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Clinical and radiological outcomes following isolated double-bundle medial patellofemoral ligament reconstruction for patellar instability in mature and normal lower limb alignment patients: a 12-year follow-up case series

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Abstract

Background The Double Bundle Medial Patellofemoral Ligament (MPFL) Reconstruction is a reliable technique for patellar instability. Clinical studies have shown its effectiveness and reliability in minimum 5-year follow-up, however, its efficacy when it comes to more than 10 years after surgery are still unclear. This retrospective study aimed to assess the effectiveness at least 12 years postoperatively.

Methods A total of 68 patients with chronic patellar instability who underwent surgery from May 2005 to February 2010 were included prospectively. Tegner Activity Scale (TAS), Kujala score, Lysholm knee score, objective physical examination and radiological outcomes including Sulcus Angle (SA), Congruence Angle (CA), Patellar Tilt Angle (PTA) and Osteoarthritis Computed Tomography-Score (OACT-score) were assessed preoperatively, 6 years and 12 years postoperatively and survival rate was calculated at the last follow-up.

Results Median follow-up time for the patients was 169.02 ± 14.11 months. At the last follow-up, 54 patients were enrolled in the end and underwent face-to-face follow-ups with mean TAS value of 7.35 ± 0.86, Kujala score of 93.81 ± 2.76 and Lysholm score of 92.06 ± 3.89. Radiological outcomes showed no abnormalities and were all under pathological threshold with mean SA value of 136.86 ± 3.67, CA value of -6.37 ± 2.76 and PTA value of 4.15 ± 3.03. Four patients showed OACT-score of 2 at the last follow-up. The 12-year survival rate was 96.3%.

Conclusion This retrospective minimum 12-year analysis showed satisfactory results in long-term follow-up of double bundle MPFL reconstruction and further confirmed it as an ideal technique to manage patellar instability.

Keywords Patellar instability, Medial patellofemoral ligament reconstruction, Radiological outcome, Long-term follow-up

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Introduction

The medial patellofemoral ligament (MPFL) serves as the primary restraint to lateral patellar translation, contributing approximately 50–60% of the total medial stabilizing force. It is injured in approximately 92% of patients following a first-time lateral patellar dislocation and accounts for nearly 3% of all knee injuries [1, 2]. The MPFL was first described by Kaplan in 1957 as a transverse reinforcement extending from the base of the patella to the tendon of the medial head of the gastrocnemius [3]. The MPFL is composed of two distinct fiber bundles: the inferior straight bundle (ISB) and the superior-oblique bundle (SOB). Both the ISB and SOB function as static restraints, while the SOB additionally contributes to dynamic patellar stabilization [4]. Inadequate management of a first-time patellar dislocation may lead to recurrent instability, chronic knee pain, and progressive development of patellofemoral osteoarthritis [5]. 40% of recurrent dislocation rate has been reported after single acute patellar dislocation [6]. Therefore, timely and appropriate interventions are essential to prevent further complications.

The role of surgical intervention following a first-time patellar dislocation remains controversial [7, 8]. However, it has demonstrated greater effectiveness in managing recurrent patellar dislocation with better functional score and lower redislocation rate. A variety of surgical techniques have been employed, including MPFL repair, MPFL reconstruction, medial retinacular repair, medial reefing, lateral release, and tibial tuberosity transfer, among others [9]. Pathoanatomic study and clinical observations suggest that MPFL reconstruction is preferable owing to its superior clinical outcomes [10, 11]. Regarding graft bundle selection, both single- and double-bundle techniques effectively restore knee function and stability. However, the double-bundle approach has been associated with superior clinical outcomes, higher knee function scores, and a lower postoperative patellar instability rate [12]. The relationship between predisposing factors and clinical outcomes remains a subject of ongoing debate [13, 14].

Anatomical factors such as patella alta, trochlear dysplasia, malalignment syndromes, and limb axis deformities may predispose individuals to patellar instability and increase the risk of recurrence. These conditions can result in damage to the articular surface, potentially leading to osteochondral lesions and progression to patellofemoral osteoarthritis [15–17]. While favorable outcomes on patellofemoral chondral lesions and arthritis after MPFL reconstruction can be seen in different short-term and mid-term clinical studies, the outcomes of long-term clinical observation and research are still needed to clarify this issue [18]. In our previous mid-term clinical study, we evaluated the efficacy of anatomical double-bundle reconstruction of the MPFL in patients with chronic patellofemoral instability and normal alignment of the lower limb [19]. The results demonstrated significant improvements in patient-reported outcome measures, including the Tegner Activity Scale, Kujala Score, and Lysholm Score. These findings suggest that double-bundle MPFL reconstruction yields favorable clinical outcomes with sustained benefits over an extended period [19]. However, further long-term clinical observations and studies are required to fully elucidate the sustained durability and long-term efficacy of this surgical technique. Therefore, the present study aims to conduct a long-term follow-up of patients who underwent double-bundle reconstruction of the MPFL more than 12 years ago, in order to better clarify its long-term clinical efficacy.

Materials and methods

Study design

The study was designed as a retrospective case series. From May 2005 to February 2010, a total of 68 patients with patellar instability underwent surgical intervention and were assessed preoperatively and postoperatively. Inclusion criteria were as follows: (1) chronic patellar instability, defined as two or more patellar dislocations with a persistent positive apprehension test following a 6-month rehabilitation protocol; (2) closed growth plates; (3) a Q angle less than 20° and a patellar height ratio below 1.3, as determined by the Insall-Salvati method; and (4) a tibial external rotation angle under 8°. Exclusion criteria included: (1) the presence of arthrosis or generalized ligamentous laxity; (2) concurrent injuries involving the anterior cruciate ligament, posterior cruciate ligament, or meniscus; (3) chondral damage graded 3 or 4; (4) significant trochlear dysplasia, categorized as Dejour type B, C, or D; (5) a history of prior knee surgeries; (6) fractures located in or around the knee joint. The cohort inluded 22 male and 46 female patients, with a mean age of 21 years (range 16–32) at the time of their first admission. The median duration of preoperative patellar instability was 12 months, ranging from 6 months to 3 years. A total of 14 patients were lost to follow-up. The median follow-up duration was 169.02 ± 14.11 months. This study was performed in accordance with the principles of the Declaration of Helsinki and approved by the Institutional Review Board of Wangjing Hospital of China Academy of Chinese Medical Sciences (WJEC-KT-2020-008-P003).

Surgical technique

The surgical techniques and procedures have been described in detail in our previous study [19]. All arthroscopic MPFL reconstruction procedures followed the same technique outlined in a prior study. In summary, patients were positioned supine and received spinal

anesthesia. Knee arthroscopy confirmed patellar instability. The semitendinosus tendon was harvested through a 2- to 3-cm longitudinal incision near the tibial insertion of the pes anserinus. A separate 4- to 5-cm incision was made approximately 2 cm medial to the patella, where a bony rim was prepared at the MPFL attachment site. Two suture anchors (GIITM, DePuy Mitek, Raynham, MA) with no. 3 nonabsorbable braided suture were placed at the midpoint and superomedial pole of the patella.

The adductor tubercle on the medial femoral condyle was then identified, with the natural MPFL attachment located distally. Proper placement of the Kirschner wire was confirmed via an isometric test using the braided suture from the anchors to the Kirschner wire. A 7-mm diameter tunnel was drilled over the guidewire. The graft's midpoint was secured to the patellar anchors, while the ends were passed through the femoral bone tunnel by removing the guidewire. Graft tension was adjusted to align the patella during knee motion. After manually positioning the patella in the correct femoral groove location, the graft was fixed using an absorbable interference screw (BIOCRYL Interference Screw, DePuy Mitek) with the knee flexed at 30°. Arthroscopy was repeated to confirm accurate patellar alignment within the trochlea after reconstruction.

Postoperative rehabilitation

Immediately after surgery, a simple leg brace was applied to the knee. Patients began straight leg-raising and quadriceps-setting exercises as soon as they were able to tolerate them. During the first two weeks, they walked with a fully extended knee and full weight-bearing. Between weeks 2 and 4, patients performed exercises within a range of motion (ROM) of 0 to 90° while continuing full weight-bearing walking. From weeks 4 to 6, the permitted ROM increased to 120°, with full weight-bearing walking maintained. After six weeks, patients achieved full ROM and were allowed unrestricted activity. Individual sports, such as running, were permitted after three months, while contact sports, such as basketball, were allowed after six months.

Clinical and radiologic outcome assesments

All patients were assessed 12 years postoperatively in this study and the functional scores were compared with the data of prior study which was assessed preoperatively and 6 years postoperatively. Subjective patient evaluation included activity level and pain, and was performed using the Tegner Activity Scale (TAS), Kujala scoring and Lysholm score. The objective physical examination included palpable pain, positive apprehension test, and ROM. Radiological outcome including sulcus angle (SA), congruence angle (CA), patellar tilt angle (PTA) and Osteoarthritis Computed Tomography-Score (OACT-score) were recorded at the last follow-up by doing a CT scan. Complications as delayed union of the incision, skin hypoesthesia, and patellar clicking at knee flexion were considered. Postoperative dislocation was requested immediately, and treatment was decided by an orthopedist.

Statistical analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). For count data, either the χ^2 test or Fisher's exact test was applied. Ordinal data were analyzed using the rank sum test. Measurement data conforming to a normal distribution were expressed as the mean ± standard deviation ($\bar{x} \pm s$). Comparisons of normally distributed data were conducted using the paired sample t-test for within-group analysis and the independent sample t-test for between-group analysis. A P-value of < 0.05 was considered to indicate statistical significance.

Results

Clinical outcomes

The mean TAS score was 7.35 ± 0.86. None of the patients felt knee pain at rest. Fifty patients were pain-free when performing activities of daily living (Tegner level 4), 35 resumed recreational sports activities (Tegner level 7) and 8 patients successfully returned to competitive sports (Tegner level 9). Although the overall TAS score showed no significant differences, a higher level of athletic performance with minimal pain was observed, as evidenced by 8 patients returning to competitive sports at Tegner level 9 (Table 1). Regarding knee function, the mean Kujala score was 93.81 ± 2.76 and the mean Lysholm score was 92.06 ± 3.89, which were significantly higher than the result of our previous study. (Table 2).

Physical examination

No palpable pain and positive apprehension test were observed at the final follow-up. The mean ROM was 130.7°, which showed no significant differences between postoperative follow-ups.

Radiological outcomes

For radiological examination at the last follow-up, all three outcome parameters remained within non-pathological thresholds, with the mean SA angle of 136.86 ± 3.67°, mean CA angle of -6.37 ± 2.76°and mean PTA of 4.17 ± 3.03°. Four patients showed mild joint space narrowing with an OACT-score of 2, and no additional signs of patellofemoral osteoarthritis were observed.

Complications

No intraoperative complications were observed. Anchor fixation minimized patellar bone loss, preventing

Table 1 Pain evaluated at various time points according to Tegner activity level

	Pain at rest		Pain during activities of daily living Tegner level 4		Pain during sports activities Tegner level 7		Tegner Activity Scale
	Positive	Negative	Positive	Negative	Positive	Negative	
Preop	13	55	45	23	68	0	2.85 ± 0.78
6y postoperative	0	60	8	52	46	14	7.82 ± 0.89
12y postoperative	0	54	4	50	19	35	7.64 ± 0.86
t, *p* Value [a]							t = 1.096, *p* = 0.276

[a] *p* value in this table represents the differences between 6 years and 12 years postoperative scores

Table 2 Functional scores at different follow-up times

	Preoperative	6 years postoperative	12 years postoperative	t, *p* Value [a]
Kujala score	57.53 ± 8.59	88.92 ± 3.84	93.81 ± 2.76	t = −8.178, *p* = 0.000
Lysholm score	43.53 ± 10.20	89.67 ± 4.13	92.06 ± 3.89	t = −5.711, *p* = 0.000

[a] *p* value in this table represents the differences between 6 years and 12 years postoperative scores

fractures. Two patients required secondary incision closures, three reported mild hypoesthesia (6 cm^2), and two experienced non-disruptive patellar clicking at 30° knee flexion, which required no additional treatment.

Two cases of redislocations were observed 10 years after surgery (126 m, 140 m) and revision surgeries were performed. Trauma was identified as the primary cause of redislocation in one case and the factors that are responsible for the other case of redislocation remain unclear. Possible contributing factors include graft loosening, graft rupture, or failure to recognize additional risk factors for recurrent patellar instability. Revision surgeries are conducted by the same surgeon and the physical examination, functional and radiographic outcomes at the last follow-up returned to optimal levels.

Discussion

The most important finding of this study is that functional scores and radiographic assessments remain improved compared to preoperative values and all showed differences between the last two follow-ups with a survival rate of 96.30%. A network meta-analysis by Fang et al. [20] reported that MPFL reconstruction yielded superior functional outcomes compared to other soft tissue procedures. Additionally, a recent meta-analysis demonstrated that double-bundle MPFL reconstruction was superior to single-bundle reconstruction in terms of knee function scores and postoperative patellar stability [12]. Compared to other interventions including conservative treatment, double-bundle MPFL reconstruction could better restore the anatomy of the native ligament and yields superior long-term clinical outcomes [21–24].

In this study, we found that improvements in functional scores were sustained and showed significant differences compared to our previous mid-term follow-up results [19]. SA, CA, and PTA values were evaluated against established cutoff values from previous studies. SA, defined as the angle between the deepest point of the femoral sulcus and the peaks of the femoral condyles on axial imaging, has a widely accepted cutoff value of 145° [25–27]. SA values exceeding 145° are indicative of pathological trochlear flattening. The mean SA value in this study (136.86 ± 3.67) was below the pathological threshold, indicating a normal trochlear morphology. CA is defined as the angle between the bisector of the SA and the line connecting the deepest point of the trochlear groove to the apex of the patella, with a cutoff value of 4°, and a mean value of -8°in normal knees according to previous studies [28–30]. With a mean CA value of -6.37 ± 2.76, no signs of patellar lateralization were seen at the last follow-up. PTA, formed between the longitudinal axis of the patella and the posterior condylar tangent, has a proposed pathological threshold of 20° [25]. Mean PTA value at the last follow-up was 4.17 ± 3.03, showing no patellar tilt in patients. Collectively, the SA, CA, and PTA measurements revealed no signs of trochlear dysplasia, patellar lateralization, or patellar tilt, suggesting preserved patellofemoral alignment and bony morphology 12 years after double-bundle MPFL reconstruction. For osteoarthritis and chondral damage assessment, we utilized OACT-score, which was reported to exhibit near-perfect reliability in evaluating both patellofemoral and femorotibial compartments [31]. OACT-scores at the final follow-up were generally favorable, with only four patients exhibiting mild joint space narrowing, potentially attributable to older age at the time of surgery and prolonged intervals between dislocation episodes and surgical intervention. Despite these favorable outcomes, 2 cases of redislocation were observed 10 years postoperatively, resulting in a failure rate of 3.7% which is slightly lower than the failure rate reported as around 4% in other studies [32, 33].

The favorable long-term clinical outcomes observed in this study may be closely attributed to the strict inclusion criteria employed. Only patients with recurrent patellar instability and normal lower limb alignment were included in this study, and all underwent isolated double-bundle MPFL reconstruction without concomitant procedures. Patients with abnormal Q angles, Dejour type B, C or D trochlear dysplasia and patella alta were excluded. In contrast, Wei-Li Shi et al. [34] reported a mean 47.3 months follow-up results of double-bundle MPFL reconstruction in patients with trochlear dysplasia, elevated TT-TG distance and patella alta. Significant postoperative improvements were observed in Kujala score (52.7 ± 11.7 preop to 91.1 ± 4.8 postop), Lysholm score (49.6 ± 10.1preop to 92.5 ± 3.6 postop), TAS (2.9 ± 0.8 preop to 5.2 ± 0.9 postop) and subjective satisfaction of 9.3 ± 1.0. Similarly, Sung-Yup Hong et al. [35] presented 5-year follow-up data on patients with Dejour type A, B and C trochlear dysplasia, reporting substantial improvements in Kujala score (52.7 ± 11.7 preop to 91.1 ± 4.8 postop), Lysholm score (49.6 ± 10.1 preop to 92.5 ± 3.6 postop), TAS (2.9 ± 0.8 preop to 5.2 ± 0.9 postop), along with promising radiographic findings. Additionally, the severity of patellofemoral osteoarthritis was evaluated using the Iwano classification, and no radiographic progression was observed when compared to preoperative findings. Despite the promising mid-term outcomes reported, long-term clinical evidence regarding the impact of patient selection on surgical and functional outcomes remains limited and warrants further investigation.

This study has several limitations that should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings. Future studies with larger sample sizes and higher methodological standards are needed to validate these results. Additionally, baseline radiographic and arthroscopic data were unavailable, precluding the ability to evaluate longitudinal changes. Consequently, the final radiographic data could only be assessed by comparison with cut-off values established in well-documented studies. Moreover, MRI examination was not utilized in this study due to its longer time span which may increase the likelihood of poor patient compliance among high-functioning individuals with relatively stable clinical situation. Nonetheless, this study provides valuable insights and helps bridge the gap in long-term follow-up data regarding double-bundle MPFL reconstruction.

Conclusion

In conclusion, the double-bundle MPFL reconstruction technique demonstrated reliable and favorable outcomes in terms of knee functional scores, physical examinations, and radiographic assessments, while also yielding satisfactory results in long-term follow-up in mature and normal lower limb alignment patients.

Abbreviations

MPFL	Medial patellofemoral ligament
TAS	Tegner activity scale
ROM	Range of motion
SA	Sulcus angle
CA	Congruence angle
PTA	Patellar tilt angle
OACT-score	Osteoarthritis computed tomography-score
ISB	Inferior straight bundle
SOB	Superior-oblique bundle

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by JW and TC. The first draft of the manuscript was written by JW and TC and all authors commented on previous versions of the manuscript. JW and TC contributed equally to this work. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Wangjing Hospital of China Academy of Chinese Medical Sciences (WJEC-KT-2020-008-P003) and all patients voluntarily signed an informed consent form.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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