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Comparison of knees after patellofemoral stabilisation with asymptomatic contralateral knees

Igor Potparić [a], Matej Drobnič [a,b], Nik Žlak [a,b,*]

[a] Department of Orthopaedic Surgery, University Medical Centre Ljubljana, Zaloška cesta 9, 1000 Ljubljana, Slovenia
[b] Chair of Orthopaedics, Faculty of Medicine, University of Ljubljana, Vrazov trg 2, 1000 Ljubljana, Slovenia

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ABSTRACT

Purpose: Patellofemoral instability (PFI) can significantly hinder and limit knee function. A widely accepted treatment of PFI is the medial patellofemoral ligament reconstruction (MPFLR), with or without additional procedures. This study aimed to evaluate postoperative functional outcomes in patients undergoing MPFLR by comparing the operated knee to the contralateral, asymptomatic knee using validated patient-reported outcome measures (PROMs).

Methods: From a prospective database, 71 adult patients (18 years or older) treated for chronic unilateral PFI between 2012 and 2019 were enrolled in a retrospective cohort study. Patients undergoing MPFLR, either in isolation or with TTT, with an asymptomatic contralateral knee were included. Pre- and postoperative comparisons of Knee Injury and Osteoarthritis Outcome Score (KOOS), Tegner Activity Scale, and EQ-5D-3L were conducted. Statistical significance was set at $p < 0.05$.

Results: Seventy-one patients were included; median follow-up was 3.8 years. Postoperatively, significant improvements were observed in all KOOS subscales ($p < 0.001$), EQ-5D-3L-TTO ($\Delta 0.11$, $p = 0.002$), and EQ-5D-VAS ($\Delta 13$, $p < 0.000$), alongside increased Tegner Activity Scale scores ($\Delta 1$, $p = 0.002$). Despite these gains, operated knees demonstrated persistent functional deficits compared to contralateral asymptomatic knees across all KOOS subscales ($p < 0.001$). EQ-5D-3L-TTO showed significant inter-limb differences; small nonsignificant differences were noticed in the EQ-5D-VAS and Tegner Activity Scale score.

Conclusion: MPFLR significantly improves knee function, pain, and quality of life, yet does not fully restore function to the level of the asymptomatic contralateral knee. Persistent deficits highlight the need for further refinement in surgical techniques to optimize long-term outcomes.

Level of evidence: level III.

Abbreviations: PFI, Patellofemoral instability; MPFL, medial patellofemoral ligament; VM, vastus medialis; TT, tibial tubercle; TT-TG, tibial tuberosity-trochlear groove; MPFLR, MPFL reconstruction; OA, osteoarthritis; BMI, body mass index; KOOS, Knee Injury and Osteoarthritis Outcome Score; EQ-5D, European Quality of Life in Five Dimensions; SD, standard deviation; MCID, minimal important clinical difference; SCB, substantial clinical benefit; PF, patellofemoral; TF, tibiofemoral.

* Corresponding author at: Zaloška cesta 9, 1000 Ljubljana, Slovenia.
E-mail address: nik.zlak@kclj.si (N. Žlak).

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1. Introduction

Patellofemoral instability (PFI) encompasses a whole spectrum of conditions ranging from intermittent subluxations to complete dislocation. Among knee injuries, patellar dislocation accounts for about 2 % to 3 % of cases [1–3], with 50 % to 60 % occurring as a result of sports trauma. It mainly affects people between the ages of 10 and 20 and it can lead to PFI [2].

There are four main types of patellar dislocation: acute traumatic, recurrent or chronic, habitual and congenital [4]. Acute patellar dislocation is typically unilateral and is caused by trauma, often caused by a non-contact twisting injury or a direct blow to the medial side of the knee. Soft tissue damage that occurs during initial and subsequent dislocations, particularly tears of the medial patellofemoral ligament (MPFL) and medial retinaculum, contribute significantly to PFI [2,5].

Several risk factors for PFI have been identified, including patella alta (Caton-Deschamps index >1.2), trochlear dysplasia, joint hypermobility, tightness of the lateral retinaculum, hypoplasia of the vastus medialis (VM) of the quadriceps, excessive lateralisation of the tibial tuberosity (TT) with increased distance between the tibial tuberosity and trochlear groove (TT-TG distance >20 mm), femoral and tibial torsional deformities and an increased Q angle (>15 degrees) [2,3,5,6]. As anatomical risk factors are often present in both knees, up to 20 % of patients with PF instability have bilateral symptoms [3,7].

Both first-time and recurrent patellar dislocations can lead to osteochondral fractures and cartilage injuries, which can evolve into patellofemoral arthritis [3]. Treatment of a first-time dislocation is usually conservative [6,8], but recurrence rates are between 40 % and 60 % [5]. The preferred surgical treatment for PFI is MPFL reconstruction (MPFLR) [1–6], which is often accompanied by additional procedures such as trochleoplasty or TT transfer, depending on the risk factors [1,2,3,6,8]. Surgical procedures have been shown to effectively stabilise the patella, prevent further dislocation and provide good to excellent improvements in knee function in the short to medium term. In the long term, however, there appears to be a deterioration in knee function, which is mainly due to patellofemoral osteoarthritis [9].

The aim of this study was to analyze a cohort of patients treated for chronic unilateral PFI in a single university orthopaedic centre. The standardised treatment protocol included either MPFLR in isolation or MPFLR in conjunction with TT transfer. The primary objective was to evaluate patient-specific outcomes pre- and postoperatively and to compare the operated patella unstable knee with the contralateral asymptomatic knee.

2. Methods

This study was designed as a retrospective analysis using prospectively collected data from adult patients treated for chronic PFI with a known history of a first patellar dislocation at a university orthopaedic referral centre. Ethical approval was granted by the National Medical Ethics Committee of the Republic of Slovenia (KME 0120-169/2020/4). Inclusion criteria included adult patients (18 years and older) who had undergone unilateral MPFLR between January 2012 and December 2019, either as a stand-alone procedure or in combination with tibial tuberosity transfer, and who had asymptomatic contralateral knees. Concomitant non-reconstructive arthroscopic procedures such as plica resection, meniscal debridement and cartilage debridement were allowed and recorded. Patients with additional reconstructive or repair procedures on either knee, such as ligament, meniscus or cartilage repair, any type of osteotomy (high tibial or distal femoral osteotomy) or trochleoplasty, and patients with congenital or habitual patellar dislocation were excluded. Patients with systemic diseases of the musculoskeletal system or diseases affecting the musculoskeletal system were also excluded. Minimum follow-up was 1 year after surgery. All procedures were performed by a single surgeon, one of the co-authors, who had more than five years of experience in reconstructive knee surgery prior to the start of data collection.

2.1. Data and surgical procedures

A total of 71 patients treated for chronic unilateral PFI met the inclusion criteria. 20 of them were male and 51 were female. All surgical procedures were performed according to the established protocol. First, a diagnostic arthroscopy was performed to assess the condition of the ligaments, cartilage and meniscus, and any necessary procedures such as cartilage debridement, meniscal resection or plica removal were performed. All additional findings and procedures were documented. MPFLR was performed using a standardised technique described by Žlak et al [3]. In cases where pre-operative imaging demonstrated patella alta or lateralization of the patellar tendon insertion, a TT osteotomy was performed, transferring the tubercle to the calculated position and securing it with one or two cortical screws.

Rehabilitation was performed according to a standardised protocol for all patients. Weight-bearing with crutches was allowed as tolerated during the first six weeks postoperatively, regardless of the procedure. During this time, rehabilitation focused on maintaining passive knee mobility and performing isometric exercises for the knee extensors, supplemented by electrotherapy and cryotherapy. After six weeks, the crutches and braces were removed and active knee flexion and extension exercises were introduced in a closed kinetic chain together with hydrotherapy and proprioception exercises. After three months, the intensity of activities was gradually increased while continuing to avoid uncontrolled contact, excessive knee flexion and rotational forces on the operated knee. After 6 months, the rehabilitation programme was considered complete and patients were allowed to return to their normal daily activities within their capabilities. Whilst the rehabilitation programme primarily focused on the operated leg, bilateral exercises were also recommended as the protocol progressed.

2.2. Clinical and radiological evaluation

Preoperative data collection included patient demographics (age, gender, body mass index [BMI]), medical history (general health, duration of PFI symptoms, clinical status of primary/revision surgery (documented according to the International Knee Documentation Committee survey). Radiological parameters (e.g. native radiographs) included patellar height (Caton–Deschamps index, normal range 0.8–1.2) [10], trochlear dysplasia (Dejour classification, types A-D) [11] and degree of patellofemoral osteoarthritis (Kellgren-Lawrence criteria, 0–4) [11] and were recorded for both knees. Three patient-reported outcome measures (PROMs) were used separately for both knees, the operated and the contralateral knee: the Knee Injury and Osteoarthritis Outcome Score (KOOS), the Tegner Activity Scale and the European Quality of Life in Five Dimensions (EQ-5D). The KOOS and the Tegner Activity Scale were translated into Slovenian and back-translated for accuracy and had already been used in several studies [3,9,11,12,13], while the EQ-5D was validated for the Slovenian population [14]. A country-specific EQ-5D 3-level score (EQ-5D-3L-TTO) based on the time-trade-off was calculated to determine the index numbers corresponding to the 5-digit score of the patients' health states. The EQ-5D-VAS (Visual Analogue Scale) score was recorded on a scale from 0 (worst result) to 100 (best result). Postoperative revision procedures and injuries that recurred on the operated or contralateral knee were also documented. The final analyses were performed using the same PROMs and sent by post. Patient demographics, medical history, and surgical details are listed in Table 1.

Table 1
Patient demographics, medical history, and operative details for the 71 cases enrolled in the study.

Age	23 (8) years			
Gender				
Female	51 (72 %)			
Male	20 (28 %)			
Body mass index (BMI)	24.8 (5.2) kg / m^2			
Operated side				
Left	22 (31 %)			
Right	49 (69 %)			
Revision surgery	5 (7 %)			
Symptoms duration				
<1 year	5 (7 %)			
1–3 years	16 (22 %)			
3–5 years	5 (7 %)			
>5 years	45 (64 %)			
Concomitant procedures				
None	27 (38 %)			
Plica shaving	19 (27 %)			
Cartilage debridement	3 (4 %)			
Plica + Cartilage	19 (27 %)			
Others	3 (4 %)			
Operative technique				
Lateral release	17 (24 %)			
TT transfer (med / dist / both	31 (43 %) / 5 (7 %) / 9(15%)			
Graft options				
Gracilis tendon	64 (90 %)			
Semitendinosus tendon	7 (10 %)			
Caton-Deschamps index	*Patella unstable knee*	*Asymptomatic knee*		
Pre-operatively	1.2 (0.2)	1.1 (0.1)		
Post-operatively*	1.1 (0.1)	n.a.		
Dejour dysplasia	*Patella unstable knee*	*Asymptomatic knee*		
None	*4*	*20*		
Type A	*28*	*22*		
Type B	*21*	*19*		
Type C	*13*	*10*		
Type D	*5*	*0*		
Kellgren – Lawrence	*Patella unstable knee*		*Asymptomatic knee*	
knee osteoarthritis score	PF	TF	PF	TF
0	47	47	60	55
1	17	16	8	13
2	5	7	3	3
3	2	2	0	0
4	0	0	0	0

Categorical variables are presented as frequencies (%); continuous variables are presented as means (std.), PF, patellofemoral; TF, tibiofemoral; n.a., non-applicable. *latest available radiograph.

2.3. Statistical analysis

Descriptive statistics were used to summarise patient demographics, medical history and surgical details of all 71 cases. Categorical variables are presented as frequencies with corresponding percentages, while continuous variables are presented as means with standard deviation (SD). Follow-up times and Tegner Activity Scale were expressed as medians (min–max). Paired t-tests or Wilcoxon signed-rank tests were applied to compare preoperative and postoperative differences (Δ) in all PROMs. Statistical analyses were performed using SPSS software (version 23.0; IBM, Chicago, IL, USA), with significance set at $p < 0.05$. The cumulative KOOS score was defined as the primary outcome. A post-hoc analysis showed a significance of 0.99 with an effect size of 0.45 (G*Power Ver 3.1.9.4, University of Kiel, Germany).

3. Results

The median follow-up time was 3.8 (1.0–8.9) years. Five patients had undergone previous PFI surgeries (e.g. lateral release, medial reefing, TT transfer or their combination), none of which included MPFLR. The mean (SD) Caton–Deschamps index for the operated knee was 1.2 (0.1) preoperatively and 1.1 (0.1) postoperatively. For the asymptomatic contralateral knees, the mean value was 1.1 (0.1). The distribution of trochlear dysplasia according to Dejour for the patella unstable knees and the contralateral asymptomatic knees was as follows: no dysplasia in 4 treated and 20 contralateral knees; type A in 28 treated and 22 contralateral knees; type B in 21 treated and 19 contralateral knees; type C in 13 treated and 10 contralateral knees; and type D in 5 treated and 0 contralateral knees. Most of the treated knees showed no (grade 0) up to mild arthritic changes (grade 2) as assessed by the Kellgren-Lawrence scale, while almost no degenerative changes were observed in the contralateral knees. MPFLR was primarily performed with a gracilis tendon graft. A total of 45 distal stabilisation procedures were performed. During the first arthroscopy, 44 knees (62 %) underwent concomitant non-reconstructive procedures, including meniscal debridement, cartilage debridement and plica removal. The data are shown in Table 1.

Postoperative PROMs were collected from 61 (86 %) patients. All KOOS subscales improved significantly from preoperative baseline to final follow-up. Significant improvements were also observed in EQ-5D-3L-TTO and EQ-5D-VAS scores, indicating improved patient quality of life and reduced pain. Physical activity, as measured by the Tegner Activity Scale, also increased significantly postoperatively. In addition, the minimum important clinical difference (MCID) was achieved in the KOOS subscales for pain and sport subscales, while a substantial clinical benefit (SCB) was found in the KOOS subscales for symptoms, ADL and quality of life (4). Of the 71 patients, 52 exceeded the MCID in the KOOS pain and sport subscales, while 43, 50 and 60 patients met the SCB criteria in the KOOS ADL, symptoms and quality of life subscales, respectively. The scores of the contralateral, asymptomatic knees remained high and were significantly higher in all KOOS subscales than the operated knees. Small but non-significant differences were noted in the EQ-5D VAS and Tegner activity scale scores between the patella unstable knees and the asymptomatic contralateral knees, while a significant difference remained between the operated and contralateral asymptomatic knees on the EQ-5D-3L-TTO (0.79 versus 0.90). At final follow-up, 56 (79 %) patients reported no knee-related pain, 12 (17 %) required analgesics occasionally and 3 patients (4 %) used analgesics weekly. Six patients (8 %) reported mild PFI discomfort postoperatively, but none of them required PFI revision surgery during the observation period. A total of 14 (20 %) revision procedures were performed on the operated knees, mainly arthroscopic procedures. Full details of this data can be found in Tables 2 and 3.

4. Discussion

Our study provides insight into the results of surgical interventions for PFI by comparing the treated knee with asymptomatic contralateral knees before and after surgery. The main finding of our study was significant postoperative improvements in knee function, pain and quality of life as measured by KOOS subscales, EQ-5D scores and the Tegner Activity Scale. Despite marked improvements, the asymptomatic contralateral knees had better functional scores on all KOOS subscales, indicating persistent residual deficits in the treated knees after surgery.

Table 2
Patient reported joint-specific patient outcome measures in the PFI group.

	PreOP (N = 71)	**PostOP** (N = 61)	***P*-value**	**PreOP to PostOP Difference (Δ)**
KOOS Symptoms	73 (17)	82 (16)	<0.001	9 (1)*
KOOS Pain	78 (15)	84 (16)	<0.002	6 (1)•
KOOS ADL	84 (15)	91 (15)	<0.001	7 (0)*
KOOS Sport	50 (23)	67 (26)	<0.000	17 (3)•
KOOS QoL	39 (18)	63 (27)	<0.000	24 (9)*
KOOS Cumulative	70 (15)	78 (18)	<0.000	8 (3)•
EQ-5D-3L-TTO	0.69 (0.20)	0.80 (0.21)	<0.002	0.11 (0.01)
EQ-5D-VAS	69 (16)	82(15)	<0.000	13 (−1)
Tegner Activity	3 (0 – 10)	4 (0 – 10)	<0.002	1 (0)

Table 3
Patient reported joint-specific patient outcome – comparison of the patella unstable knee and the asymptomatic knee.

	Patella unstable knee (N = 61)	**Asymptomatic knee** (N = 61)	***P*-value**	**Difference (Δ)**
KOOS Symptoms	82 (16)	93 (14)	<0.000	9 (2)
KOOS Pain	84 (15)	93 (14)	<0.000	9 (−1)
KOOS ADL	91 (15)	97 (9)	<0.000	6 (−6)
KOOS Sport	67 (26)	87 (21)	<0.000	20 (−5)
KOOS QoL	63 (27)	78 (27)	<0.000	15 (0)
KOOS Cumulative	78 (18)	90 (15)	<0.000	12 (−3)
EQ-5D-3L-TTO	0.80 (0.21)	0.90 (0.20)	<0.001	0.10 (−0.01)
EQ-5D-VAS	82 (15)	85 (17)	<0.080	3 (2)
Tegner Activity	4 (0 – 10)	4 (0 – 10)	<0.109	0 (0)

PreOP, preoperative; PostOP, postoperative; KOOS, Knee Osteoarthritis Outcome Score; ADL, Function, activities of daily living; QOL, quality of life; EQ-5D-VAS and TTO, European Quality of Life in Five Dimensions Visual Analog Scale; EQ-5D-3L-TTO, European Quality of Life in Five Dimensions 3-level time-trade-off; *SCB, substantial clinical benefit; •MCID, minimal important clinical difference.

On average, the postoperative KOOS score for the operated knee increased by 12 points, with the most significant improvements in the sports and quality of life subscales, which is consistent with the literature [3,15,16]. In a similar study, Mulliez et al [16] also found the greatest improvements in these subscales, but their average increase was 20 points. This discrepancy may be due to differences in inclusion criteria (our inclusion criteria were broader) and a different follow-up period (3.8 years compared to 1 year in Mulliez's study). Conversely, Vivod et al [9] reported lower scores in all KOOS categories compared to our results, most notably in sport (10 points lower) and quality of life (18 points lower) subcategories after a longer follow-up period of 22.5 years on average. Although different treatment modalities for PFI then and now may have influenced the results to some extent, the duration of observation could also play a decisive role in the progression of osteoarthritis.

Although the postoperative KOOS scores improved in all subcategories compared to the preoperative scores, they did not reach the level of the asymptomatic contralateral knees. The KOOS subscale results for our asymptomatic knee group were consistent with data reported by Marot et al [17] for a population of comparable age and body mass index (BMI). However, our cohort had slightly lower scores in the quality of life subcategory. This discrepancy could indicate indirect effects on quality of life that could be due to limitations or lifestyle changes related to the injured knee. Toomey et al [18] found that patients with knee injuries, including ligament injuries (e.g. MPFL, ACL, MCL and/or meniscal tears), had lower KOOS subscale scores in at least one KOOS subscale 1–4 years after injury and after surgery. In addition, the systematic review by Moiz et al [19] found that patients receiving non-surgical treatment for single or recurrent patellar dislocations generally achieve approximately 80 % of the maximum KOOS score. This finding closely matches the postoperative outcomes observed in our cohort, suggesting that the initial injury may be the primary contributor to the reduced KOOS scores.

A similar trend of significant improvement from preoperative to postoperative was seen in EQ-5D scores and Tegner Activity Scale scores. An increase of 0.11 in the EQ-5D-3L-TTO and 13 points in the EQ-5D-VAS was observed, with postoperative scores reaching those of asymptomatic knees and averaging above 0.80 for the EQ-5D-3L-TTO and 80 for the EQ-5D-VAS, which is in line with Slovenian population norms reported by Prevolnik Rupel et al [20]. As pain is one of the main barriers to daily activities, the improvement in daily function and pain scores indicate the importance of patellar stabilisation procedures. On the other hand, the Tegner Activity Scale showed an improvement of one point in postoperative outcomes, which is consistent with the results reported by Matic et al. in their systematic review [21] and confirmed by Migliorini et al [13]. Conversely, postoperative Tegner activity scores were similar to those of the control knee but below the average score of 5.7 for individuals with normal knees, as found by Briggs et al [22]. These results emphasise the critical impact that the injured knee has on the patient's overall performance as assessed by the Tegner Activity Scale.

The asymptomatic contralateral knees also had a lower degree of trochlear dysplasia and better values of CDI. This more optimal knee geometry could be the reason why they remained asymptomatic. In addition, mild arthritic changes were observed in the treated knees compared to the asymptomatic contralateral knees, with patellofemoral and tibiofemoral osteoarthritis occurring with comparable frequency and severity. It remains difficult to determine whether surgery directly influences the occurrence of OA or whether it is a consequence of PF instability. Salonen et al [23] reported that both initial and rare traumatic patellar dislocations are associated with osteoarthritic changes; however, no correlation was found between subjective PFI symptoms and the extent of these changes. This suggests that the OA changes observed in our surgically treated cohort may have developed independently of surgical intervention, although further research is required to support this hypothesis.

Given the non-randomised, non-blinded cohort design, potential selection bias cannot be ruled out. An additional limitation is the inability to strictly classify the cohort by etiology into distinct traumatic and dysplastic subgroups. Although congenital and habitual dislocations were excluded, all included patients reported a traumatic event of varying intensity at their first episode of dislocation and had varying degrees of trochlear dysplasia. While the degree of dysplasia was included in the statistical model and showed no significance, the intensity of the primary trauma could not be considered as it was a remote and not objectively recorded event. However, these limitations are mitigated by several strengths. The

controlled, single-centre environment minimised variability in treatment protocols and ensured a high follow-up rate and exceptional patient response rate. Furthermore, the comparison of injured and asymptomatic knees, though challenging, provides valuable insight into real-life clinical scenarios and outcomes. We see the potential to expand on this topic with additional objective measurements and tests such as ROM measurements, isokinetic strength tests, single-leg hop tests and other standardised tests, as these could also provide additional insights into the treatment of PFI.

5. Conclusion

We were able to show that surgical interventions in PFI lead to significant improvements in knee function, pain and quality of life. However, the functional outcomes of treated knees lag behind those of asymptomatic contralateral knees and the general population, highlighting the remaining deficits after current treatment options. Although surgical and conservative approaches to the treatment of PFI have made significant progress, further advances are needed to better restore the original biological state of the knee.

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Ethics statement

Ethical approval was obtained from the National Medical Ethics Committee of the Republic of Slovenia (KME 0120-169/2020/4). All participating patients provided formal, informed consent. Original approval document and consent forum are available upon request with the corresponding author.

CRediT authorship contribution statement

Igor Potparić: Writing – original draft, Project administration, Conceptualization. **Matej Drobnič:** Writing – review & editing, Supervision, Formal analysis, Data curation, Conceptualization. **Nik Žlak:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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