Int J Clin Exp Med 2016;9(6):9064-9072
www.ijcem.com /ISSN:1940-5901/IJCEM0019917

Original Article

A medium-term follow-up outcome of medial retinaculum plasty versus double-bundle anatomical medial patellofemoral ligament reconstruction for recurrent patellar dislocation in adults

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Received November 17, 2015; Accepted March 25, 2016; Epub June 15, 2016; Published June 30, 2016

Abstract: The aim of this study is to compare the outcome of medial retinaculum plasty with that of double-bundle anatomical medial patellofemoral ligament reconstruction for recurrent patellar dislocation on the evaluations of the clinic, function and the computed tomograghy in adults. There were fifty-four patients who were randomly divided into two groups: One group with twenty-six patients performed double-bundle anatomical medial patellofemoral ligament reconstruction (group I); The other group with twenty-eight patients undertaken medial retinaculum plasty (group II). And follow-ups were conducted at 12, 24 and 48 months postoperatively. There were forty-four patients left who achieved completely the final follow-up, and each group had twenty-two patients respectively. In terms of the evaluations of CT scans, good outcome was significantly observed in group I and group II respectively compared preoperatively. But it was relatively better results that were found in the group I compared to the group II. With respect to the rehabilitation of knee function, similarly, the two groups gained the statistically differences compared preoperatively. However, greater results were still observed in the group I. Finally, we conclude that both group I and group II obtain statistically significant differences respectively compared preoperatively. Moreover, the outcome of the group I is a little better than that of the group II. Level of evidence II.

Keywords: Patellar dislocation, medial patellofemoral retinaculum plasty, double-bundle anatomical medial patellofemoral ligament reconstruction

Introduction

Recurrent patellar dislocation is a common disorder in both adolescents and adults. However, there are two main predisposing factors which include bony and soft tissue's problems, such as femoral trochlear dysplasia, the increase of the tibial tubercle-femoral groove distance, medial soft tissue laxity, lateral tissue contraction, etc [7, 8]. In the light of the pathogenesis of patellar dislocation, a growing number of surgical procedures were performed, such as the medial capsule reefing, lateral retinacular release, medialization of the tibial tubercle, medial retinaculum plasty, etc [2, 9-12, 15]. While medial retinaculum plasty is a relatively new procedure. This procedure was invented by Dr. Wang [9], and he used the vastus medialis obliquus head, the fascia, and joint capsule as the medial retinacular stabilizer. Meanwhile the clinical outcome was much satisfactory.

As we all known, medial patellofemoral ligament (MPFL) providing 53% to 67% force to the lateral patellar translation, is a primary soft tissue restraint and prevalently awared of among the senior scholars [4, 5]. The concept of MPFL reconstruction, therefore, has been realized and accepted. And a great quantity of surgeons performed MPFL reconstruction by transfering autologous or allogenic tendon for the recurrent patellar dislocation, such as Ostermeier [13] using the semitendinosus tendon as a substitution of the MPFL, Steensen [14] transferring the

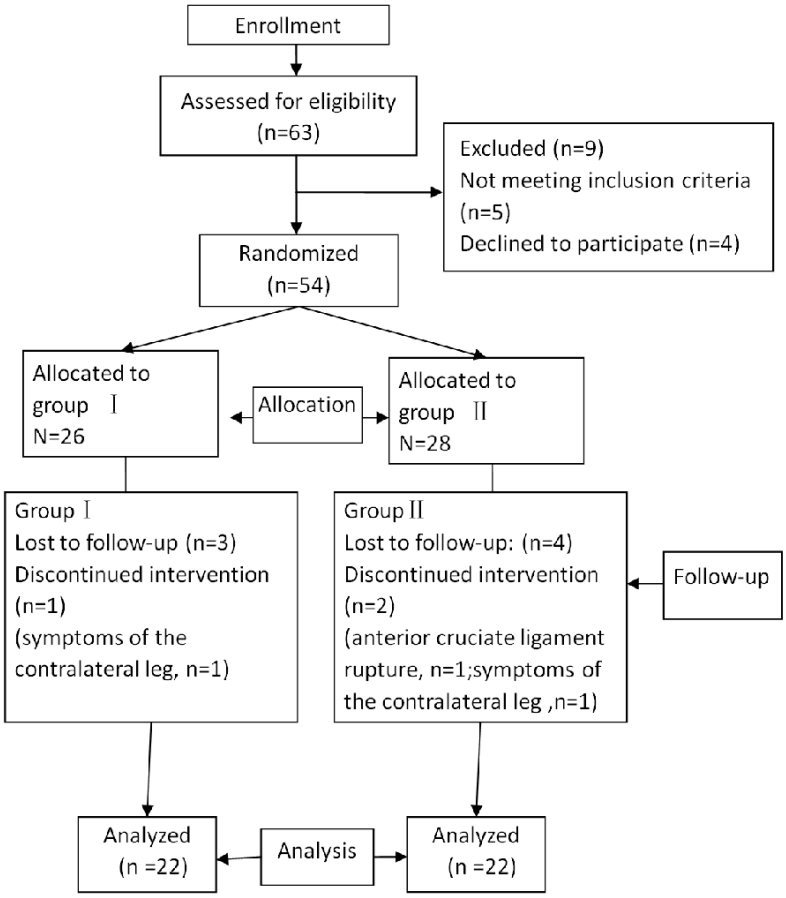

Figure 1. Patients flow diagram. Group I, double-bundle anatomical medial patellofemoral ligament reconstruction; Group II, medial retinaculum plasty.

gracilis tendon, etc. Although these mentioned above reinforced the dynamic stability of the knee to some extent, they didn't restore the anatomical reconstruction. Due to the deep knowledge on the anatomical MPFL, there is a relatively new concept called double-bundle anatomical medial patellofemoral ligament reconstruction. Wang et al [3] demonstrated that there were significantly clinical results by undertaking the double-bundle anatomical reconstruction. The comparison between the clinical outcome of medial retinaculum plasty and that of double-bundle anatomical medial patellofemoral ligament reconstruction, however, was well unknown. It was hypothesized that the clinical result of the group I yielded a little better than that of the group II.

Material and methods

Between February 2010 and July 2011, a total of fifty-four patients with recurrent patellar dislocation were randomly divided into two groups according to a computer algorithm: 26 patients comprised in group, 28 patients comprised in group II. During this period, sixty-three patients were treated for recurrent patellar dislocation in our study by the senior author (F.W.).

Inclusion criteria

In this study, the inclusion criteria were as follows: (1) the patients had a history of patellar dislocation and patellar instability symptoms (pain, subluxation, or both) had existed over three months after the first dislocation; (2) the occurrence of dislocation was confirmed by MRI, and computed tomography (CT); (3) patellar apprehension sign was positive; (4) conservative treatment was unsuccessful.

Exclusion criteria

Exclusion criteria were as follows: (1) the MPFL injury at around the patellar attachment, which was found by the MRI scan (**Figure 2**); (2) previous surgical procedures of the knee; (3) cruciate ligament rupture combined with or not the complicated collateral ligament injury(ies); (4) patellar height: Insall index >1.2, Q angle >20°; (5) CT measurements of the knee-joint: femoral trochlear groove angle >150°, TT-TG >15 mm; (6) knee symptoms in the contralateral leg; (7) associated with rheumatoid arthritis, bone necrosis or the level of articular cartilage defects above Outerbridge III.

Before the procedure, MRI and CT examinations were performed for all the patients. Then the anatomic site of the MPFL injury was evaluated by MRI. However, Patellar tilt angle (PTA), congruence angle (CA) were evaluated on CT scans. Patellar apprehension was undertaken by the senior author. In addition, the distance of lateral shift was measured by defining the start-

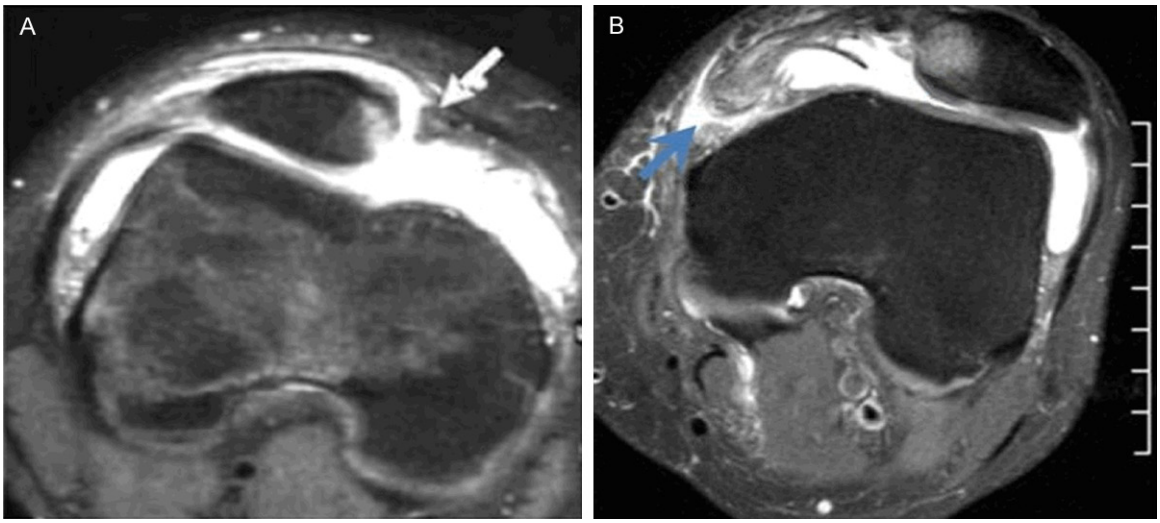

Figure 2. A. MPFL injury at the patellar attachment (white arrow); B. MPFL injury at the femoral attachment (blue arrow).

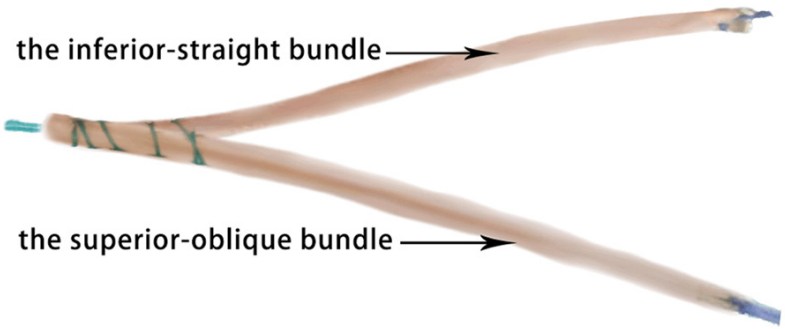

Figure 3. The schematic diagram of the double-bundle.

ing point and the ending point in the line through the transversal axis of the patella. The starting point was measured in the middle point of the medial line of the patella at full extension, and the ending point was measured in the middle point of the medial line of the patella at 30 degree of flexion with a laterally directed force. Knee function was measured with Kujala score and Lysholm score.

Surgical technique

All identified patients in our institution were performed by the same senior surgeon (F.W). In the group I, all the harvested tendons were from the autologous semitendinosus tendons or the autologous semitendinosus tendons combined with gracilis tendons in case of thin semitendinosus tendons. After anesthesia, anteromedial and anterolateral or superolateral portals were routinely adopted. Arthroscopy then was carried out to assess and address intra-articular lesion. The mobility of the patella under medial force, which was less than one-fourth width of the patella, indicated lateral overstrain [16]. Lateral retinacular release (LRR) was, therefore, performed on request.

Double-bundle anatomical medial patellofemoral ligament reconstruction

The surgeon used a tendon stripper to harvest a around 20-cm length of the semitendinosus tendon (if it was too thin, the gracilis tendon was also adopted). Then the graft was folded, including a folded end and two free ends (**Figure 3**). The folded end was braided about 2.5-cm in length with Ethicon No. 2 non-absorbable sutrue. And the two free ends were braided with the same suture in the similar way. The midpoint, which was between the highest point of medial femoral epicondyle and the adductor tubercle, was selected as the femoral insertion site. And the proximal and the centre medial borders of the patella were selected as the insertions of the superior-oblique bundle and the inferior-oblique bundle respectively. Then a 2.4-mm guide pin with an eyelet was inserted into the femoral insertion, monitored by a fluo-

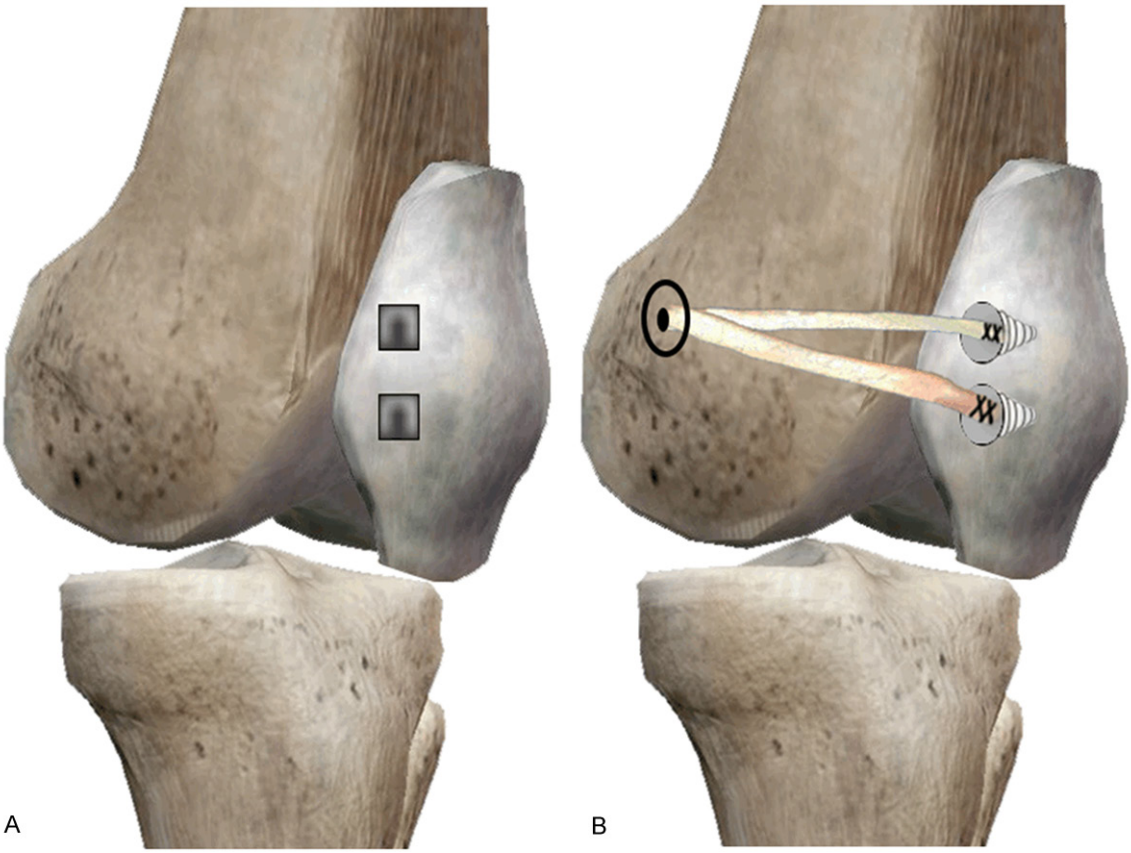

Figure 4. A. Two bony grooves with one drilled at the proximal medial border patella and the other drilled at the centre medial patella, which were 0.5 cm*0.5 cm*0.5 cm in volume respectively. B. The folded and braided end was inserted into the femoral tunnel, which was fixed with a 7*23 mm absorbable screw. The superior-oblique bundle and the inferior-straight bundle were fixed by two anchors.

roscopy machine in a straight lateral view. And a 1-cm longitudinal skin incision was made around the femoral insertion. Subcutaneous tissue was dissected to expose the femoral cortical bone. And a femoral tunnel with 3-cm in depth was drilled using a seven milimetre diameter reamer, whose diameter was approximately with that of the folded end. Thus the folded and braided end was inserted into the femoral tunnel and was fixed with a 7*23 mm absorbable screw.

Another around 3-cm longitudinal skin incision was made over the medial edge of the patella. Then subcutaneous tissue was dissected to expose the patellar cortical bone. And two bony grooves were made with one drilled at the proximal medial borde patella and the other one drilled at the centre medial patella, which were 0.5 cm*0.5 cm*0.5 cm in volume respectively (**Figure 4**). Next two suture anchors with No. 3 non-absorbable suture were placed into the two bony grooves, and the superior-oblique bundle was fixed at the proximal medial anchor, yet the inferior-straight bundle was fixed at the other anchor. The graft fixation tensioning was properly adjusted before sutured to the anchors. And after the two separated grafts were fixed, the tension was evaluated by the mobility of the knee from 0 to 90 in order to maintain the right tracking of the patella. The 30 degree of knee flexion was defined as the final fixation. And then, the vastus medialis was sutured to the superior-oblique bundle. Finally, the incisions were subsequently closed in layers [3].

Medial retinaculum plasty

When the avulsion of medial retinaculum occured mostly in the femoral attachment, the surgery procedure would be undertaken as follows (**Figure 5**).

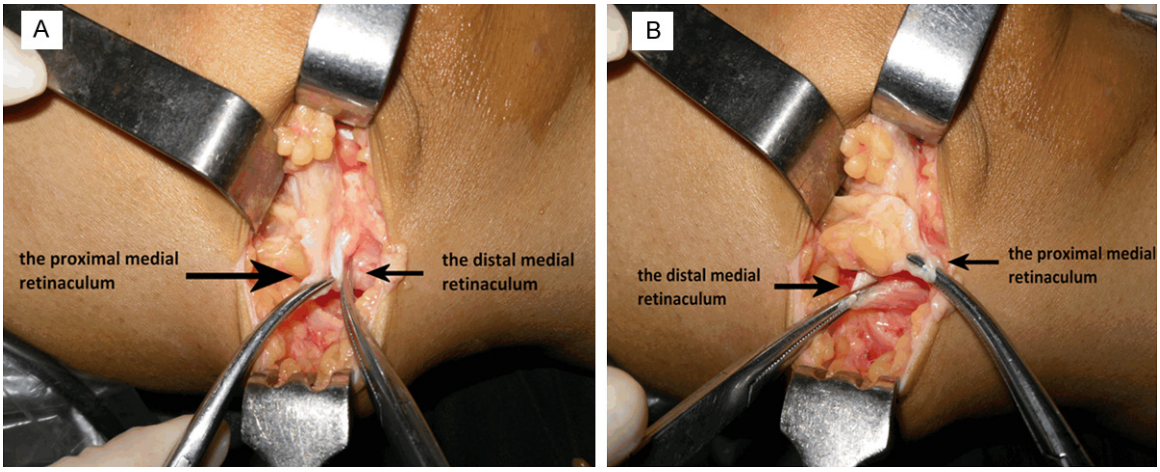

Figure 5. A. A 3-cm longitudinal incision was made between the adductor tubercle and the medial epicondyle. Then a transverse incision was made, which divided the medial retinaculum into two parts, including a proximal part and a distal part with temporary sutures respectively. B. On the femoral attachment, the distal part was pulled to the proximal edge of the adductor tubercle, while the proximal part was pulled to the distal edge of the adductor tubercle. Finally, the incisions were closed in layers.

Table 1. Patient demographic data[a]

Variables	Group I (n=22)	Group II (n=22)	x^2 or t Value	*P* Value
Male/Female, No.	10/12	9/13	x^2=.093	.761[#]
Age	27.46±4.84	25.64±3.35	t=1.023	.318[&]
Left side/Right side, No.	12/10	8/14	x^2=1.467	.226[#]
CA (▫)	20.60±1.96	20.09±3.28	t=-.442	.663[&]
PTA (▫)	12.35±1.31	12.66±2.26	t=.393	.700[*]
PLS (mm)	15.27±1.89	13.87±2.78	t=-1.384	.184[*]
Kujala score	61.73±4.88	60.46±6.55	t=-.517	.611[&]
Lysholm score	59.91±3.81	59.55±4.78	t=-.197	.846[&]

[a]Group I, double-bundle anatomical medial patellofemoral ligament reconstruction; Group II, medial retinaculum plasty. [*]The *p* value of the Levene's Test for equality of variances is lower than .10, separate variance estimation t-test was adopted. [#]Pearson Chisquare test was adopted. [&]Independent-Samples t-test was used. CA, congruence angle; PTA, patellar tilt angle; PLS, patellar lateral shift.

A 3-cm longitudinal skin incision was made between the adductor tubercle and the medial epicondyle. And the subcutaneous tissue, superficial and deep fascias were ordinally dissected. Then a transverse incision was made, which divided the medial retinaculum into two parts, including a proximal part and a distal part with temporary surtures respectively. After evaluating the patellar activity by hand, the congruence of patellofemoral joint was observed with the knee at full extension and the tracking of patella was observed during the flexion under arthroscopy. Then Patellar tracking was kept in the right position via adjusting the temporary surtures. On femoral attachment, the distal part was pulled to the proximal edge of the adductor tubercle, while the proximal part was pulled to the distal edge of the adductor tubercle. Then the two parts were sutured with PDS-I whipstitch. And the incisions were closed in layers [9].

Postoperative treatment

The rehabilitation programme was similar in the two groups. There was a need to make the affected limb immobilized postoperatively. The first day after operation, the patients started moderate exercises, such as isometric contraction of the quadriceps, the affected limb straight rising, etc. Two days later, a slight knee flexion was admitted. And the degree of the knee flexion was gradually increasing from 0 to 90 during one month. At the third day after

Table 2. The Data among preoperative and 12, 24, and 48-month data in group I[a] (mean ± standard deviation)

Indexes	A	B	C	D	P_{AB}	P_{AC}	P_{AD}	P_{BC}	P_{BD}	P_{CD}
PTA (▫)	12.35±1.31	6.73±1.05	6.96±0.54	7.13±0.61	.000	.000	.000	.571	.321	.667
CA (▫)	20.60±1.96	6.31±1.48	6.48±1.05	6.53±0.88	.000	.000	.000	.775	.718	.940
PLS (mm)	15.27±1.89	7.26±1.34	7.45±1.26	7.57±0.96	.000	.000	.000	.715	.598	.833
Kujala score	61.73±4.88	95.09±3.56	93.09±2.66	92.46±2.25	.000	.000	.000	.186	.084	.671
Lysholm score	59.91±3.81	95.18±2.82	93.18±2.27	92.36±1.91	.000	.000	.000	.101	.023	.497

Group I, double-bundle anatomical medial patellofemoral ligament reconstruction; [a]the LSD-t test was used for statistical analysis. A, preoperative time; B, postoperative 12 month; C, postoperative 24 month; D, postoperative 48 month; PTA, patellar tilt angle; CA, congruence angle; PLS, patellar lateral shift; P, *p* value.

operation, the patients could walk on crutches. Three weeks later, the affected limb was allowed partially weight-bearing and full weight-bearing five weeks or later after operation. And the immobilizer was removed three months later. Then, the patients participated in normal sports six months after operation.

CT imaging and knee function evaluations

For preoperatively and postoperatively, CT scans were taken by the same senior radiologist at the 20 of knee flexion. All the results were recorded in order to examine patellar tilt angle (PTA), congruence angle (CA) and patellar lateral shift (PLS). In addition, Kujala score [31] and Lysholm score were used to assess patients' satisfactoriness.

Statistical analysis

The collected data were compared between the preoperative and postoperative examinations using the LSD-t test within each group. And we compared the indexes at 12-month and final follow-up points using Independent-Samples t-test between groups. Levene's test is adopted to assess homogeneity of variance between data. However, if the *p* value of the Levene's test is lower than .10, separate variance estimation t-test is used. Pearson Chi-square test and Independent-Samples t-test were also used in patient demographic data. Numeric data were noted down as mean ± standard deviation (SD). And the significant level was defined as .05.

Results

To the final follow-up date, there were 44 patients left who achieved the complete follow-up for 22 patients in each group respectively. And three patients were lost because of loss of contact number, with one at the 12-month time point and two at the 24-month time point in group I. Meanwhile, four patients were lost due to the broken contact, with one at the 12-month time point, two at 24-month time point and one at the 48-month time point in group II. There were totally three patients who were excluded from this analysis: two patients experienced 1 episode of patellar dislocation or at least 2 episodes of patellar instability in the contralateral leg, one patient sustained an anterior cruciate ligament (ACL) rupture (**Figure 1**). During the postoperative follow-up, the positive was none in the apprehension test each group. And there were no superficial wound infection, no deep vein thrombosis and joint flexion-extension limitation in each group. In addition, Patellar redislocation didn't exhibited in any group. General characteristics were indicated (**Table 1**).

CT examination

In group I, the comparisons of patellar tilt angle (PTA), congruence angle (CA), patellar lateral shift (PLS) had a statistically significant difference among the preoperative and each postoperative point. However, there was no significant difference among postoperative points in three indexes. And in group II, the results of CT evaluation were similar with group I (**Tables 2** and **3**).

However, there were statistically significant differences at the 12-month and the final follow-up points between group I and group II respectively (**Table 4**).

Functional outcome

With respect to Kujala score and Lysholm score, there were statistically significant differences among the preoperative and follow-up points in

Table 3. The data among preoperative and 12, 24, and 48-month data in group II[a] (mean ± standard deviation)

Indexes	A	B	C	D	P_{AB}	P_{AC}	P_{AD}	P_{BC}	P_{BD}	P_{CD}
PTA (▫)	12.66±2.26	8.35±1.96	8.56±1.57	8.69±1.52	.000	.000	.000	.793	.664	.864
CA (▫)	20.09±3.28	8.14±2.17	8.24±1.91	8.35±1.77	.000	.000	.000	.921	.836	.914
PLS (mm)	13.87±2.78	9.36±2.04	9.42±1.99	9.59±1.75	.000	.000	.000	.953	.808	.853
Kujala score	60.46±6.55	84.82±4.07	83.82±3.71	82.55±3.11	.000	.000	.000	.609	.249	.516
Lysholm score	59.55±4.78	84.64±3.85	84.55±3.14	82.82±2.99	.000	.000	.000	.955	.264	.288

Group II, medial retinaculum plasty; [a]The LSD-t test was used for statistical analysis. A, preoperative time; B, postoperative 12 month; C, postoperative 24 month; D, postoperative 48 month; PTA, patellar tilt angle; CA, congruence angle; PLS, patellar lateral shift; P, *p* value.

Table 4. The comparative results between group I and group II at 12-month and final follow-up points

Indexes	B		D	
	T	P	T	P
PTA (▫)	2.414	.029*	3.158	.007*
CA (▫)	2.306	.032&	-3.042	.008*
PLS (mm)	-2.862	.011*	3.358	.004*
Kujala score	-6.299	.000&	-8.559	.000&
Lysholm score	-7.322	.000&	-8.912	.000&

*The *p* value of the Levene's Test for equality of variances is lower than .10, separate variance estimation t-test was adopted. &Independent-Samples t-test was used. Group I, double-bundle anatomical medial patellofemoral ligament reconstruction; Group II, medial retinaculum plasty; B, postoperative 12 month; D, postoperative 48 month; PTA, patellar tilt angle; CA, congruence angle; PLS, patellar lateral shift; T, T Value; P, *p* value.

group I. While there were no statistically significant differences among follow-up points. The similar results had been observed in group II (**Tables 2** and **3**).

With the comparisons of functional assessment between group I and group II, there were statistically significant differences between the 12-month and final follow-up point respectively (**Table 4**).

Discussion

Amis et al. [17] pointed it out that the MPFL played a predominant role in maintaining the patellar stability. Subsequently, we focused on injury patterns of the MPFL, and we obtained a good procedure to repair or reconstruct the MPFL. With regard to the pathogenesis of patellar dislocation, Nomura et al. [22] demonstrated that lesions of MPFL nearly existed most of the cases. In addition, Peter Balcarek et al. [23] reported that the MPFL injury occured in 98.6 % of the patients with patellar dislocation.

Meanwhile, Balcarek et al. [23] also considered that an isolated injury of the MPFL at or close to the femoral region was found in 50.0%, nevertheless, the injuries to the patellar attachment, the midsubstance site, or to more than one site were found in 13.9%, 13.9% and 22.2% respectively. And Wang et al [9] divided the injury patterns of the MPFL into three portions, named isolated region injury, combined region injury and combined injury respectively. In addition, Kang et al. [32] made the MPFL divided into three parts by cadaver anatomy, called overlap region, non-overlap region and combined injury of both regions respectively. Some portions of MPFL which were near the femoral attachment, were relatively isolated, named non-overlap regions. But on the patellar attachment, the MPFL gradually merged with the VMO and extended to the proximal patella, named overlap region [3, 9, 15, 32]. So the occurrence rate of the avulsion of MPFL was in femoral attachment higher than in other portions. And the medial retinaculum plasty was performed mostly in femoral attachment.

However, Aragão et al. [28] and Steensen et al. [29] found that the patellar side of the patellofemoral ligament attachment point was flexible, as a fan-shaped attachment over a wide range from the superior patellar pole to the midpoint of the patella. So Dr. Wang undertook another procedure, which was double-bundle anatomical medial patellofemoral ligament reconstruction. Kang et al. [30] pointed it out that MPFL fibers grew as two major different shapes: an ascending superior-oblique bundle and a horizontal inferior-straight bundle. The former acted as a dynamic stability of the patella, and

then the latter offered a static strength to ensure the normal motion of the joint. Therefore, from a biomechanical point of view, the double-bundle anatomical medial patellofemoral ligament reconstruction mimiced the structure of MPFL in morphology to maximum extent. When we approximately imitated the natural structure of MPFL, it could possibly make patellar trajectory in the centre of femoral trochlear groove, reducing the risk of articular cartilage damage and patellar pain. The patients finally attained a great satisfactoriness. Toritsuka et al. [27] treated 20 patients with double-bundle anatomical MPFL reconstruction, and no patella redislocation occurred in the following 30 months, while the Kujala score rose to 96±5 and patient satisfaction rate was 100% by the Crosby and Insall grading system. So double-bundle anatomical MPFL reconstruction has been widely accepted as an effective treatment for recurrent patellar dislocation [1, 9, 15]. Yet, Lattermann et al. [26] pointed that the LRR had not evidently influenced on treating the patellar dislocation. So in the present study, we had not compared the difference between LRR (+) and LRR (-) in both group I and group II.

From above, we knew that both medial retinaculum plasty and the double-bundle reconstruction would attain a good outcome. So we wanted to gain which one was better. In our study, with respect to Lysholm score at the final follow-up point, group I attained 92.36±1.91, while group II gained 82.82±2.99 respectively. Certainly, the comparison between group I and group II about the CT evaluations had shown in our study. In short, the outcome of double-bundle anatomical MPFL reconstruction was a little better than that of medial retinaculum plasty.

Conclusion

In the present study, good outcome was significantly observed in both group I and group II respectively, compared preoperatively. However, we found that the outcome of group I was a little better than that of group II.

Acknowledgements

The authors gratefully acknowledge funding from the National Natrual Science Foundation of China. Approval number: 81371910.

Disclosure of conflict of interest

None.

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