300
90° A-P	0+=8, 1+=3, 2+=1	0+=5, 1+=4, 2+=2	0+=3, 1+=3, 2+=3	2.863	0.239
0° M-L	0+=8, 1+=3, 2+=1	0+=7, 1+=2, 2+=2	0+=4, 1+=3, 2+=2	1.194	0.550
30° M-L	0+=7, 1+=4, 2+=1	0+=6, 1+=3, 2+=2	0+=2, 1+=5, 2+=2	2.699	0.259

Knee laxity grading: The joint surfaces translation or separate under stress comparing the involved with the uninvolved knee. Graded as 0 for 0-2 mm side-to-side difference, 1+=3-5 mm difference, 2+=6-10 mm difference, 3+=More than 10 mm difference. X°=Degrees of knee flexion, A-P=Anterior-posterior, M-L=Medial-lateral, NS=Not significant, EA repair=Extraarticular repair

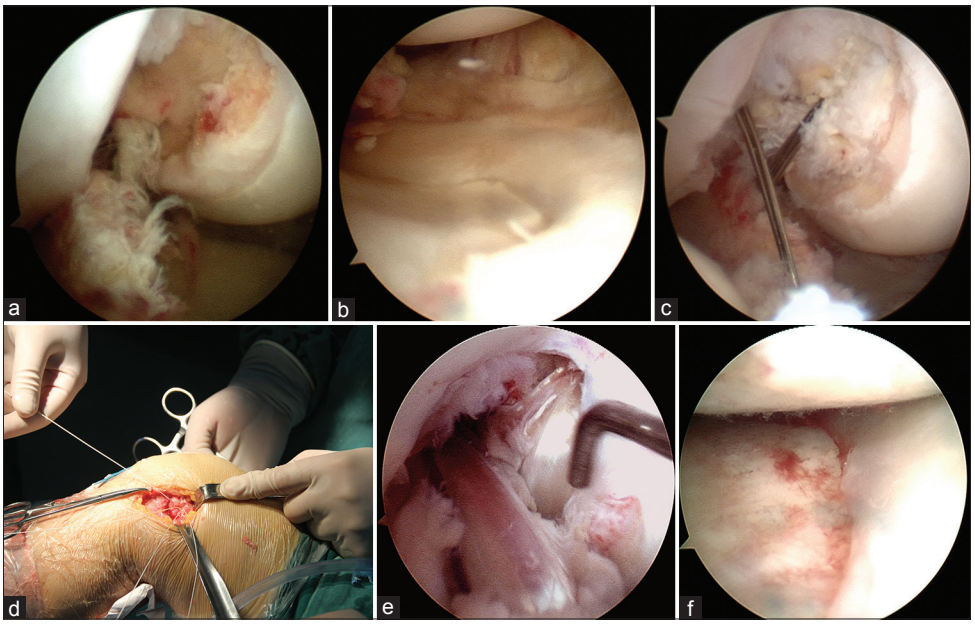

Figure 1: Arthroscopic examination and repair or reconstruction of all injured ligaments in a single stage. (a) Both anterior cruciate ligament and posterior cruciate ligament were completely torn, associated with subluxation of the knee. (b) Abnormal widening of the posteromedial compartment with the normal attachment of the medial meniscus on the tibial plateau was shown under arthroscopy. (c) After creating femoral and tibial tunnels for both anterior cruciate ligament and posterior cruciate ligament with preservation of proper remnant, two steel wire loops were individually placed for the introduction of the grafts. (d) After a posteromedial incision on the femoral side was made according to arthroscopic findings, avulsion of superficial medial collateral ligament, posterior oblique ligament, and posterior capsule near to femoral insertion was identified, then, individually repaired by anchor sutures and continuous sutures at knee flexion. (e) Grafts of posterior cruciate ligament and anterior cruciate ligament were introduced, tensioned, and secured in normal femorotibial alignment. (f) After accomplishment of all repairs and reconstructions, the medial compartment regained normal space under valgus stress

In the staged group, PMC or PLC repair or reconstruction was conducted in the first stage of operation in the same way in the one-stage group. After operation, the affected knee was immobilized with a hinge brace locked at 10° of flexion to avoid tension on repaired structures for 4 weeks, subsequently, ROM and other rehabilitative exercises with protection were applied for another 4–6 weeks. At 8–10 weeks after the primary operation, ROM more than 120° of flexion without deficiency of extension was regained in all of the 11 patients. At the second stage of operation, both ACL and PCL were reconstructed under arthroscopy in 9 of the 11 patients, while only the deficient ACL in a patient and the PCL in another patient were reconstructed, because the other corresponding cruciate ligament had well healed with proper tension [Table 4].

In the EA ligament repair group, just the torn EA ligament was repaired in accordance with the primary operation in the staged group.

Statistical analysis

A power analysis was performed using NCSS PASS version 11.0 software (NCSS, LLC, Kaysville, UT, USA). As $\alpha = 0.05$ and $\beta = 0.2$, the sample size in each group was <8 for keeping the power of test more than 0.8.

Table 4: Involved structures and surgical methods in 32 patients with multiligament injured knee

Group (total number)	Involved structure	No	Surgical methods
One-stage (12)	ACL/PCL/PMC	7	PMC repair, ACL/PCL reconstruction
	ACL/PCL/PLC	2	PLC reattachment, ACL/PCL reconstruction
	ACL/PCL/PLC	3	ACL/PCL/PLC reconstruction
Staged (11)	ACL/PCL/PMC	5	First stage: PMC repair
			Second stage: ACL/PCL reconstruction
	ACL/PCL/PMC	1	First stage: PMC repair
			Second stage: ACL reconstruction
	ACL/PCL/PLC	2	First stage: PLC reattachment
			Second stage: ACL/PCL reconstruction
	ACL/PCL/PLC	2	First stage: PLC reconstruction
			Second stage: ACL/PCL reconstruction
	ACL/PCL/PLC	1	First stage: PLC reconstruction
			Second stage: PCL reconstruction
EA repair (9)	ACL/PCL/PMC	7	PMC repair
	ACL/PCL/PLC	2	PLC reattachment

ACL=Anterior cruciate ligament, PCL=Posterior cruciate ligament, PLC=Posterolateral complex, PMC=Posteromedial complex, EA repair=Extraarticular repair

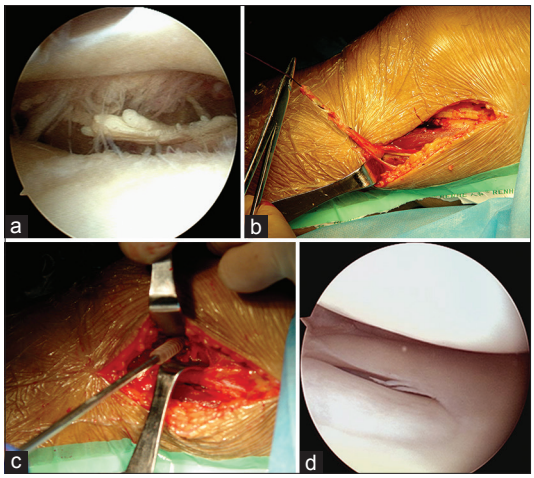

Figure 2: Posterolateral complex injuries and reconstruction with biceps tenodesis. (a) Arthroscopic examination revealed abnormal widening of the posterolateral compartment with an elevation of the lateral meniscus and torn popliteal tendon. (b) A posterolateral incision was made to expose the biceps femoris; subsequently, the tendon was free with an intact attachment on the fibula head. (c) A bone tunnel was made at the lateral epicondyle, then, the free end of the tendon was introduced into the bone tunnel. Subsequently, the tendon was fixed with an interference screw under continuous tensioning at knee flexion and valgus position. (d) After finishing all repairs and reconstruction, the lateral compartment recovered normal space under varus stress

SPSS version 19.0 software (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Preoperative data were compared with those at the latest followup within each group using paired Student's *t*-test for the quantitative data and paired Wilcoxon signed ranks test for the ranked data. Furthermore, comparing data among three groups, ANOVA and LSD mean comparison were applied to the quantitative data, while Kruskal–Wallis test and Mann–Whitney U-test were used for the ranked data. It was statistically significant where $P < 0.05$.

Results

No severe complication such as neurovascular damage, compartment syndrome and infection occurred in any one of the 32 patients. The patients were followed up from 18 to 91 months, with an average of 34.7 ± 12.1 months. At the latest followup, no patients had gross mal-alignment or gait abnormalities such as limp, varus thrust, or valgus thrust. Comparing preoperative data versus those at the latest followup, significant improvements in knee stabilities ($P < 0.01$), Lysholm score ($P < 0.01$) and International Knee Documentation Committee (IKDC) grade ($P < 0.01$) were noted in all groups.

Overall comparisons among 3 groups are shown in Tables 1-3 and 5. At the latest followup, no statistical difference was found by overall comparison among the three groups in ROM, Lysholm score, IKDC grade and knee laxity. However, a significant difference in Lysholm score was shown between the one-stage group and the EA repair group by multiple mean comparison ($P = 0.040$). Moreover, comparing Knee Injury and Osteoarthritis Outcome Score (KOOS), there were significant differences in subscales of sports and knee symptoms among three groups. Multiple mean comparison showed a significant differences in the subscale of sports between the one-stage group and the EA ligament repair group ($P = 0.002$), a meaningful difference in the subscale of knee symptom between the one-stage group and the EA ligament repair group ($P = 0.005$).

Discussion

Various treatments for multiple ligament injured knee have been reported in the literature.[7-11] Nevertheless, no

Table 5: KOOS at the latest followup and comparison among groups

Subscale	Mean±SD			*F*	*P*
	One-stage	Staged	EA repair		
Pain	94.7±7.8	96.5±4.5	92.8±6.9	0.772	0.471
Activities of daily living	90.8±5.7	86.5±6.3	87.7±7.3	1.342	0.277
Sports	89.3±7.3	84.2±6.6	78.9±6.2	6.083	0.006
Knee symptoms	89.1±7.6	85.7±5.2	80.4±6.2	4.673	0.017
Quality of life	88.0±6.3	85.5±6.9	82.1±7.6	1.877	0.171

KOOS=Knee Injury and Osteoarthritis Outcome Score, SD=Standard deviation, EA repair=Extraarticular repair

one of them is universally suitable for every patient.[12] We accentuate personalized treatment based on the specific circumstances of the patients. In the present study, significant improvements in knee function and stability were achieved in all of the three groups. However, subscales in KOOS, including sports and knee symptoms, were markedly different among the three groups at the latest followup, which implied a tendency that the one-stage group was superior to the merely EA repair group in term of knee function. In our opinion, each strategy in this study has distinctive indication and advantages. The staged operation with high safety is proper for the patients in relative poor condition, merely EA ligament repair with high cost efficient meets need of the sedentary patients, by contrast, one stage of surgical treatment with the best chance of regaining ligamentous stability is suitable for the young and active patients in the definitive condition.

Compared with EA ligament repair or reconstruction, ACL/PCL reconstruction had continuously been a hotter topic in the literature for the past decade,[13-18] which might lead to a misunderstanding that the intraarticular ligaments were more essential stabilizers than the EA ligaments for the knee. However, biomechanical studies have confirmed that PMC, PLC and posterior capsule are the primary restraints to varus-valgus and rotational displacement near to knee extension, whereas ACL/PCL becomes the primary restraint to anterior-posterior displacement and secondary restraint to rotational stability.[1-4,19] Additionally, 0–30° of knee flexion meets the need for standing and walking, which mean the EA ligaments might be crucial static stabilizer of the knee for daily activity. As an important finding of our study, 9 patients in the EA repair group got reasonable outcomes without statistical differences in IKDC rates and knee laxity compared with the one-stage and the staged groups. This phenomenon indicates that more attention should be paid to EA ligament repair or reconstruction in the surgical treatment of multiple ligament injured knee.

Repair and reconstruction of all injured ligaments in a single stage of operation are complex and time consuming. The key points of the operative techniques include accurate location of the insertions of the reconstructed ligament, restoration of the normal femorotibial alignment, proper tension on the reconstructed ligament and reliable fixation of the grafts. Several authors recommended that ACL/PCL should be firstly tensioned at 70–90° of knee flexion under fluorographic monitoring for maintaining femorotibial alignment, followed by the tautness of EA ligament at 30° of knee flexion.[15,20,21] We also used similar technique in the early treated patients,[22] latterly, modified the manipulation as follows: The EA ligaments, including PMC and PLC, were firstly tensioned and secured at 30° of knee flexion where it was easy to repair or reconstruct under proper tension. Subsequently, grafts of ACL/PCL are simultaneously tensioned and fixed at 10° of flexion, where repaired EA ligaments were tight, associated with interaction of simultaneous tension on both ACL and PCL graft during cycles of 10–90° of knee motion, to pull the corresponding bone ends to normal femorotibial alignment spontaneously. In the present study, all of 12 patients in the one-stage group regained normal femorotibial alignment and satisfactory stability of the knee.

The limitations of this study are: First, this study was only a retrospective analysis on the outcome of surgical treatments grossly classified into three categories. The patients were not randomly assigned to each group. Additionally, even in the same group, there were some variations in the actual structures injured, surgical intervention and individual characters among the patients. Furthermore, the 32 patients were consecutively included in the study only if he or she was definitively diagnosed as more than two ligament injuries of the knee and treated surgically. Moreover, the number of patients included in this study trended to be less for comparing among groups. Consequently, the conclusions drawn from this study need to be verified in further clinical researches.

To conclude, surgical treatment based on the specific circumstance of each patient is a reliable modality for multiple ligament injured knee with a reasonable outcome. Repair or reconstruction of the EA ligaments should be paid more attention compared to intraarticular ligament reconstruction. Combined EA and intraarticular reconstruction or/and repair in stages or a single stage is a justifiable treatment for the young and active patients.

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Conflicts of interest

There are no conflicts of interest.

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