Original Article

Elevated Instability Resolution Angle Predicts Inferior Patient-Reported Outcomes in Isolated Medial Patellofemoral Ligament Reconstruction

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Purpose: To investigate the prognostic utility of an examination under anesthesia (EUA) by evaluating the patient-reported outcome scores (PROs) and failure rates of patients undergoing primary, isolated medial patellofemoral ligament reconstruction (MPFLR) relative to their EUA findings. **Methods:** A retrospective review was performed on patients who underwent primary, isolated MPFLR between August 2015 and August 2021. During the EUA the instability resolution angle (IRA) was identified by applying a lateral force on the patella through increasing knee flexion and defined by the degree of flexion the patella ceased lateral translation. PROs, including International Knee Documentation Committee (IKDC), Knee Injury and Osteoarthritis Outcome Score Jr, and Kujala, were collected at 1-year and 2-year minimum after surgery. In addition, MPFLR failure was recorded and defined by patellar redislocation. **Results:** In total, 94 patients met inclusion criteria, with 42 patients having an IRA $<60^\circ$ and 52 patients with an IRA $\geq 60^\circ$ of knee flexion. At 2-year minimum follow-up, IKDC and Kujala PROs were significantly lower in patients with IRA $\geq 60^\circ$ compared with patients with IRA $<60^\circ$ for both final and delta PROs. Mean tibial tubercle-trochlear groove distance examined on preoperative magnetic resonance imaging was 17.21 ± 5.00 mm for the IRA $\geq 60^\circ$ cohort and 14.36 ± 4.89 mm for the IRA $<60^\circ$ cohort ($P < .01$). Four patients redislocated their patella, and all 4 had an IRA $\geq 60^\circ$ ($P = .07$). **Conclusions:** Patients who underwent isolated MPFLR with an IRA $\geq 60^\circ$ had significantly lower IKDC and Kujala scores than similar patients with IRA $<60^\circ$ of knee flexion at 2-year minimum follow-up. Four (7.7%) patients with IRA $\geq 60^\circ$ redislocated their patella, whereas zero patients with IRA $<60^\circ$ experienced redislocation. **Level of Evidence:** Level III, retrospective cohort study.

Management of patellofemoral instability (PFI) remains complex, without distinct indications for the various surgeries available to address this pathology.[1] The effectiveness of isolated medial patellofemoral ligament reconstruction (MPFLR) in treating recurrent PFI is well established, but there is ongoing debate regarding the necessity of including osseous procedures in the treatment plan.[2-4]

Traditionally, imaging parameters, such as tibial tubercle-trochlear groove (TT-TG) distance, Caton-Deschamps Index (CDI), trochlear dysplasia grade, coronal alignment, and femoral rotation have been used to help guide treatment decisions.[5] Several issues exist with this manner of decision making. First, using imaging parameters categorizes patients on the basis of measurements above or below a specific threshold (for instance, TT-TG >20), with recommendation for a corresponding surgery if the patient's radiographic measurement surpasses the threshold.[1] However, it is more likely that failure is a result of the combined influence of multiple factors and should not be determined by a single factor with a fixed threshold. Second, these measurements are subject to nuances of imaging modalities and interobserver variability.[6] Third, several studies have demonstrated success of isolated MPFLR, regardless of the presence of risk factors, such as elevated TT-TG or CDI.[7-11] Although these measurements remain important, there has been recent exploration for other factors to guide treatment.[12-14]

Physical examination findings are an appealing adjunct to the PFI equation, as they are patient-specific by nature

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and may be better suited to evaluate functional patellar instabilty.[6] As the MPFL is a primary medial stabilizer from 0 to 20° of flexion, continued PFI beyond 20 to 60° may suggest osseous etiology and the need for additional bony treatment beyond isolated MPFLR.[15,16] An examination under anesthesia (EUA) enables surgeons to assess patellar stability by manipulating the patella through varying degrees of knee flexion, providing insight into the extent and nature of the instability. The purpose of this study was to investigate the prognostic utility of an EUA by evaluating the patient-reported outcome (PRO) scores and failure rates of patients undergoing primary, isolated MPFLR relative to their EUA findings. The authors hypothesized that patients whose patella continues to subluxate past 60° of knee flexion would have worse PROs and a greater failure rate at a minimum 2-year final follow-up.

Methods

Patient Selection

After institutional review board approval (ORA number: 19102202-IRB01; Principal Investigator: Adam Yanke; Project Title: Correlation of Patient Reported Outcome Survey Data in Patellar Instability Patient), a retrospective review was performed on patients who underwent primary, isolated MPFLR between August 2015 and April 2021. Because of the retrospective nature of this study, informed consent was not obtained. The study included patients who met the following criteria: had recurrent PFI, underwent MPFLR, had a documented EUA, and had a minimum 2-year follow-up from the surgery date. Exclusion criteria included any patient who received an additional surgical procedure for PFI (e.g., a tibial tubercle osteotomy (TTO), trochleoplasty, distal femoral osteotomy, or derotational osteotomy). We did not exclude patients who received nonstability-related procedures, such as concomitant meniscectomy, loose body removal, or chondroplasty.

Preoperative Imaging

Radiographs were used to assess for presence of loose bodies and chondral lesions, measure patella height (using CDI),[17] and assess for trochlear dysplasia using the Dejour classification.[18] TT-TG was measured on axial-view magnetic resonance imaging (MRI) as the medial-lateral distance between the deepest cartilaginous point of the trochlear groove and the midpoint of the patellar tendon insertion at the tibial tubercle.[19,20] Knee rotation angle, tibial tubercle lateralization, patellar width, and trochlear width were measured on MRI using the methods described by Hevesi et al.[21] Valgus alignment was assessed by measuring the angle between the femoral and tibial mechanical axes on radiograph. Angles greater than 180° were classified as positive values, indicating valgus alignment, whereas angles less than 180° indicated varus alignment. Continuous trochlear morphology measurements including sulcus angle and cartilaginous trochlear bump height were measured on axial and sagittal MRI, respectively.[22,23]

Examination Under Anesthesia

The EUA was performed by sports fellowship−trained surgeons (A.B.Y., B.J.C., N.V.). The EUA was performed after general anesthesia and was induced with the patient in a supine position. Each EUA included range of motion of the knee and hip bilaterally, as well as PFI testing including a lateral translation measurement and an instability resolution angle (IRA). Lateral translation was defined by the distance the patella would subluxate with a lateral force applied in full extension and measured on a scale of 1 to 4 quadrants: 1 indicates up to 25% displacement, 2 is 25% to 50%, 3 is 50% to 75%, and 4 is full dislocation. The IRA was obtained by laterally translating the patella in full extension and continuing the lateral force through increasing knee flexion. IRA was then defined by the degree of knee flexion the applied force no longer induced any lateral displacement of the patella.

Surgical Technique

Patients were positioned supine, placed under general anesthesia, and a tourniquet was placed on the thigh. After standard preparation and draping, a diagnostic arthroscopy was performed to evaluate the patellar and trochlear chondral surfaces, remove loose bodies, and inspect the knee. Any intra-articular procedures would be performed at this time. Associated pathologies, including loose bodies and cartilaginous defects, were treated concomitantly, when present. After this, the arthroscope was removed and the tourniquet was inflated. A semitendinosus allograft was harvested and used for the MPFLR.

The technique involved a 2- to 3-cm incision 1 cm medial to the medial border of the patella, beginning at the superomedial pole. Dissection was carried down until the space between layers 2 (retinaculum) and 3 (capsule) was identified and this interval was developed. Electrocautery was then used to expose the proximal half of the patella, just anterior to the cartilage. Loaded knotless anchors were placed at the 50-yard line of the patella distally and at the superomedial border proximally. An onlay technique was used, with the center of the graft placed between these 2 anchors, then secured with the knotless mechanism.

A second medial incision was made centered over Schottle's point[24] with fluoroscopic guidance. Dissection was performed until the sulcus between the medial epicondyle and adductor tubercle was reached. Using fluoroscopic assistance, a guide pin was placed at this location. Graft isometry was checked, confirming the graft loosened in flexion and tightened in extension. The pin was then over-reamed and the graft was shuttled from the patellar site, through the interval between layers 2 and 3, and the free limbs were passed into the femoral tunnel. Patellar mobility was assessed to ensure adequate tension, and if felt to be appropriate, a tenodesis screw was placed in the femoral tunnel to secure the construct.

Outcome Metrics

PROs, including International Knee Documentation Committee (IKDC),[25] Knee Injury and Osteoarthritis Outcome Score Jr (KOOS Jr),[26] and Kujala[27] questionnaire, were collected preoperatively, at 1-year postoperatively, and at a minimum 2-year postoperatively. Redislocation events and reoperation were recorded and reviewed.

Statistical Analyses

Patients were divided into 2 groups: those who had an IRA <60° and those with IRA ≥60°. Sixty degrees was chosen as a cutoff retrospectively because it proved most predictive of poor postoperative PROs and failure, as it demonstrated a significant difference between groups. Specifically, patients with instability beyond 60° of knee flexion had worse outcomes, including lower scores on validated PROs and greater rates of failure than those without instability beyond this angle. Patient demographics, concomitant procedures, imaging measurements, PROs, and redislocations were compared between the 2 groups. Mean ± standard deviation was used to present continuous variables, and independent sample *t* tests were employed for intergroup comparisons. Frequency counts were used to present categorical variables, and comparisons were made using the chi-square test. To calculate PRO delta scores, the preoperative score was subtracted from either the 1-year or minimum 2-year final follow-up score. For lateral translation, patients were grouped into 1 and 2 quadrants versus 3 and 4 quadrants. Differences in proportions of those that reached substantial clinical benefit for IKDC and KOOS Jr were evaluated (no published substantial clinical benefit for the Kujala score was available). All statistical comparisons were performed using Microsoft Excel (Microsoft Corp, Redmond, WA). Statistical significance was set at $P < .05$.

Results

A total of 94 patients met inclusion criteria and were eligible for this study. Of these, 42 patients had cessation of patella subluxation prior to 60° of knee flexion (IRA <60°), and 52 patients had continued subluxation at or beyond 60° of knee flexion (IRA ≥60°). There were no significant demographic differences between the groups including age at surgery, sex (male or female), body mass index, or laterality (Table 1). The <60° and ≥60° IRA cohorts had a mean final follow-up of 2.37 ± 0.62 years and 2.42 ± 0.80 years, respectively. Four patients redislocated their patella (4.2%), and all 4 had an IRA ≥60° on EUA ($P = .07$). Concomitant procedures included meniscectomy, chondroplasty, osteochondral fixation, microfracture, and loose body removal. Number of concomitant procedures performed was not significantly different between groups (Table 1).

Both TT-TG and sulcus angle were elevated in patients with IRA ≥60°, whereas tubercle lateralization, knee rotation angle, CDI, mechanical axis, patellar width, trochlear width, and bump height were insignificant between groups. Mean TT-TG was 17.21 ± 5.00 mm for patients with an IRA ≥60° and 14.36 ± 4.88 mm for patients with an IRA <60° ($P < .01$). Mean sulcus angle of patients with an IRA ≥60 was 156.78 ± 10.18° and 149.12 ± 11.48° for patients with IRA <60° ($P < .01$). TT-TG ($P < .01$) and sulcus angle ($P < .01$) were positively correlated with IRA, whereas knee rotation angle ($P = .05$) was not statistically significant. Patellar width ($P = .02$) and trochlear width ($P = .02$) were negatively correlated with IRA. No significant correlations were observed between IRA and tubercle lateralization, CDI, mechanical axis, or bump height. Trochlear dysplasia was significant between groups, with Dejour type B exhibiting individual significance on post hoc analysis (Table 2).

There were no significant differences between groups at 1 year follow-up for both delta and final PRO scores (Table 3). At 2-year minimum follow-up, IKDC and Kujala PROs were significantly increased in patients with IRA <60° compared with patients with IRA ≥60° for both final and delta PROs (Table 3). All PROs exhibited an improvement at 1-year and 2-year minimum from baseline. However, for patient with IRA ≥60°, IKDC, KOOS Jr, and Kujala declined from 1-year postoperative to 2-year minimum final follow-up. Patient with IRA <60° improved from 1-year postoperative to 2-year minimum final follow-up via all PROs.

The χ^2 analysis demonstrated lateral translation, measured as 1 to 4 quadrants in full extension, did not predict whether patients achieved substantial clinical benefit for IKDC or KOOS Jr PROs at 1-year or 2-year minimum final follow-up (IKDC 1-year: [χ^2 {1, $N = 61$} = 0.461.3, $P = .49$]; IKDC 2-year minimum: [χ^2 {1, $N = 62$} = 0.97, $P = .32$]; KOOS Jr 1-year: [χ^2 {1, $N = 60$} = 2.57, $P = .11$]; KOOS Jr. 2-year minimum: [χ^2 {1, $N = 65$} = 0.22, $P = .64$]).

An inverse correlation was identified between IRA and 2-year minimum PRO scores, encompassing IKDC final, IKDC Δ, KOOS Jr Δ, Kujala final, and Kujala Δ. When we compared the correlations of IRA with 2-year minimum PROs with those of TT-TG and 2-year

Table 1. Comparison of Patient Demographics and Concomitant Procedures

	IRA <60°	IRA ≥60°	*P* Value
Demographic variable			
No. of overall patients	42	52	–
Age at surgery, yr	20.57 ± 8.25	19.26 ± 6.84	.40
Female sex, n (%)	26 (61.9%)	37 (71.2%)	.34
BMI	26.0 ± 6.57	25.8 ± 6.64	.88
Right knee, n (%)	17 (40.5%)	18 (34.6.%)	.55
Concomitant Procedure			
Concomitant procedure, n (%)	15 (35.7%)	19 (35.8%)	.98
Meniscectomy (medial)	1 (2.41%)	1 (1.89%)	
Cartilage procedure			
Chondroplasty	4 (9.50%)	12 (22.6%)	
Osteochondral fixation	3 (7.14%)	2 (3.77%)	
Microfracture	1 (2.41%)	–	
Loose body removal	4 (9.50%)	5 (9.43%)	

NOTE. Bold face indicates statistical significance ($P < .05$).
BMI, body mass index; IRA, instability resolution angle.

minimum PROs, it was observed that an increased IRA was more significantly associated with suboptimal PROs at 2-year minimum follow-up. Specifically, this association was particularly pronounced for KOOS Jr ($P = .03$) and Kujala ($P = .03$) final PROs (Table 4).

Discussion

The most important findings from the current study are that patients with a high IRA (≥60°) had significantly worse PRO scores at 2-year follow-up compared with patients with a low IRA (<60°). Lateral translation in full extension was not predictive of PROs or dislocation. Results of this study suggest IRA may be a useful adjunct in surgical decision making for patients with recurrent PFI.

Isolated MPFLR is a viable treatment in many cases of PFI, is relatively low risk, and has a fairly expeditious recovery without need for a period of non–weight-bearing.[8,28,29] Conversely, although TTOs and trochleoplasties are procedures for providing stability, they are associated with longer recoveries, more postoperative pain, and more complications than isolated MPFLR.[30-35] Consequently, the decision to incorporate these osseous-stabilizing procedures should be made with careful consideration of the patient's risk factors, rather than solely on radiographic parameters.

Research by Fathalla et al.[12] and Zimmerman et al.[13,14] have helped refine criteria for determining which patients would benefit most from isolated MPFLR versus more complex procedures. Fathalla et al.[12] found that patients patellae dislocated beyond 30° of knee flexion during EUA experienced greater rates of postoperative instability with isolated MPFLR compared with those whose patellae resisted dislocation before 30° of flexion. Zimmerman et al.[13] and Colatruglio et al.[35] further demonstrated that an

Table 2. Patellar Instability Measures

Measurement	IRA <60°, Mean ± SD	IRA ≥60°, Mean ± SD	*P* Value_t	r	*P* Value_r
TT-TG, mm	14.36 ± 4.88	17.21 ± 5.00	**<.01**	+0.27	**<.01**
Tubercle lateralization, mm	47.53 ± 5.23	47.69 ± 5.85	.90	+0.03	.77
Knee rotation angle, °	0.85 ± 6.65	3.00 ± 6.38	.15	+0.21	**.05**
Caton-Deschamps Index (CDI)	1.28 ± 0.14	1.31 ± 0.15	.46	+0.19	.06
Valgus, °	0.81 ± 2.39	0.67 ± 2.85	.83	−0.06	.63
Patellar width, mm	36.90 ± 4.14	35.94 ± 4.02	.26	-0.24	**.02**
Trochlear width, mm	29.41 ± 5.80	27.12 ± 6.65	.07	−0.24	**.02**
Sulcus angle, °	149.12 ± 11.48	156.78 ± 10.18	**<.01**	+0.39	**<.01**
Bump height, mm	5.73 ± 1.54	5.40 ± 1.56	.31	−0.06	.53
Trochlear dysplasia	IRA <60°	IRA ≥60°			
Normal	10	10			
Dejour A	18	11			
Dejour B	3	16			
Dejour C	6	6			
Dejour D	1	4			

NOTE: Bold face indicates statistical significance ($P < .05$).
IRA, instability resolution angle; SD, standard deviation; TT-TG, tibial tubercle-trochlear groove.

Table 3. Patient-Reported Outcomes at 1-Year and 2-Year Minimum

Patient-Reported Outcome Type	IRA <60°, Mean ± SD	IRA ≥60°, Mean ± SD	*P* Value
1 yr			
IKDC final	83.93 ± 15.65	79.90 ± 21.83	.40
IKDC Δ	30.15 ± 19.60	25.56 ± 22.21	.39
KOOS Jr final	88.50 ± 15.36	86.70 ± 15.68	.65
KOOS Jr Δ	16.55 ± 18.10	14.33 ± 15.80	.62
Kujala rinal	90.70 ± 9.95	89.03 ± 12.56	.57
Kujala Δ	26.20 ± 18.09	24.54 ± 17.11	.72
2-yr minimum			
IKDC final	87.35 ± 11.30	74.99 ± 22.29	**<.01**
IKDC Δ	37.19 ± 20.33	22.87 ± 24.73	**.015**
KOOS Jr final	88.96 ± 13.69	84.31 ± 15.42	.19
KOOS Jr Δ	23.41 ± 23.40	14.36 ± 18.08	.085
Kujala final	94.91 ± 6.65	79.48 ± 18.49	**<.01**
Kujala Δ	32.5 ± 18.01	19.32 ± 18.80	**<.01**

NOTE. Δ indicates final patient-reported outcome scores − preoperative patient-reported outcome scores. Boldface indicates statistical significance ($P < .05$).

IKDC, International Knee Documentation Committee; IRA, instability resolution angle; KOOS Jr, Knee Injury and Osteoarthritis Outcome Score Jr; SD, standard deviation.

increased IRA, which they defined as the angle of knee flexion the patient demonstrated apprehension toward lateral patellar translation, correlated with a higher number of structural patellofemoral risk factors. In a 2023 follow-up, Zimmerman et al reported that patients without a J-sign or high-flexion apprehension could achieve successful outcomes with isolated MPFLR alone.[14]

These findings underscore the importance of using patient-specific examination maneuvers to inform surgical decisions, potentially improving outcomes and reducing unnecessary surgeries. Although previous studies, including those by Zimmerman et al.[13] and Colatruglio et al.,[35] investigated the association between apprehension and structural abnormalities, they did not fully assess impact on clinical outcomes. Fathalla et al's study[12] used a 30° cutoff for high IRA and reported high failure rates, although it involved only 23 patients and lacked PRO scores. Zimmerman et al's later work[14] compared outcomes for patients with a low IRA undergoing isolated MPFLR with patients with a high IRA who required additional osseous procedures. Therefore, a need existed for a study to determine what effect, if any, a high IRA had on outcomes of patients undergoing isolated MPFLR.

In the current study, patients treated with isolated MPFLR in the setting of a high IRA on the basis of EUA were found to have similar PROs to patients with a low IRA at 1-year follow-up, with both groups reaching clinical significance for Kujala and IDKC.[36] However, from 1- to 2-year follow-up, patients with a high IRA experienced a deterioration of PROS, specifically IKDC and Kujala, whereas patients with a low IRA continued to improve. This resulted in a significant difference

Table 4. Comparisons of Correlation

	R	*P* Value_r	Fisher z	SE_diff	z -Statistic	*P* Value_z
IKDC final vs TT-TG	−0.09	.46	−0.09			
IKDC final vs IRA	−0.41	**<.01**	−0.43	0.18	1.91	.06
IKDC Δ vs TT-TG	−0.16	.21	−0.16			
IKDC Δ vs IRA	−0.39	**<.01**	−0.41	0.19	1.35	.18
KOOS Jr final vs TT-TG	0.17	.19	0.17			
KOOS Jr final vs IRA	−0.23	.06	−0.23	0.18	2.24	**.03**
KOOS Jr Δ vs TT-TG	0.01	.91	0.01			
KOOS Jr Δ vs IRA	−0.30	**.02**	−0.31	0.18	1.75	.08
Kujala final vs TT-TG	−0.15	.25	−0.15			
Kujala final vs IRA	−0.50	**<.01**	−0.55	0.19	2.13	**.03**
Kujala Δ vs TT-TG	−0.11	.42	−0.11			
Kujala Δ vs IRA	−0.36	**<.01**	−0.38	0.19	1.4	.15

NOTE. Boldface indicates statistical significance ($P < .05$).

IKDC, International Knee Documentation Committee; IRA, instability resolution angle; KOOS Jr, Knee Injury and Osteoarthritis Outcome Score Jr; SE, standard error; TT-TG, tibial tubercle-trochlear groove.

between cohorts at 2 years. This drop-off is interesting, as it is in conflict with the results of Erickson et al.,[8] who found results generally continued to nonsignificantly improve in their cohort of isolated MPFLR between 1- and 2-year follow-up, although they did not include an assessment of flexion instability. From an absolute value perspective, the IKDC, KOOS Jr, and Kujala scores of the low IRA cohort at 2 years (Table 2) are all greater than those reported in a large systematic review by Schneider et al.,[37] and by Erickson et al.,[8] whereas the high IRA cohort had lower IKDC and Kujala scores. Taken together, this suggests patients with a high IRA may represent a different category of patients with PFI—namely, one that has instability as the result of factors other than loss of medial restraint. This could explain why reconstructing the MPFL provided temporary symptom improvement but could not sustain it.

Relatedly, there were 4 patients with a high IRA who sustained a redislocation (7.7%), whereas no patients with a low IRA redislocated. Although this difference did not reach statistical significance, likely as the result of power, it is a notable finding worth exploring. This rate is substantially lower than 39% reported by Fathalla et al.,[12] although their cohort was smaller and used IRA at greater than 30° of knee flexion as their cut-off value. Conversely, 7.7% is greater than studies that did not differentiate IRA, such as that reported by Mackay et al. (2.4%),[28] Schneider et al. (1.2%),[37] or Erickson et al. (2.1%).[8] This discrepancy in recurrent instability for patients with high IRA further supports the notion that these patients are either subject to additional destabilizing forces or are lacking stabilizing forces that patients with low IRA exhibit. This would suggest these patients may benefit from an additional procedure beyond an isolated MPFL.

In contrast to the observed association between instability in flexion and outcomes, this study did not find any impact on outcomes related to instability in full extension, as assessed through lateral translation. Although quadrant translation in extension remains an important component of PFI preoperative work-up,[14,38-40] it is largely an examination of competence of medial soft-tissue stabilizers.[15,16] This is because it assesses patellar instability in the low flexion range (0-20°), where the MPFL is the primary stabilizer to lateral translation. It therefore is a reasonable examination maneuver to determine whether PFI is present but would not necessarily help determine if anything beyond an MPFLR would be beneficial.

The cause of a high IRA remains elusive, and results of this study cannot identify a specific structural cause. There were no significant differences between IRA groups for CDI, valgus malalignment, patellar width, trochlear width, knee rotational angle, tubercle lateralization, or bump height. This contrasts with Zimmerman et al.[13] and Colatruglio et al.,[35] who found patients with high IRA had increased valgus malalignment and CDI, respectively. On the contrary, the present study corroborates previous findings by Zimmerman et al.,[13] demonstrating a notable association between trochlear dysplasia in individuals with a high IRA. This study also aligns with the observations made by Colatruglio et al.,[35] who similarly identified both trochlear dysplasia and sulcus angle as significant factors linked to a high IRA. In addition, our study revealed a significant difference in TT-TG values between high and low IRA patients, which is consistent with the findings from Colatruglio et al.[35] but deviates from the observations from Zimmerman et al.[13] Given the poorer outcomes of patients with high IRA in this study and their association with increased TT-TG and trochlear dysplasia, IRA may prove valuable in determining the need for concomitant tibial tubercle osteotomy or deepening tracheoplasty, especially in borderline cases. However, a definitive structural cause for IRA remains uncertain, and further investigation is required to determine if there is a single etiology, or a combination of several factors.

Results of this study, as well as that of previous works, suggest EUA may be a useful adjunct to surgical decision making. As discussed, although radiographic parameters are useful, there are flaws in basing algorithms solely on such measurements. An EUA may add valuable information, and ultimately help a surgeon determine what procedure will best help their patient, while minimizing unnecessary surgery. The current findings suggest patients with a high IRA may benefit from additional osseous procedures; however, it is important to note that this was not a comparative study of treatment type. It therefore cannot definitively determine if adding osseous procedures to patients with a high IRA would be beneficial. In addition, which specific osseous procedure (TTO, DFO, and/or trochleoplasty) would be highly patient-specific. Although an EUA does seem to merit inclusion in patient work-up, more work will be needed to determine how best to use it in surgical decision-making.

Limitations

The results of this study must be understood through the context of its limitations. There are multiple confounding factors for patella instability. It is difficult to assess whether an increased IRS is the primary cause of instability or if it is due to another anatomic abnormality. The primary consideration for the EUA is that while it is helpful in that it removes patient apprehension, it also removes dynamic restraints due to the anesthesia. However, the EUA does not provide a perfect assessment of PFI as would be experienced in an awake patient with active quadriceps pull. Additionally, while 60° was selected based on statistical significance, osseous restraints become paramount >30°. Therefore, a 60° cut-off may be more specific and ultimately useful, and results of this study cannot provide guidance for patients that have persistent instability in the 30-60° range.

Conclusions

Patients who underwent isolated MPFLR with IRA ≥60° had significantly lower IKDC and Kujala scores than similar patients with IRA <60° of knee flexion at 2-year minimum follow-up. Four (7.7%) patients with IRA ≥60° redislocated their patella also, whereas zero patients with IRA <60° experienced redislocation.

Disclosures

All authors (Z.W., D.K., N.D., E.H., K.C., T.E., N.V., B.J.C., A.B.Y.) 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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