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Long-term clinical and radiological outcomes after multiligament knee injury using a delayed ligament reconstruction approach: A single-center experience

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ABSTRACT

Purpose: To present long-term clinical and radiological results of patients treated with delayed reconstruction of multiligament knee injuries.
Methods: Clinical data from 26 patients (21 men, five women, mean age 27.44 years) were retrospectively reviewed. Patients were evaluated at final follow-up with the use of: The International Knee Documentation Committee score (IKDC), Knee injury and Osteoarthritis Outcome Score (KOOS), Tegner Activity level, Lysholm Knee Scoring Scale, EuroQol subjective knee evaluation form, and KT-2000 arthrometer. Mean follow-up time was 105.38 months. Both knees were radiographically evaluated for osteoarthritis according to the Kellgren–Lawrence classification.
Results: No patient required mobilization under anesthesia for adhesion lysis at the immediate or later postoperative duration. There was no statistically significant difference in range of motion between the healthy and operated sides ($P = 0.713$). Mean time to final range of motion regain was 2.1 ± 0.4 months. Average KT-2000 side-to-side (operated vs. normal) difference was 2.03 ± 1.1 mm, and the difference was statistically significant ($P = 0.007$). The mean IKDC, KOOS, Lysholm, Tegner, and Euroqol-5D postoperative scores were 82.13 ± 17.5, 84.59 ± 16.8, 90.6 ± 6.4, 4.3 ± 1.3, and 80 ± 11.74, respectively. Multiple regression analysis showed that age and follow-up time had significant effects on each clinical score, except for the Lysholm and Tegner scores. Progression of osteoarthritic changes of the reconstructed knee and its contralateral side was significantly different ($P = 0.003$).
Conclusion: Excellent clinical results were reported from this center's long-term experience with delayed ligament reconstruction, and osteoarthritic changes of reconstructed knees were recorded.

1. Introduction

When at least two or more of the knee stabilizers are disrupted – anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), lateral collateral ligament (LCL) and posterolateral corner (PLC), and medial collateral ligament (MCL) and posteromedial corner (PMC) – the term multiligament injury is used. Knee dislocation (KD) or substantial subluxation is likely to have occurred in some of these injuries [1–3]. The energy of such injuries varies from high-velocity injuries (road traffic accident), low-velocity injuries (contact sports) to ultra-low-velocity injuries (everyday activities in the obese population) [4,5]. However, the energy re-

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quired for such injuries to occur is always high, even in low-velocity injuries. The incidence of true knee dislocation in the general population has modestly been estimated to be 0.072 dislocation events/100 patient-years [6]. The Schenck classification is currently the prevalent descriptive classification of ligamentous injury after KD, as modified by Washer et al., and it differentiates between medial and lateral ligamentous complex injuries [7].

The current treatment pathway has discarded conservative management, due to unsatisfactory short-term and long-term clinical outcomes [8]. However, there is disagreement regarding timing of operative management (acute or chronic) among orthopedic surgeons. The widely accepted timeframe for the threshold between acute and chronic timing of operative treatment is three weeks after injury. Outcomes following acute surgical repair or reconstruction have been acceptable, although not without drawbacks [9]. For instance, almost 15% of patients may require manipulation under anesthesia due to complaints of stiffness [3,10,11]. On the contrary, favorable results have been published when treatment with delayed reconstruction was studied [3,12]. Delayed reconstruction probably demonstrates the best combination of long-term outcomes, cost-effectiveness, and minimal complications.

This study presents the results after long-term follow-up of patients who were treated with delayed reconstruction of multiple ligamentous knee injuries. It was hypothesized that no complications would occur, long-term clinical results would be good or excellent, and patient satisfaction would be high.

2. Materials and methods

2.1. Patient selection and methodology

Between August 2003 and May 2012, 32 patients were surgically treated for multiligament knee injuries at a single institution. Inclusion criteria were: injury of at least two major knee stabilizing ligaments (except for the ACL + MCL combination); delayed reconstruction of said knee injuries (>3 weeks after initial injury) in adults; patient compliance with postoperative physiotherapy protocol; and attendance of follow-up meetings as an outpatient. A prerequisite to include a patient was pre-operative full knee extension and knee flexion of >125°. When that goal had been achieved, surgical treatment was offered. Six patients were excluded from this study for different reasons: a paraplegic patient, a patient who opted for total knee arthroplasty shortly after initial surgery, a patient who was operated on eight days after injury, and three patients lost to follow-up. The remaining sample consisted of 26 participants.

Two independent clinicians performed thorough subjective and objective pre-operative and postoperative evaluation with the use of: the International Knee Documentation Committee (IKDC), Knee injury and Osteoarthritis Outcome Score (KOOS), Tegner Activity Level, Lysholm Knee Scoring Scale, EuroQol (EQ-5D) subjective knee evaluation form, and an instrumented exam for ACL function using the KT-2000 knee joint arthrometer. Range of motion (ROM) was also measured. Radiographic evaluation consisted of bilateral standing anteroposterior knee joint radiographs, which were graded according to the Kellgren–Lawrence (K–L) system. Patients without evidence of osteoarthritis were considered K–L Grade 0–1, whereas patients with radiographic evidence of osteoarthritis were considered K-L Grade 2–4.

2.2. Surgical technique

Arthroscopically assisted graft placement was the standard of care for ACL and PCL reconstruction. The ACL was reconstructed based on footprint landmarks on the tibia and the femur through the medial working portal. Quadruple autologous hamstrings graft was used from the ipsilateral or contralateral side. For PCL reconstruction, an Achilles tendon allograft was used. An accessory posteromedial portal aided in identifying the tibial PCL footprint and debriding it. A transtibial tunnel, using the transeptal approach, was drilled from the anteromedial aspect of the proximal tibia one to two centimeters below the tibial tubercle, with an exit point in the inferior lateral aspect of the PCL anatomic insertion site (under fluoroscopic imaging). Posterolateral corner instability was treated according to the Arciero technique, with anatomic reconstruction of the LCL and popliteofibular ligament by autologous semitendinosus graft through a transfibular tunnel. The insertion sites of the LCL and popliteus muscle on the femur were recreated by using a dual femoral socket technique [13]. Finally, patients who had sustained injury to the PMC were treated with reconstruction of the critical triangle of the MCL, the posterior oblique ligament, and the semitendinosus tendon [14]. Whenever a concomitant meniscal tear in the red-red zone was present, an attempt to suture was made. The PCL graft was tensioned and first fixed in 90° flexion, while the step-off was reduced with an anterior drawer, followed by the ACL in 10° flexion, and then the lateral or medial structures in 30° flexion. There were no staged reconstructions performed. All interventions were performed by the same surgeon.

Different rehabilitation programs were followed with different injury patterns, with certain common denominators. The first was early motion, which has been shown to minimize the deleterious effects of immobilization, such as articular cartilage degeneration, excessive collagen formation, and pain [15–17]. Immediate postoperative knee rehabilitation included early motion protected with a brace, and quadriceps awakening to prevent arthrofibrosis. Certain goals were made and individualized for each case. Each patient was expected to develop quadriceps control and progress ROM, establish a normal gait pattern, and demonstrate the ability to ascend and descend normal steps. Close monitoring of the rehabilitation of each patient in conjunction with time frames were used for the first nine months after surgery. In cases of PCL injuries, weight bearing was initially limited (depending on a concomitant PCL injury) and a brace was kept locked at 0° extension for ambulation, as PCL graft healing has been reported to require almost twice the amount of time compared with ACL graft healing [18–21].

2.3. Statistical analysis

Regression and Pearson correlation were used to correlate all scores with age, body mass index (BMI) and follow-up time. Paired *t*-test was used to compare measurements with the KT-2000 between normal and injured side. Fisher's exact test was used to correlate K-L radiographic signs between sides and KD classification. A *P*-value of <0.05 was considered significant. All statistical analysis was performed in Microsoft Excel for Mac, version 2015.

3. Results

The average age at the time of surgery was 27.44 ± 8.73 years, with male sex dominance (21 males and five females). Mean BMI at the time of operation was 25.4 ± 3.45 kg/m^2. Mean time of operation from initial injury was 16.5 ± 15.96 months. There were 15 patients with a right knee injury and 11 with a left knee injury. Mean time of follow-up was 105.38 ± 33.92 months (Table 1).

According to the Schenck classification, the combinations of ligament disruption observed were: KD II (ACL + PCL = 7), KD I (PCL + PLC = 7), KD IIIL (ACL + PCL + PLC = 2), KD I (ACL + PLC = 8) and KD IIIM (ACL + PCL + PMC = 2). Meniscal tears were also present in three patients with the ACL + PLC pattern of injury (Table 2). According to the energy of injury classification, all injuries were considered high-velocity, such as road traffic accidents, ski accidents or falls from a height. There were also two patients with vascular injuries: one with an acute popliteal artery tear at the time of injury and one with delayed presentation of arterial occlusion after the injury, as a consequence of an unrecognized initial arterial intimal tear. Both injuries resulted from posterior knee dislocation. In the patient with the KD IIIM type of injury, the vastus medialis was also torn. Two patients following road traffic accidents had serious concomitant injuries (one had a contralateral fractured femur, the other was a polytrauma patient with pelvic and rib fractures and pneumothorax). No postoperative neurovascular complications were recorded, and no patient required mobilization under anesthesia for adhesion lysis at the immediate or later postoperative duration.

At final follow-up, there was no statistically significant difference in ROM between the healthy and operated sides ($P = 0.713$). Clinical examination revealed an average passive knee flexion of 133.33 ± 12.8° and average active knee flexion of 116.45 ± 11.5°. Average KT-2000 side-to-side (operated vs. normal) difference was 2.03 ± 1.1 mm, and the difference was statistically significant ($P = 0.007$) (Table 3). Mean time to final ROM regain was 2.1 ± 0.4 months.

The mean IKDC, KOOS, Lysholm, Tegner, and Euroqol-5D postoperative scores were 82.13 ± 17.5, 84.59 ± 16.8, 90.6 ± 6.4, 4.3 ± 1.3, and 80 ± 11.74, respectively. By using multiple regression to estimate the effect of age, follow-up time, BMI and KD classification on each score, the model was significant for all scores ($P < 0.05$) except the Lysholm and Tegner scores. The variables that had a statistically significant effect on each score were age and follow-up time. More specifically, IKDC, KOOS, and Euroqol-5D scores seemed to deteriorate with longer follow-up, and with advanced age at the time of injury.

In time, 18 of 26 reconstructed knees (69.2%) exhibited radiographic signs of osteoarthritis, as graded by the K-L system (grade 1 = 8, grades 2 + 3 = 18, grade 4 = 0). When separated by subgroup, seven of 15 KD I, seven of seven KD II, and four of four KD III patients had radiographic evidence of OA. The K-L progress was positively correlated with age, follow-up and Schenck classification ($P < 0.5$). The K-L progression of osteoarthritic changes of the reconstructed knee and its contralateral healthy side was statistically different ($P = 0.003$) (Figure 1). All 26 patients returned to their previous employment, including high-demand jobs (e.g., policeman), while 22 of 26 returned to recreational and sporting activities such as long-distance running, dancing and riding a bicycle.

4. Discussion

Good long-term functional outcomes were reported with a delayed reconstruction treatment approach of multiligament knee injuries. All patients returned to work, while some returned to recreational activities such as dancing or long-distance running. Age at the time of injury, follow-up time, and injury classification were the factors that appeared to mostly affect the final outcome. Patients' satisfaction was high, according to functional scores and clinical examination, and ROM was excellent at final follow-up. Mean time of surgery from initial injury was quite prolonged in this cohort because the vast majority were delayed referrals from other institutions or definitive treatment was delayed due to concomitant injuries.

It seems that delayed surgery allows for recovery of soft tissues with resolution of swelling, improved restoration of preoperative knee ROM, resulting in less stiffness and wound complications postoperatively [22–24]. The main risk of acute single-stage ligament surgery versus single-stage delayed management is the development of postoperative knee stiffness that may

Table 1
Sample demographics.

Number of patients	26
Sex	21 male vs. 5 female
Injured side	15 right vs. 11 left
Mean age, years (SD) (range)	27.44 (8.73) (18–45)
Mean follow-up time, months (SD)	105.38 (33.92)
Mean body mass index, kg/m^2 (SD)	25.4 (3.45)

Table 2
Injury pattern.

Schenck classification	Ligaments affected	Number of patients (n = 26)
KD I	ACL + PLC	8
	PCL + PLC	7
KD II	ACL + PCL	7
KD IIIM	ACL + PCL + PMC	2
KD IIIL	ACL + PCL + PLC	2

ACL, anterior cruciate ligament; PLC, posterolateral corner; PCL, posterior cruciate ligament; PMC, posteromedial corner; KD, knee dislocation.

require additional surgery [25,26]. Patients who have staged treatments are as likely to require additional procedures for joint stiffness as those who undergo acute surgery [27,28]. There were no cases of postoperative stiffness that required lysis of adhesions in the current study. Another advantage of delayed arthroscopic intervention is soft tissue condition. Arthroscopic cruciate ligament reconstructions in KD are not recommended within the first days after traumatic events because of the possible development of compartment syndrome due to extravasation of fluid from the torn capsule [22].

4.1. Range of motion

In the review by Levy et al., mean ROM and flexion loss was similar between early and delayed reconstruction groups, with good published results (mean ROM 129°) [9]. Mook et al. reached the same conclusion, with reported mean ROM 124.5°, 130.5°, and 129.4° for the acute, chronic, and stage groups, respectively. The type of rehabilitation following delayed surgical treatment of multiligament knee injuries does not seem to affect ROM as much as it does in cases of acute treatment, and early mobilization has been observed to have a deleterious effect in patients who have received delayed treatment [25]. Total ROM did not show any difference in a recent review and meta-analysis between early and delayed reconstruction of multiligament knee injuries [29].

4.2. Complications

Chronic surgery can achieve good clinical results and has shown a lower incidence of complications, such as arthrofibrosis, compared with acute or staged surgery. Mook et al. systematically reviewed retrospective studies including 396 knees with KD III classification or worse that were managed with acute, staged or delayed reconstruction of injured structures. Acute treatment was associated with increased residual anterior knee instability when compared with delayed reconstruction. Significantly more patients who were managed acutely were found to have flexion deficits of >10° when compared with those who were managed in a delayed fashion. Consequently, additional treatment for joint stiffness was significantly more likely in cases of acute (17%) or staged (15%) treatment, compared with none whatsoever in delayed treatment (0%) [25].

Cook et al. described their center experience in a retrospective analysis of 130 patients with multiligament knee injuries, and their results also support the notion that delayed reconstruction offers superior results. Unfortunately, surgical management was not consistent and a variety of surgical techniques were chosen, including either repair only or reconstruction only or a combination of both approaches. From their results, it stands out that patients operated on in the acute phase (<3 weeks after injury) were at risk of knee stiffness requiring manipulation under anesthesia and/or lysis of adhesions. It was also concluded that the type of surgical intervention regarding repair and/or reconstruction did not show a significant increase in complication rate nor did the type of graft (i.e., autograft and/or allograft) used in reconstruction [3].

In other published small case series, early reconstruction appears to increase the risk of additional surgery due to postoperative joint stiffness. According to Harner et al., four of 19 patients required manipulation under anesthesia because of arthrofibrosis or severe flexion deficit. In the research by Liow et al., one of seven patients underwent additional surgery for adhesion lysis [10,11].

Table 3
Objective and subjective evaluation scores.

Average passive ROM (SD)	133.33° (±12.8)
Average active ROM (SD)	116.45° (±11.5)
IKDC (SD)	82.13 (±17.5)
KOOS (SD)	84.59 (±16.8)
Lysholm (SD)	90.6 (±6.4)
Tegner	4.3 (±1.3)
Euroqol-5D (SD)	80 (±11.74)
Average KT-2000 side to side difference (SD)	2.03 (±1.1 mm)

IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; ROM, range of motion.

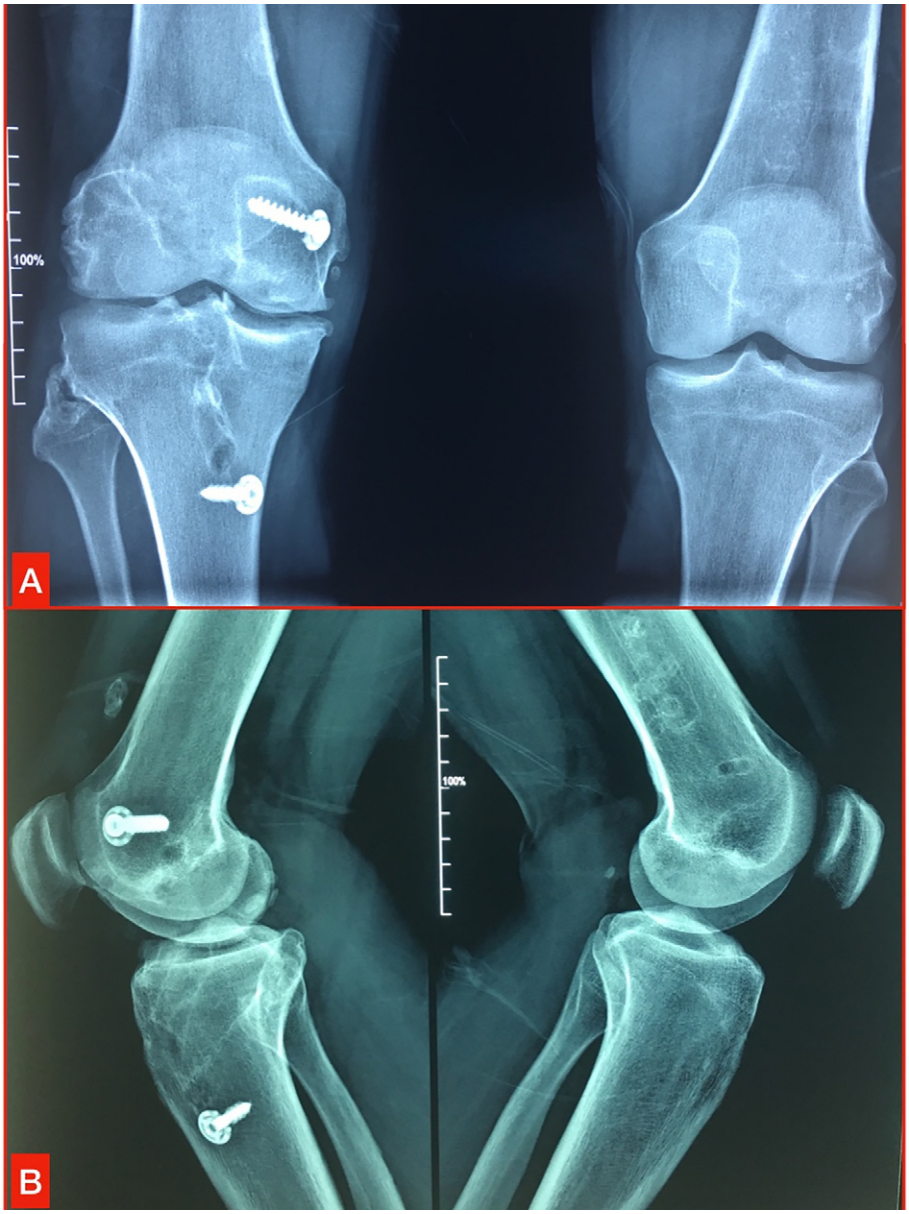

Figure 1. Bilateral anteroposterior (A) and lateral (B) knee X-ray of a 28-year-old male patient, 124 months postoperation. He initially sustained a KD IIIL type of injury in his right knee.

4.3. Patient satisfaction

As far as patient satisfaction is concerned, in the research by Mook et al., the percentage of patients who had excellent or good subjective outcomes in the staged treatment group (79%) was significantly greater than that in the chronic treatment group (37%) and than that in the acute treatment group (52%) [25]. There was no difference in average Lysholm scores between acutely and chronically managed patients. On the other hand, a very recent systematic meta-analysis concluded that early reconstruction (mean 10.6 days) produces superior patient-reported and clinical outcomes compared with late surgical intervention (mean 294 days) [29]. Nevertheless, the authors comment that implications for practice are unclear since all published studies were either limited to level IV case series or other non-randomized study designs and displayed significant heterogeneity, introducing multiple biases that may have rendered their results reversible in the future. Classification of injuries and type of surgery (reconstruction or repair) were not independently studied and results were not pooled accordingly.

In another systematic review for determining optimal timing of surgery with respect to injury pattern (KD III) of 153 knees, excellent or good results according to IKDC were demonstrated in 79.1% of cases managed with staged treatment versus 58.4% of cases that underwent acute surgery, and versus 45.5% of cases that underwent chronic surgery. No statistically significant

difference was found in the percentage of excellent or good results between the acute and chronic surgery groups, or between the KD IIIM and KD IIIL groups [24].

Compared with other long-term or mid-term follow-up studies, the current study reported less complications with satisfactory objective and subjective clinical results. Unfortunately, the development of osteoarthritis in this cohort of patients was high (69.2%), even compared with other series, although there was great heterogeneity in patient characteristics and treatment choices [5,30]. In the study by Fanelli et al., arthritic changes were apparent in a quarter of their patient sample after a mean 10 years of follow-up, but their clinical results were good, even though they were extracted by a mixed population of acutely and chronically treated patients with KD III injuries [30]. When follow-up is prolonged, like in the current study, age and chondral injury after one traumatic event are factors that influence progression to osteoarthritis, even in a well-balanced operated knee. In another study, the degree of osteoarthritis was not correlated with the incidence of meniscal damage but was correlated with the incidence of MCL and LCL ruptures and with the status of knee stability at follow-up in a large cohort of patients [5]. In a large series with heterogeneous injury patterns, Engebretsen et al. reported 87% knee osteoarthritis in the injured knee compared with 35% in the healthy contralateral side [31]. Finally, Noyes et al. reported a relatively high failure rate of reconstructed ligaments at a mean 4.8 years of follow-up [32].

4.4. Limitations

The study had some limitations. The main ones were: small sample size, retrospective nature of the study, and heterogeneity of lesion patterns. However, it is impossible to create an identical healthy population with which to compare clinical and radiological scores. This study's main strength was the long-term follow-up of a patient cohort treated with delayed reconstruction, which is rare in the literature, and the abundance of reported clinical and radiological scores.

5. Conclusion

According to the results, good to excellent long-term clinical results can be achieved using a delayed ligament reconstruction approach in multiligament knee injuries. However, patients should be counseled about possible functional deficits and long-term consequences, like knee arthritis.

Disclosure of interest

The authors declare that they have no potential conflict of interest.

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