

Normalisation of Patella Alta with MPFL Reconstruction Reduces the Prevalence of Risk Factors Associated With Recurrent Patella Dislocations - A Prospective Cross Sectional Study

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Abstract

Background: Patella alta is a well-established risk factor for recurrent lateral patella dislocations. Medial patellofemoral ligament (MPFL) reconstruction has been shown to consistently reduce patella height. Our hypothesis is that MPFL reconstruction reduces the number of risk factors for recurrent dislocations through the correction of patella alta, resulting in a decreased risk of recurrence.

Methods: A prospective cross-sectional case series of 33 knees which underwent MPFL reconstruction for lateral patella dislocations. Information on patellar height utilising the Insall-Salvati (IS) and Caton-Deschamps (CD) ratios, Tibial Tuberosity–Trochlear Groove (TT-TG) distance, trochlear dysplasia, and outcome scores were recorded pre-operatively and post-operatively. The mean change in patella height and the number of knees which achieved normalisation of patella alta were determined. Student's paired samples T-tests were used to compare the differences in the means scores of the groups pre-operatively and post-operatively. The McNemar test for paired categorical data was used to compare the number of the patella alta corrected after MPFL reconstruction. A pre-determined significance of alpha level of 0.05 was used.

Results: The mean age of 33 patients included in the study was 21.5 years (range, 16 – 34 years). There was statistically significant reduction in patella height between pre-operative and post-operative measurements using the various patella height indices for all patients ($p < 0.001$), and normalisation of patella alta ($CD \geq 1.3$) for 90% of patients post-operatively ($p < 0.004$). One third of patients 33.3% had at least 3 risk factors pre-operatively. This was reduced to 18.2% after MPFL reconstruction, representing a 45.5% decrease. A statistically significant improvement in the outcome scores was found – Kujala score 57.1 ± 14.1 pre-operatively to 94.8 ± 5.1 post-operatively ($p < 0.0001$). The recurrent dislocation rate was 3.0%.

Conclusion: MPFL reconstruction for lateral patella dislocation results in a statistically significant improvement in clinical outcomes and decrease in patellar height ratios. Normalisation of abnormal patella height culminated in the reduction of anatomical risk factors associated with recurrent dislocations.

Background

Lateral patellar dislocation has a reported incidence of 23.2 per 100,000 person-years [1]. Recurrent dislocations have occurred in up to 71% of patients, influenced by anatomical and functional factors [2]. Dejour et al. identified the abnormal thresholds for trochlear dysplasia, patella tilt, patella alta, and tibial tuberosity–trochlear groove (TT-TG) distance as anatomical risk factors associated with patellar dislocation [3]. Other studies have since corroborated these reported findings [4-7]. Patella alta has been found to play a significant role in the recurrence of lateral patellar dislocation [8-10]. A high-riding patella engages into the trochlea groove later in knee flexion, resulting in decreased biomechanical contact forces between the patella and the trochlear – up to 3% per millimetre of change in patellar height [11].

Steensen et al. reported a majority of symptomatic patients (58%) with recurrent patella instability have at least 2 abnormal factors present [4]. The contribution of individual and interaction of factors results in a cumulative exponential increase in the risk of recurrence dislocations. Utilising these proposed risk factors, several studies have developed clinical prediction models [12-14]. In a meta-analysis of risk factors associated with recurrence for dislocation, Huntington et al. reported an overall recurrent dislocation rate of 33.6% [15]. The meta-analysis of 12 studies found younger age, open physes, trochlear dysplasia, elevated TT-TG distance, and patella alta to be significant risk factors, with a magnified risk of recurrence as the number of abnormal risk factors increased.

Understanding how the number or combination of risk factors influences the risk of recurrent dislocations may allow better prediction and guide optimal surgical interventions on a patient-specific basis. An à la carte treatment algorithm has traditionally been proposed for patients with objective recurrent patella dislocations to address the corresponding pathological anatomical abnormalities identified [16]. For instance, a medialising or distalising tibial tubercle osteotomy to correct an increased TT-TG or patella tilt; a deepening trochleoplasty to recreate the trochlear groove.

The MPFL serves as a primary static stabiliser of the patella to restrain lateral translation of the patella, providing an important biomechanical role in patella instability [17]. Injury to the MPFL has been strongly associated with the occurrence of recurrent dislocations [18, 19]. Recent systematic reviews have described the success of MPFL reconstruction for patients with patellar instability. [5, 20, 21].

As an obliquely oriented structure with a distal-medial course between the patella and the femoral insertion, the MPFL therefore also has distalizing effect on the patella. It is believed that in addition to the restoration of the medial dynamic stabilisers, MPFL reconstruction reduces patella height due to the additional inferior vector angle. Several studies have reported that isolated MPFL reconstruction reduces the patella height measurements in patients with pre-operative patella alta [22-26].

Our clinical question was whether MPFL reconstruction alone may reduce the reported anatomical risk factors of patella alta to mitigate the risk of recurrence. We propose that the correction of a specific anatomical risk factor may possibly result in a substantial decrease in the risk of recurrence. The goal of our study was to study the effects of MPFL reconstruction on 1) the reduction of patella height, 2) the resolution of patella alta and the decreased risk of recurrence based on the number of risk factors, and 3) the patient reported knee outcomes.

Methods

This was a prospective cohort study conducted in patients with recurrent patella instability who underwent MPFL reconstruction from 2013 to 2018. The study was approved by the Centralised Institutional Review Board (No. 2012/876/D). Cases were included if they underwent primary isolated MPFL reconstruction without other concomitant procedures such as a tibial tubercle osteotomy, and a minimum follow-up period of 2 years from index surgery. Exclusion criteria included concomitant injury to cruciate or collateral ligaments, or a history of prior surgery in the index knee.

A total of 33 MPFL reconstructions performed by a single senior surgeon were found to satisfy the specified criteria. The patient demographics, clinical history, and Kujala scale scores [27] both pre-operatively and at a minimum of 2 years post-operatively were recorded.

The true lateral knee radiographs (30 degrees flexion) for each case was assessed for patellar height with the Caton-Deschamps (CD) [8], and Insall-Salvati (IS) [28] ratios pre-operatively and post-operatively. All post-operative radiographs of the index knee were performed within one month after surgery. (Figure 1 & 2) The patients with patella alta prior to surgery were identified. A threshold CD ratio ≥ 1.3 was utilised as it has previously been associated with an increased risk of recurrent dislocations post-operatively [29].

The pre-operative magnetic resonance imaging (MRI) scans of the affected knee was utilised to measure the radiological parameters for TT-TG distance and trochlear dysplasia. As described by Dejour et al., the TT-TG distance was measured using superimposed slices of the trochlea and tibial tubercle in knee extension, with a cut off value of ≥ 20 mm defined as abnormal [3]. The classification system refined by Dejour et al. in 2007 was utilised to characterise the presence and type of trochlear dysplasia into Trochlear Type A, B, C and D [16].

The risk factors we chose for our cohort were the predictive factors for recurrence identified in the meta-analysis by Huntington et al. [15]. This represents the latest meta-analysis to study factors associated with the risk of recurrence for patella dislocations. The 4 risk factors used were age <20 years old, patella alta (CD ≥ 1.3), trochlear dysplasia, and increased TT-TG distance (≥ 20 mm). We tabulated the risk factors for each patient before and after MPFL reconstruction, and evaluated the reduction in risk of recurrence of patella instability after surgery.

Figure 1. Radiographic patellar height indices, a÷b. (A) Pre-operative Caton-Deschamps (B) Post-operative Caton-Deschamps (C) Pre-operative Insall-Salvati (D) Post-operative Insall-Salvati.

Surgical technique and post-operative rehabilitation

In all patients, the MPFL reconstruction was performed using a semitendinosus tendon autograft. Concomitant arthroscopy was performed in all patients prior to the reconstruction to document intra-articular pathologies. The MPFL graft fixation on the superomedial patella was achieved using two 2.4 millimetre anchors placed 1 centimetre apart. Both limbs of the graft were tunnelled under layer 2 on the medial side of the knee and fixed at the MPFL femoral insertion point described by Schöttle et al. with the use of image intensifier [30].

The post-operative rehabilitation consisted of partial weight-bearing with crutches and controlled range-of-motion to 90 degrees for 6 weeks. Full weight-bearing, full range-of-motion, and progressive strength training were commenced after 6 weeks from index surgery.

Statistical Analysis

All data were analysed using SPSS (IBM SPSS Statistics for Macintosh, version 21.0. Armonk, NY: IBM Corp). Descriptive statistics was utilised to report patient characteristics and summarise the variables. Student's paired samples T-tests were performed to compare the differences in the means of the groups pre-operatively and post-operatively. The McNemar test for paired categorical data was used to compare the number of the patella alta corrected after MPFL reconstruction. A pre-determined significance of alpha level of 0.05 was used.

Results

Epidemiology

A total of 33 knees were included in the study (Table 1). The mean age was 21.5 years (range, 16–34 years), and there were 30 males (90.9%) and 3 females (9.1%). The left knee was involved in 20 (60.6%) and the right knee in 13 (39.4%), while 7 patients (21.2%) had bilateral patellar dislocations. All patients were followed up for a minimum of two years after MPFL reconstruction with their Kujala scores performed at an average of 43 months after surgery (range, 24–96 months).

The most common cartilage lesion visualised during arthroscopy was located at the medial patella facet, 12 patients (36.4%). A majority of patients 26 (78.8%) did not have loose bodies within the knee joint.

There were 10 patients (30%) with pre-operative patella alta (CD ratio ≥ 1.3). Trochlear dysplasia was present in the majority of patients 22 (67%), while an elevated TT-TG distance (≥ 20 mm) was present in 2 (6%) of patients.

Table 1. Baseline characteristics of cases who underwent MPFL reconstruction

	Number	Percentage
Age	Mean 21.5 ± 3.62 years	Range 16 - 34 years
Gender		
Male	30	90.9
Female	3	9.1
Side		
Left	20	60.6
Right	13	39.4
Bilateral disease		
Unilateral	26	78.8
Bilateral	7	21.2
Cartilage Lesion		
Normal	12	36.4
Medial Patella Facet	12	36.4
Apex Patella	7	21.2
Medial Trochlear	1	3.0
Central Trochlear	1	3.0
Lateral Trochlear	5	15.2
Loose Bodies		
No loose body	26	78.8
Loose body	7	21.2
Patella Height (CD ≥1.3)		
Normal	23	69.7
Patella Alta	10	30.3
Trochlear Dysplasia		
Natural	11	33.3
Type A	9	27.3
Type B	6	18.2
Type C	6	18.2

Type D	1	3.0
TT-TG Distance		
<20mm	31	93.9
≥20mm	2	6.1
Kujala score, pre-operative	Mean 57.1 ± 14.1	Range 23 – 76

Patella Height

The mean pre-operative and post-operative patellar height measurements with the IS ($p<0.001$) and CD ($p<0.001$) ratios showed a statistically significant reduction in patellar height following MPFL reconstruction (Table 2). Subgroup analysis of patients with both normal and abnormal patella height indices displayed a statistically significant reduction after MPFL reconstruction – both IS ratio (abnormal >1.2) and CD ratio (abnormal ≥ 1.3) (Table 3). The CD ratio also exhibited a greater sensitivity to change for all measurements.

Table 2. Change in patella height indices

	Pre-operatively	Post-operatively	Mean Absolute Improvement	<i>p-value</i>
Insall-Salvati (IS)	1.16 ± 0.17	1.09 ± 0.16	0.07	<0.001
Caton-Deschamps (CD)	1.18 ± 0.18	1.02 ± 0.16	0.16	<0.001

Table 3. Comparison of patella height indices for patients with patella alta

	Pre-operatively	Post-operatively	Mean Absolute Improvement	<i>p-value</i>
Insall-Savati (>1.2)				
Normal patella (n=21)	1.08 ± 0.09	1.00 ± 0.9	0.08	0.002
Patell Alta (n=12)	1.34 ± 0.13	1.25 ± 0.14	0.09	0.001
Caton-Deschamps (≥1.3)				
Normal patella (n=23)	1.09 ± 0.14	0.95 ± 0.11	0.14	<0.001
Patella Alta (n=10)	1.38 ± 0.07	1.21 ± 0.10	0.17	<0.001

Using the various patella height indices, the number of patients with an abnormal patella height showed a statistically significant decrease after MPFL reconstruction – IS ratio (abnormal >1.2), 50% reduction

from 12 patients pre-operatively to 6 patients post-operatively ($p<0.031$); CD ratio (abnormal ≥ 1.3), 90% reduction from 10 patients pre-operatively to 1 patient post-operatively ($p<0.004$) (Table 4).

Table 4. Patients with correction of abnormal patella height

	Pre-operatively	Post-operatively	<i>p-value</i>
Patella Alta (IS>1.2)	12 (36.4)	6 (18.2)	0.031
Patella Alta (CD \geq 1.3)	10 (30.3)	1 (3.0)	0.004

Risk Factors

The risk factors we chose were the predictive factors for recurrence identified in the meta-analysis by Huntington et al. [15]. Most patients had 2 risk factor pre-operatively 12 (36.4%), with 23 (69.7%) patients having 2 or more abnormal risk factors. Approximately one third of patients, 11 (33.3%), were found to have at least 3 risk factors pre-operatively as compared to 6 (18.2%) post-operatively. This represents a 45.5% reduction (5/11 patients) after MPFL reconstruction.

As a consequent of correction of patella alta, 50.0% of patients with 3 risk factors were reduced to 2 risk factors, 25.0% of patients with 2 risk factors were reduced to 1 risk factor, and 14.3% of patients had all risk factors corrected. (Table 5)

Table 5. Reduction in number of risk factors after MPFL reconstruction^a

No. of Risk Factors	Pre-operatively	Post-operatively	Reduction
0	3 (9.1%)	4 (12.1%)	-
1	7 (21.2%)	9 (27.3%)	1 (14.3%)
2	12 (36.4%)	14 (42.4%)	3 (25.0%)
3	10 (30.3%)	5 (15.2%)	5 (50.0%)
4	1 (3.0%)	1 (3.0%)	-

^aThe 4 risk factors used were age <20 years old, patella alta (CD ≥ 1.3), trochlear dysplasia, and increased TT-TG distance (≥ 20 mm).

Post-Surgical Outcomes

The mean Kujala score showed a statistically significant improvement from 57.1 ± 14.1 (range, 23–76) pre-operatively to 94.8 ± 5.1 (range, 81–100) at a minimum 2 years post-operatively (average 43 months), $p<0.0001$. There were 4 (12.1%) patients who reported subjective instability symptoms and 1 (3.0%) patient experienced a recurrent dislocation which was treated non-operatively (Table 6).

Table 6. Outcome after isolated MPFL reconstruction

	Pre-operatively	Post-operatively	p-value
Kujala score (mean, range)	57.18 ± 14.1, (23 - 76)	94.8 ± 5.1, (81 - 100)	<0.0001
Instability	-	4 (12.1%)	-
Dislocation	-	1 (3.0%)	-

Discussion

This current study reports a high clinical success rate after MPFL reconstruction for lateral patellar dislocations with restoration of patella stability and significant improvement in Kujala scores. There was a statistically significant reduction in the patella height of patients after MPFL reconstruction; CD ratio 1.18 ± 0.18 pre-operatively to 1.02 ± 0.16 post-operatively ($p < 0.001$), IS ratio 1.16 ± 0.17 pre-operatively to 1.09 ± 0.16 post-operatively ($p < 0.001$). This study, along with previous studies have shown that anatomical reconstruction of the MPFL consistently results in both a restraint to lateral translation, and decrease in patellar height [22-26].

The reduction in patella index after MPFL reconstruction was first described by Lykissas et al. in a paediatric population [23], and confirmed by Fabricant et al. [22]. Subsequently, Woodmass et al. reported a reduction in patella alta from 34.0% pre-operatively to 12.5% post-operatively in an adult population [24]. Similarly, Himestra et al. and Luceri et al. found reduction in patella alta from 32.1% to 9.2% [25] and 35.8% to 7.4% [26] respectively after MPFL reconstruction. Approximately one third of patients 10 (30.3%) in our study had pre-operatively patella alta, with an eventual statistically significant 90% resultant normalisation of patella height to 1 patient (3%) ($p < 0.004$). This largely mirrors the findings of previous studies of reduction in patella indices after MPFL reconstruction.

In the largest series of 211 MPFL reconstruction, Sappey-Mariner et al. reported that pre-operative patella alta (CD ratio of ≥ 1.3) and positive J-sign was associated with an increased risk of re-dislocation [29]. From our study, one may expect a post-operative reduction in CD ratio of 0.16, and a more pronounced reduction in CD ratio of 0.17 for patients with patella alta. This would result in the normalisation of patella height in most cases of mild-moderate patella alta, addressing a significant risk factor associated with recurrent dislocations.

Tompkins et al. found in a systematic review in 2015 concerning risk factors for instability in MPFL reconstructions that trochlear dysplasia was present in 83% of studies, patella height in 75% of studies, and TT-TG distance in 42% of studies [5]. In our study, trochlear dysplasia was the most common anatomical risk factor (67%), followed by patella alta (33%), and elevated TT-TG (6%). The variability in definition of abnormal patella height amongst the studies included in the review by Tompkins et al., with some studies citing IS ratio threshold > 1.1 as abnormal, may account for the difference in frequency of patella alta in our study. Our lower frequencies of elevated TT-TG distances can also be attributed to the

inclusion of studies by Tompkins et al. that utilised a lower TT-TG threshold of <15 mm; while we utilised a threshold of <20 mm. The TT-TG measurements in our study was calculated utilising the axial images on MRI, which may underestimate TT-TG distance as compared to computer tomography (CT) [31].

Several studies, including one in a paediatric population, have been published on the risk of re-dislocations based on pre-operative variables. Lewallen et al. first stratified the risk of recurrence based on the following 3 risk factors – younger age <25 years, patella alta, and trochlear dysplasia. They reported a risk of re-dislocation of 8.6% when no risk factors were present, 11.1–26.6% with any 1 risk factor, 29.6 –60.2% with any 2 risk factors, and 70.4% with all 3 risk factors present [14]. Correspondingly, in a paediatric population, Jaquith and Parikh et al. found the risk of recurrent instability was 13.8% when no risk factors were present, 30.1% with 1 risk factor, 53.6% for any 2 risk factors, 74.8% for any 3 risk factors, and 88.4% for 4 risk factors (trochlear dysplasia, skeletal immaturity, CDI>1.45, and a history of contralateral patellar dislocation) [13]. In a case-control study, Arendt et al. found the probability of re-dislocation was 5.8% when no risk factors were present, 22.7% with 1 risk factor present, 50.9% with 2 risk factor present, and 78.5% if all 3 factors (skeletal immaturity, sulcus angle, and IS ratio ≥ 1.3) were present.

Incorporating these earlier studies, Huntington et al. conducted a meta-analysis to summarise the most significant risk factors associated with recurrence. They found the following risk factors to be significant – younger age, open physes, trochlear dysplasia, elevated TT-TG distance, and patella alta. The included studies had variations in the definitions of risk factors; patella alta defined with CD ratios ranging from >1.2 to 1.45, and IS ratio >1.2 to 1.3; and elevated TT-TG distance ranging from >14 to 20 mm. Based on the above risk factors, they reported a recurrence risk of 7.7–13.8% with no abnormal risk factors, 29.6–60.2% with 2 abnormal risk factors, and 70.4–78.5% with 3 abnormal risk factors present [15]. A majority of our patient had 2 or more abnormal risk factors (69.7%), and 11 patients (33.3%) had at least 3 risk factors. After correction of patella alta, the number of patients with at least 3 risk factors in our study was reduced by 45.5%. Overall, this may translate into a substantial reduction in re-dislocation risk after isolated MPFL reconstruction, and mitigate the need for other invasive bony corrections.

MPFL was associated with favourable outcome scores in our study, with a statistically significant improvement in Kujala scores from 57.1 ± 14.1 pre-operatively to 94.8 ± 5.1 post-operatively ($p < 0.0001$). This falls in the “excellent” category as proposed by Sillanpää et al. [32]. In a meta-analysis, Schneider et al. reported a pooled mean postoperative Kujala score 85.8 [20]. Recent studies by Erickson et al. and Sappey-Mariner et al. found an improvement in the mean postoperative Kujala score – 62.2 to 89.5 ($p < 0.001$) [21], and 56.1 preoperatively to 88.8 ($p < 0.001$) [29].

In our cohort, one patient (3.0%) had a re-dislocation after MPFL reconstruction; this patient had 1 pre-operative risk factor. Another 4 patients had instability symptoms without re-dislocation; of which three patients had 3 risk factors and one patient had 1 risk factor present respectively. Our re-dislocations rates were comparable to recent studies by Himestra et al (3.1%) [25] and Sappey-Mariner et al (4.7%) [29]. A meta-analysis found a 1.2% pooled total risk of recurrent instability after surgery [20]. However, the

reported pooled mean follow-up duration was shorter at 36.8 months than our mean follow-up duration of 43 months.

Our study reports that MPFL reconstruction is an effective option for the treatment of lateral patella dislocation, with a secondary beneficial effect on the normalisation of patella alta. What this paper adds to the literature is that it looks at the reduction at patella height after MPFL reconstruction in conjunction to the reduction in risk factor for recurrence of risk factors for patella instability. The strengths of this study are a single senior surgeon approach which ensures a consistency of technique, minimising the impact of individual variability.

There were several limitations in this study. First, this was a case series with a limited sample size. One limitation is the use of MRI in our study to calculate the TT-TG values. MRI has been shown to underestimate TT-TG distances when compared to CT [31]. We did not perform CT scan for all our patients to evaluate TT-TG. A CT scan was ordered for patients with TT-TG values >15 mm to mitigate the effects of radiation on the subgroup of adolescence. As such, we utilised the MRI measurements of TT-TG values for the entire cohort to ensure uniformity of reporting. Another limitation with our study is the lack of pre-injury radiographs. This is a perennial problem which limits the determination of patella alta as a primary risk factor or a secondary consequent of the dislocation. There was also a wide range at which the Kujala scores were performed post-operatively, minimum 24 months after surgery, with the longest at 96 months after surgery, resulting in variability in the outcomes of follow-up for our cohort.

Future studies with larger sample sizes and longer follow-ups should be performed to assess the role of MPFL reconstruction in reducing the risk of recurrence, and to determine variables which can predict post-operative dislocations.

Conclusion

MPFL reconstruction for lateral patella dislocation achieves good clinical outcomes and results in a statistically significant decrease in patellar height ratio. Normalisation of abnormal patella height occurred in 90% of cases. The ability of MPFL reconstruction to stabilise the patella medially and correct aberrant patella height accounts for its success; with reduction in the anatomical risk factors after surgery and risk of patella dislocation.

Abbreviations

CD: Caton-Deschamps

CT: Computer tomography

IS: Insall-Salvati

MPFL: Medial patellofemoral ligament

MRI: Magnetic resonance imaging

TT-TG: Tibial tuberosity–trochlear groove

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Centralised Institutional Review Board (IRB No. 2012/876/D). Participation in the study is voluntary and patients may choose to be excluded at any time.

Consent for publication

Not applicable

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SSWS was responsible for analysis of data, drafting of the manuscript, and preparation for submission. KCL was involved in the analysis of data, and drafting of the manuscript. LYHD contributed to the acquisition of data, analysis of data, and review of the manuscript. All authors read and approved the final manuscript.

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Figures



Figure 1

Radiographic patellar height indices, $a \neq b$. (A) Pre-operative Caton-Deschamps (B) Post-operative Caton-Deschamps (C) Pre-operative Insall-Salvati (D) Post-operative Insall-Salvati.