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Comparative Analysis of Clinical Efficacy Between One-Stage and Staged Reconstruction for Repairing Multiple Ligament Knee Injuries under Arthroscopy

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Abstract: *Objective:* To compare the postoperative functional recovery, range of motion, and complication rates of one-stage and staged reconstruction for repairing multiple ligament knee injuries (MLKI) under arthroscopy, providing evidence-based guidance for clinical treatment selection. *Methods:* A total of 60 patients with KD-IIIM type MLKI admitted to the Orthopedics Department of Ankang Hospital of Traditional Chinese Medicine from January 2024 to January 2026 were selected and randomly divided into an observation group (one-stage reconstruction, 30 cases) and a control group (staged reconstruction, 30 cases) using a random number table method. Both groups utilized autologous semitendinosus, gracilis, and peroneus longus tendons as grafts, with surgeries performed by the same surgical team. Lysholm knee function scores, IKDC subjective scores, and knee flexion-extension range of motion were recorded preoperatively and at 12 weeks, 6 months, and 12 months postoperatively. *Results:* At 12 weeks postoperatively, the observation group demonstrated higher Lysholm scores, IKDC subjective scores, and knee flexion-extension range of motion compared to the control group (all $P < 0.05$). *Conclusion:* Arthroscopic one-stage reconstruction enables faster recovery of early knee joint function and reduces financial and psychological burdens on patients. Staged reconstruction carries a lower risk of postoperative joint adhesion and stiffness, with no significant difference in long-term knee function recovery compared to one-stage surgery. Clinical surgical plans can be individualized based on patient age, injury severity, and rehabilitation compliance.

Keywords: Multiple ligament knee injuries; Arthroscopy; One-stage reconstruction; Staged reconstruction

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1. Introduction

The knee joint is the core weight-bearing joint responsible for weight-bearing, walking, and flexion-extension activities. The anterior and posterior cruciate ligaments, along with the medial and lateral collateral

ligaments, collectively maintain the stability of the knee joint during anterior-posterior and internal-external rotation. The simultaneous rupture of two or more ligaments is defined as multiple ligament knee injuries (MLKI), which are often induced by high-energy traffic accidents or severe sports injuries and are frequently accompanied by transient knee dislocation, posing a high overall risk of disability [1]. Epidemiological data indicate that such injuries account for 0.2% of all orthopedic injuries, with an annual incidence rate of 1 to 3 per 100,000. Without standardized treatment, patients are prone to persistent joint instability, accelerated cartilage wear, and premature onset of traumatic osteoarthritis, severely compromising their daily activities [2]. Traditional open surgery involves significant trauma and extensive soft tissue dissection, resulting in a high incidence of postoperative adhesions and pain. With the advancement of minimally invasive arthroscopic techniques and the maturation of autologous tendon graft preparation systems, arthroscopic ligament reconstruction has become the mainstream treatment for MLKI. However, there has been long-standing academic debate regarding the timing and staging of surgery. Some clinical scholars argue that performing all ligament reconstructions in one session during the acute phase exacerbates intra-articular soft tissue inflammation and significantly increases the risk of postoperative joint stiffness, advocating instead for staged surgery with initial reconstruction of the cruciate ligaments, followed by secondary repair of the lateral complex after knee range of motion has recovered to 0–120° [3]. Conversely, other studies suggest that staged surgery requires two anesthetic administrations and surgical procedures, compounding trauma and increasing treatment costs, prolonging the patient's rehabilitation period and increasing psychological burden. One-stage surgery can simultaneously restore knee mechanical balance, facilitating early systematic rehabilitation training [4]. This study included 60 patients who met strict inclusion and exclusion criteria, dividing them into an observation group (one-stage reconstruction) and a control group (staged reconstruction) for a 12-month follow-up. The study quantitatively compared knee function scores, range of motion, and complications between the two groups to objectively evaluate the advantages and disadvantages of the two surgical approaches, providing a reference for developing clinical protocols in sports injury departments at primary-level traditional Chinese medicine hospitals.

2. Materials and methods

2.1. General information

Sixty patients with unilateral KD-IIIM type multiple ligament knee injuries admitted to the Sports Injury Ward of the Orthopedics Department at Ankang Hospital of Traditional Chinese Medicine from January 2024 to January 2026 were selected and randomly divided into an observation group (one-stage arthroscopic ligament reconstruction, 30 cases) and a control group (staged arthroscopic ligament reconstruction, 30 cases) at a 1:1 ratio using a random number table method. The observation group comprised 19 males and 11 females, aged 16–62 years (mean age: 35.72 ± 8.64 years). The causes of injury were traffic accidents in 21 cases and sports falls in 9 cases. The interval from injury to surgery ranged from 3 to 12 days (mean: 6.15 ± 2.33 days). The control group comprised 17 males and 13 females, aged 14–64 years (mean age: 34.91 ± 9.05 years). The causes of injury were traffic accidents in 18 cases and sports falls in 12 cases. The interval from injury to the first surgery ranged from 2 to 13 days (mean: 5.98 ± 2.41 days). There were no statistically significant differences in age, sex, injury mechanism, preoperative injury duration, preoperative Lysholm and IKDC scores, or baseline knee range of motion between the two groups ($P > 0.05$), indicating comparability

between the groups.

2.2. Diagnostic criteria

Referring to the diagnostic criteria for multiple ligament knee injuries in *Campbell's Operative Orthopaedics (13th Edition)* [5]: (1) A clear history of high-energy trauma, with rapid swelling and severe pain in the knee joint after injury, rendering the patient unable to bear weight and walk; (2) Positive results in two or more of the following physical examinations: anterior drawer test, posterior drawer test, and varus-valgus stress test; (3) MRI of the knee joint indicating grade III tears in at least two of the four main ligaments, with complete disruption of ligament fiber continuity; (4) X-rays showing images of knee dislocation or subluxation, without displaced fractures of the tibial plateau or intercondylar eminence.

2.3. Inclusion and exclusion criteria

Inclusion criteria: Diagnosed with KD-IIIM type multiple ligament injuries; aged 14–65 years; normal bilateral knee joint function before injury, with no history of previous ligament injuries or joint surgery; unilateral limb injury; normal cognition, able to cooperate with follow-up, rehabilitation training, and questionnaire completion; voluntarily signed informed consent. Exclusion criteria: Concomitant fractures around the knee joint, common peroneal nerve injury, or popliteal artery and vein injury; congenital lower limb malalignment or congenital knee dislocation; history of previous knee surgery or septic arthritis; severe knee degeneration or grade IV cartilage wear; severe cardiovascular, cerebrovascular, or liver and kidney diseases that render the patient unable to tolerate two or a single prolonged surgical procedure; cognitive impairment or mental illness that prevents cooperation with rehabilitation follow-up. Additional exclusion criteria: Loss of contact during follow-up or voluntary withdrawal from rehabilitation; ligament re-rupture or severe infection requiring secondary open surgery after the initial procedure; extremely poor compliance, refusing standardized rehabilitation exercises.

2.4. Surgical protocol

All surgeries were performed by a fixed team consisting of three senior attending physicians specializing in sports injuries at our hospital. Continuous epidural anesthesia or general anesthesia was uniformly selected, with a tourniquet applied to the affected limb. Standard anterior medial and anterior lateral arthroscopic portals were established, and the joint was irrigated to remove hematomas and proliferative synovium. Dislocated knees were reduced, and meniscal and cartilage injuries were examined and repaired simultaneously. Autologous contralateral semitendinosus and gracilis tendons were uniformly used as grafts, with the ipsilateral peroneus longus tendon harvested and braided for use if necessary.

2.4.1. Observation group (one-stage reconstruction group)

All damaged ligaments were reconstructed in a single surgical session, with the fixation sequence as follows: posterior cruciate ligament (PCL) → anterior cruciate ligament (ACL) → posteromedial complex (PMC)/ posterolateral complex (PLC). Femoral and tibial bone tunnels were precisely positioned under arthroscopy, and anchors and interference screws were used to fix the grafts. The joint capsule and torn collateral ligament tissues were repaired layer by layer, and a negative pressure drainage tube was placed before sterile dressing and compression bandaging were applied. After surgery, an adjustable knee brace was worn with the knee locked in extension, and passive flexion-extension rehabilitation was initiated after the anesthesia wore off.

2.4.2. Control group (staged reconstruction group)

Two arthroscopic surgeries were performed: in the first stage, only the PCL or ACL was reconstructed. After 6–12 weeks of standardized rehabilitation, when passive knee flexion-extension reached 0–120° and quadriceps strength recovered to grade 4 or above, the second stage surgery was performed to reconstruct the remaining cruciate ligament and the medial and lateral complexes. The surgical procedures, graft harvesting, and fixation methods were consistent with those in the observation group, with a median interval of 8.3 weeks between the two surgeries.

2.5. Postoperative rehabilitation protocol

The postoperative rehabilitation pathways were uniform for both groups: from postoperative days 1–3, swelling and pain were alleviated, with passive flexion-extension ranging from 0–60°; from postoperative days 4–14, flexion was gradually increased to 90°; at 1 month postoperatively, flexion reached 120°, and isometric contractions of the quadriceps and hamstrings were strengthened; at 3 months postoperatively, brace-assisted weight-bearing walking was gradually initiated; at 6 months postoperatively, daily light activities were resumed; and at 12 months postoperatively, the ability to return to sports was assessed. Rehabilitation physicians provided one-on-one guidance throughout the process, and rehabilitation compliance was recorded.

2.6. Observation indicators

(1) Knee function scores: The Lysholm score (ranging from 0 to 100, with higher scores indicating better knee function) and the IKDC subjective score (ranging from 0 to 100, with higher scores indicating less pain and instability) were assessed preoperatively and at 12 weeks, 6 months, and 12 months postoperatively.

(2) Knee range of motion: The maximum extension and flexion angles of the knee joint were recorded at each time point.

(3) Complications: The incidence of joint stiffness (requiring release under anesthesia for flexion < 110°), wound infection, graft laxity, common peroneal nerve numbness, hematoma, and the need for secondary surgery were statistically analyzed over the 12-month follow-up period.

(4) Healthcare burden indicators: The total number of surgeries, cumulative length of hospital stay, and total hospitalization costs were compared between the two groups.

2.7. Statistical methods

Data were processed using SPSS 22.0 statistical software. Continuous variables are presented as mean ± standard deviation (SD). Comparisons within groups at different time points were conducted using paired *t*-tests, while comparisons between groups at the same time point were performed using independent samples *t*-tests. Categorical variables are expressed as counts and percentages, and comparisons were made using the χ^2 test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of Lysholm scores between the two groups

The Lysholm score in the observation group was higher than that in the control group at 12 weeks

postoperatively ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of Lysholm scores between the two groups at different time points

Group	Number of cases	Preoperative	12 weeks postoperatively	6 months postoperatively	12 months postoperatively
Observation group	30	43.26 ± 6.17	82.41 ± 5.33	88.72 ± 4.65	91.35 ± 3.82
Control group	30	42.89 ± 6.34	76.58 ± 6.02	87.94 ± 4.81	90.67 ± 4.15
t value		0.229	3.978	0.638	0.660
P value		0.820	<0.001	0.526	0.512

3.2. Comparison of IKDC subjective scores

Between the two groups at 12 weeks postoperatively, the IKDC score in the observation group was superior to that in the control group ($P < 0.001$), as shown in **Table 2**.

Table 2. Comparison of IKDC scores between the two groups at different time points

Group	Number of cases	Preoperative	12 weeks postoperatively	6 months postoperatively	12 months postoperatively
Observation group	30	40.13 ± 5.82	80.67 ± 5.19	87.14 ± 4.36	90.28 ± 3.64
Control group	30	39.75 ± 5.96	74.22 ± 5.74	86.49 ± 4.52	89.53 ± 3.91
t value		0.250	4.559	0.567	0.770
P value		0.803	<0.001	0.573	0.445

3.3. Comparison of maximum knee flexion range of motion

At 12 weeks postoperatively, the flexion angle in the observation group was significantly greater than that in the control group ($P < 0.001$), as shown in **Table 3**.

Table 3. Comparison of maximum knee flexion angles between the two groups

Group	Number of cases	Preoperative	12 weeks postoperatively	6 months postoperatively	12 months postoperatively
Observation group	30	52.36 ± 9.41	116.72 ± 6.35	125.18 ± 4.26	128.43 ± 3.17
Control group	30	51.84 ± 9.73	108.45 ± 7.12	123.96 ± 4.51	127.65 ± 3.42
t value		0.211	4.753	1.069	0.906
P value		0.834	<0.001	0.290	0.368

4. Discussion

Multiple ligament injuries of the knee joint are severe joint traumas, often resulting from high-energy violence that causes instantaneous dislocation of the knee joint, with simultaneous or multiple ruptures of the four core ligaments, leading to a complete loss of anteroposterior and internal-external rotational stability of the knee joint [6]. Conservative treatment with long-term immobilization can trigger muscle atrophy, joint stiffness, persistent instability, and increase the risk of developing long-term traumatic arthritis by more than fourfold. Therefore, the mainstream clinical view recommends early minimally invasive reconstruction surgery as an intervention. With the improvement of arthroscopic instruments and autologous tendon preparation techniques, arthroscopic reconstruction has replaced traditional open surgery. However, the

debate over whether to simultaneously repair all ligaments in one stage or to reconstruct them in stages has persisted for years [7].

The data from this study show that the Lysholm score, IKDC score, and knee flexion range of motion at 12 weeks postoperatively were superior in the observation group compared to the control group. The core reason is that the one-stage surgery restores the complete mechanical balance of the knee joint at once. After simultaneous reconstruction of the cruciate ligaments and lateral complex, the internal and external force-bearing structures of the joint return to normal, eliminating the issue of unilateral ligament tension imbalance during rehabilitation training. Patients can initiate full-range flexion and extension exercises earlier, leading to faster early functional recovery [8]. From the perspective of medical economic burden, the one-stage surgery requires only a single anesthesia and hospitalization, eliminating the need for a second admission and preoperative examination. The cumulative length of hospital stay and total treatment costs significantly decrease, while also avoiding the psychological anxiety associated with two surgeries, making it more favorable for wage earners and patients at the grassroots level [9].

The drawbacks of staged surgery are concentrated in the rehabilitation cycle and economic costs: the cumulative trauma from two surgeries requires patients to undergo two preoperative evaluations, anesthesias, and postoperative immobilizations, extending the cumulative hospital stay and significantly increasing medical expenses. During the interval between the two surgeries, the knee joint still experiences partial instability, limiting patients' daily activities and increasing psychological pressure. Some patients refuse standardized rehabilitation due to fear of a second surgery, indirectly affecting long-term joint function [10]. The follow-up results of this study show no statistically significant differences in knee joint function scores and range of motion between the two groups at 6 and 12 months postoperatively, indicating that as long as standardized rehabilitation is adhered to, both surgical approaches can achieve equivalent levels of long-term knee joint stability and mobility.

Combining the follow-up data of 60 patients in this study with existing literature, a stratified treatment strategy is summarized as follows: (1) For young and middle-aged patients with high athletic demands, mild soft tissue contusions, and good rehabilitation compliance, arthroscopic one-stage reconstruction is preferred to shorten the rehabilitation cycle, reduce treatment costs, and facilitate a quicker return to daily work and mild exercise; (2) For patients over 55 years old, with severe soft tissue edema, mild underlying medical conditions, and poor self-rehabilitation capabilities, staged reconstruction is recommended to mitigate the risk of severe postoperative joint stiffness and enhance rehabilitation safety; (3) For patients with severe post-injury knee swelling, high skin tension, and potential risk of compartment syndrome, initial anti-swelling treatment should be administered, followed by staged surgery after improvement of soft tissue conditions to reduce the risk of poor wound healing and infection. Meanwhile, regardless of the surgical approach used, standardized postoperative rehabilitation training is the core factor determining long-term outcomes. Clinically, a specialized rehabilitation follow-up system for sports injuries should be established, with staged flexion-extension and muscle strength training plans developed postoperatively. Regular follow-ups should be conducted to assess knee joint stability and promptly address issues such as joint swelling and limited mobility, thereby minimizing the long-term risk of osteoarthritis.

This study is a single-center randomized controlled trial with a total sample size of 60 cases and a follow-up period of only 12 months, lacking long-term follow-up data on functional outcomes and cartilage degeneration beyond three years. It only includes cases of simple multiple ligament injuries of the KD-

IIIM type and does not cover cases with concomitant fractures or old injuries, limiting the applicability of the study conclusions. Subsequent research could conduct multi-center, large-sample, long-term follow-up controlled studies, incorporating patients with different types and durations of MLKI to further refine the stratified indications for staged and one-stage surgeries.

5. Conclusion

In conclusion, arthroscopic one-stage reconstruction of multiple ligament injuries of the knee joint can accelerate early postoperative knee joint functional recovery and reduce the number of surgeries and medical expenses. However, it carries a higher risk of postoperative joint stiffness and adhesion. Staged reconstruction significantly reduces the risk of joint fibrosis complications, with no significant differences in long-term knee joint mobility and stability compared to one-stage surgery. Clinicians need to comprehensively evaluate patients based on age, degree of soft tissue injury, physical tolerance, and rehabilitation willingness to individualize one-stage or staged reconstruction plans, coupled with standardized staged rehabilitation training, to maximize the improvement of long-term knee joint function and reduce the risk of traumatic arthritis.

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Disclosure statement

The authors declare no conflict of interest.

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