

# Anteromedial Tibial Tubercle Osteotomy Improves Results of Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Instability in Patients With Tibial Tuberosity–Trochlear Groove Distance of 17 to 20 mm



Carlos Eduardo Franciozi, M.D., Ph.D., Luiz Felipe Ambra, M.D., Ph.D.,  
Leonardo José Bernardes Albertoni, M.D., Pedro Debieux, M.D., Ph.D.,  
Geraldo Sergio de Mello Granata Jr., M.D., Ph.D., Marcelo Seiji Kubota, M.D.,  
Mario Carneiro, M.D., Ph.D., Rene Jorge Abdalla, M.D., Ph.D.,  
Marcus Vinícius Malheiros Luzo, M.D., Ph.D., and Moisés Cohen, M.D., Ph.D.

**Purpose:** To compare the midterm clinical outcomes of anteromedialization tibial tubercle osteotomy combined with medial patellofemoral ligament reconstruction (TTO+MPFLR) with MPFLR alone (MPFLRa) for the treatment of recurrent patellar instability (RPI) in patients with a tibial tuberosity–trochlear groove (TT-TG) of 17 to 20 mm. **Methods:** From January 2008 to August 2013, patients with RPI and a TT-TG of 17 to 20 mm were divided into 2 groups: TTO+MPFLR or MPFLRa. Subjects were evaluated for J sign classification (1-4+); patellar glide (1-4+); the apprehension test; increased femoral anteversion; the Caton index; trochlear dysplasia; TT-TG; and Kujala, Lysholm, International Knee Documentation Committee (IKDC), and Tegner scores. Kujala improvement was the primary outcome. **Results:** Forty-two subjects were evaluated, 18 in the TTO+MPFLR group and 24 in the MPFLRa group. Mean follow-up time was 40.86 months (range, 24-60 months). Demographics between the groups were not different. Preoperatively, there was no statistically significant difference between groups regarding J sign classification; patellar glide; the apprehension test; increased femoral anteversion; the Caton index; trochlear dysplasia; TT-TG; and Kujala, Lysholm, IKDC, and Tegner scores. Postoperative J sign classification mean results comparing TTO+MPFLR and MPFLRa, respectively, were 1 and 1.33 ( $P = .006$ ). Improvement was significantly higher in the TTO+MPFLR group in all scores except for Tegner. Kujala improvement, 30.27 and 23.95, respectively ( $P = .003$ ), was also clinically significant, favoring TTO+MPFLR. Lysholm improvement was 40.5 and 36.2, respectively ( $P = .02$ ), and IKDC improvement was 38.59 and 31.6, respectively ( $P = .002$ ). There were no reported recurrent subluxations or dislocations in either group. **Conclusions:** TTO+MPFLR resulted in better functional outcome scores and patellar kinematics compared with MPFLRa in the surgical treatment of RPI in patients with a TT-TG distance of 17 to 20 mm. **Level of Evidence:** Level II, prospective comparative study.

The surgical treatment for recurrent patellar instability (RPI) is composed of soft tissue procedures, such as medial patellofemoral ligament reconstruction (MPFLR), and bony procedures, such as tibial tubercle osteotomy (TTO), trochleoplasty, and femoral and tibial

osteotomies. These procedures can be performed individually or combined.<sup>1,2</sup>

MPFLR alone (MPFLRa) is indicated to treat RPI, even in the presence of a patella alta or an increased tibial tuberosity–trochlear groove (TT-TG).<sup>3-7</sup> However,

From the Department of Orthopaedics and Traumatology, Escola Paulista de Medicina, Federal University of São Paulo (C.E.F., L.F.A., L.J.B.A., P.D., G.S.d.M.G., M.S.K., M.C., R.J.A., M.V.M.L., M.C.); Knee Institute, Hospital do Coração (C.E.F., L.J.B.A., R.J.A.); and Hospital Israelita Albert Einstein (C.E.F., M.C., M.C.), São Paulo, SP, Brazil.

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Address correspondence to Carlos Eduardo Franciozi, Rua Borges Lagoa, 783, 5th Fl, Vila Clementino, São Paulo, Brazil 04038-032. E-mail: [acarlos66@hotmail.com](mailto:acarlos66@hotmail.com)

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some studies support that TTO should be indicated for patients with a TT-TG >15 mm, solely or in combination with MPFLR.<sup>8-15</sup> To date, no controlled clinical trial has compared the outcomes of the combined TTO and MPFLR with those of the MPFLRa to treat RPI. There is a lack of consensus of when to indicate a combined TTO in addition to the MPFLR. Considering that the additional morbidity of the combined procedure can overcome its biomechanical advantages, the decision to consider either the TTO combined with the MPFLR or MPFLRa to treat RPI is a matter of debate.

The purpose of this study was to compare the midterm clinical outcomes of anteromedialization TTO combined with MPFLR (TTO+MPFLR) versus the MPFLRa for the treatment of RPI in patients with a TT-TG of 17 to 20 mm. The hypothesis was that the combined procedure would present better results.

## Methods

From January 2008 to August 2013, patients with RPI seen in the clinic were identified for possible inclusion in the study. Fifty-one patients were enrolled to participate. Inclusion criteria were defined as 2 or more episodes of patellar dislocation, skeletal maturity, a positive apprehension test, and a TT-TG distance ranging from 17 to 20 mm. Patients were excluded in cases of an absence of patellofemoral cartilage lesions, patellar lesions of Outerbridge grade 3 or 4 involving the medial facet or the proximal region and medial facet, and a Caton index >1.40. The exclusion criteria rationale was based on anteromedialization TTO relative contraindications and a mandatory indication for tibial tubercle distalization osteotomy.<sup>2,16</sup> During informed consent, the hypothesis was explained to each potential subject. Although we believe the combined procedure could achieve slightly better results mainly at the mid- and long term, improving patellofemoral tracking and optimizing pressure distribution on the cartilage of the patella and better addressing pain-related problems, the combined procedure could also be related to a higher complication rate and different problems, such as tibial fracture and hardware complaints, in addition to an extra 7- to 10-cm surgical incision and a longer rehabilitation period. Both procedures were expected to have similar success addressing "giving way" episodes specifically related to patellofemoral instability. Both interventions, risks, and specific pros and cons were explained to the patient by the first author (C.E.F.), and the patient chose which group to participate in: TTO+MPFLR or MPFLRa. Briefly, the stated hypothesis was that the combined procedure, TTO+MPFLR, could achieve slightly better results. The Ethics Committee approved this study.

Historical data were collected for each patient. The physical examination variables, assessed by the first author (C.E.F.), included J sign classification; patellar

glide (lateral patellar translation) at 30° of flexion graded as 1, 2, 3, or 4+ according to quadrants of lateral translation<sup>17</sup>; the evaluation of the apprehension sign<sup>18</sup>; and the clinical presence or absence of increased femoral anteversion.<sup>8</sup> J sign classification was graded from 1 to 4 according to the dynamic lateral translation of the patella in terminal extension during patellofemoral tracking through active knee flexion-extension cycles (Table 1). J sign classification is related to the J sign severity during patellofemoral tracking, and it was introduced to improve patellar maltracking evaluation. Patellar luxation without apprehension or apprehension during passive patellar glide evaluation at 30° of flexion was rated as a positive apprehension test or subluxatable patella. To be considered as increased femoral anteversion, the patient had to fulfill 3 criteria: have differences of more than 30° between passive hip internal and external rotation, favoring internal rotation measured at the prone position; have 70° or more of hip internal rotation determined by the Staheli method in prone position; and have 30° or more of femoral neck anteversion determined by the Ruwe method in the prone position.<sup>8</sup>

Knee radiographs included preoperative and postoperative anteroposterior and lateral at 30° of knee flexion views. The Caton index<sup>19</sup> was used for evaluation of the height of the patella. A Caton index >1.2 was considered as a patella alta. Trochlear dysplasia was evaluated by David Dejour's trochlear dysplasia classification.<sup>20</sup> All 4 grades or the absence of dysplasia were used. In addition, patients with dysplasia were divided into low grade (A) or high grades (B, C, D) to improve observer agreement.<sup>21</sup>

All patients were submitted to a computerized axial tomography study, and an independent reader measured the TT-TG.<sup>22</sup>

Patient-reported outcomes were measured with the Kujala,<sup>23</sup> Lysholm,<sup>24</sup> International Knee Documentation Committee (IKDC) subjective knee evaluation form,<sup>25</sup> and Tegner activity scale.<sup>26</sup> Tegner values preoperatively were rated as the activity level at the time just before the index injury and not the current impaired level at the time of the initial visit to the

**Table 1.** J Sign Classification According to the Dynamic Lateral Translation of the Patella in Terminal Extension During Patellofemoral Tracking Through Active Knee Flexion-Extension Cycles

Grade	J Sign Classification
1	Gentle or normal: showing up to 1 quadrant of motion
2	Moderate: showing >1 and up to 2 quadrants of motion
3	Severe: showing >2 quadrants of motion
4	Habitual dislocation in extension: the patella dislocates completely in extension with each knee cycle of flexion-extension

physician. Kujala improvement was considered the primary outcome.<sup>8,15,27-29</sup> Kujala improvement was considered the average change (delta) in the Kujala score measured as the difference between the postoperative and preoperative Kujala scores. Lysholm and IKDC improvements were addressed the same way.

Functional failure postsurgery was considered as a positive apprehension test, patient reported repeated subluxation, and patient-reported repeated dislocation.

### Surgical Technique

All surgeries were performed by the same surgeon (C.E.F.). The procedure began with a routine arthroscopic examination via the anterolateral and anteromedial portals. Articular cartilage was carefully evaluated. Lesions were evaluated for location and size, and they were graded according to the Outerbridge classification.

The osteotomy performed was similar to the one described by Fulkerson et al.<sup>16</sup> The medialization distance to normalize the TT-TG to 10 to 12 mm was estimated from the preoperative computed tomography measurements, in millimeters. Applying trigonometry, osteotomy obliquity was targeted at 60° to obtain approximately 8 mm of medialization and 15 mm of tibial tubercle anteriorization. If distalization was necessary (Caton index >1.2), it was estimated from the lateral radiography to normalize the Caton index to 1 and the tibial tubercle was fully detached. Once satisfactory tracking was achieved, final tibial tuberosity fixation was made with two 4.5-mm bicortical Arbeitsgemeinschaft für Osteosynthesefragen screws of appropriate length and washers.<sup>8</sup>

The MPFLR was performed using a semitendinosus autograft placed at the patella at the transition between the proximal and middle third of the medial border and at the femur 1 cm distal to the adductor tubercle and 1 cm posterior to the medial epicondyle being tested for isometry. Patella fixation was made by a 5-mm Twinfix titanium anchor (Smith & Nephew, Andover, MA). The graft was routed at the second layer of the medial compartment from the patella to the femur by a Kelly clamp. Satisfactory isometry consisted of <3 mm of migration during flexion-extension testing after patellar graft fixation. Femoral fixation was made by a bioabsorbable interference screw (BIORCI-HA; Smith & Nephew) at 60° flexion with a Kelly clamp underneath the graft to avoid overconstraint of the patellofemoral joint. Nonabsorbable protection sutures were applied to the graft securing it to soft tissues at the patella and femur insertion sites.<sup>8,30,31</sup>

Fluoroscopy was used to check the patella and femur insertion sites before anchor insertion and tunnel confection. In addition, it was used to certify implants and tunnel positions. After the end of this procedure, patellar tracking, range of movement, and lateral

displacement of the patella were tested. The final objective was to have a slight lateral glide of just 1 quadrant with a distinctive end point in extension rather than no lateral glide, which could lead to increased pain, worse rehabilitation, and limited range of movement.<sup>8</sup>

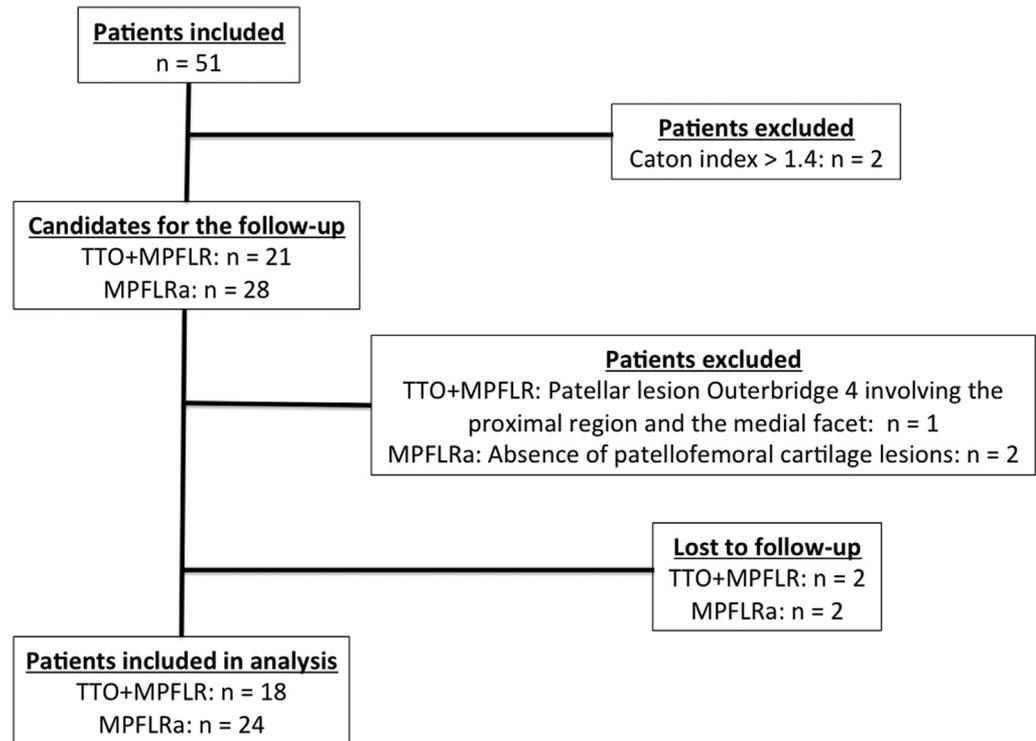
### Postoperative Rehabilitation

Subjects' knees were wrapped with compression dressing and treated with a knee brace and elevation. Movement was encouraged at the first postoperative day with the brace removed. Range of motion was increased based on patient tolerance. Early quadriceps strengthening exercises were initiated. Subjects from the TTO+MPFLR group were kept to toe-touch weight bearing with a brace and crutches for the first 6 weeks. They then proceeded to progressive weight bearing with a brace and crutches for up to 8 weeks. After 8 weeks, brace and crutches restrictions were discontinued based on patient progression. Subjects from the MPFLRa group were kept to toe-touch weight bearing with a brace and crutches for the first 2 weeks. They then proceeded to progressive weight bearing with a brace and crutches for up to 4 weeks. After 4 weeks, brace and crutches restrictions were discontinued based on patient progression. Rehabilitation continued with care to instruct on patellofemoral friendly exercises. Return to sports was based on each subject, surgical procedure, and sport, with higher-risk sports such as soccer involving a longer rehabilitation period.

### Statistical Analysis

A power calculation, using a prior study based on a significant difference in the mean Kujala score ( $8 \pm 8$  points), determined a sample size of 34 patients, with at least 17 subjects in each group as necessary to detect significant changes with 80% power and 95% confidence. Estimating 10% of losses on follow-up, at least 19 patient should be included in each group.<sup>9</sup>

Means, standard deviation, range, and frequencies were used to describe patient information and clinical assessment. A Shapiro-Wilk normality test was used. Parametric tests were used for the data following a normal distribution (Student's *t*-test), and nonparametric tests were used for the data not following a normal distribution ( $\chi^2$ , Wilcoxon, Mann-Whitney *U*). The  $\chi^2$  test was used to detect differences between groups regarding gender, side, patella alta, trochlear dysplasia, J sign classification, and patellar glide. The Wilcoxon signed-rank test was used to compare changes within each group from the preoperative state to the follow-up. Mann-Whitney *U*-tests were used to compare mean scores between the groups preoperatively and at the latest follow-up and to compare changes from the preoperative state to the follow-up visit (difference scores). The Student's *t*-test was used



**Fig 1.** Flowchart of patients through the study.

to compare age, cartilage defect size, TT-TG distance, and follow-up between the groups. Statistical significance was set at  $P < .05$ . The statistics were performed using statistics software Stata Version 14.1 (1985-2015; Stata, College Station, TX).

## Results

Over the period of this study, 42 subjects with RPI who were submitted to the TTO+MPFLR or MPFLRa procedure with a minimum of 2 years of follow-up, ranging from 24 to 60 months with a mean of 40.86 months, were evaluated (Fig 1). Table 2 shows the details of demographic characteristics of the subjects.

Distalization was required in 44% of the subjects (Caton index  $>1.20$ ) from the TTO+MPFLR group, and, after surgery, all of them presented a Caton index within normal ranges (0.8-1.2), with a mean of  $1.0 \pm 0.08$  (range, 1.0-1.12). Distalization was not performed in any subjects from the MPFLRa group. However, if a Caton index  $>1.20$  were applied to this group, 33% (8 of 24) of the subjects would require distalization.

Cartilage lesions were present on the patella of all included subjects. The majority were located at the lateral facet, followed by the distal portion of the ridge. Trochlear lesions were not present in any patient. Eight patients were submitted to surgical treatment of Outerbridge 4 patella cartilage lesions.<sup>32,33</sup> Four lesions were located at the lateral facet ( $n = 3$ ) and distal portion ( $n = 1$ ) of the ridge.

Five of them were treated with microfractures: 1 in the TTO+MPFLR group and 4 in the MPFLRa group. Three patients were treated with osteochondral autologous transplantation: 2 in the TTO+MPFLR group and 1 in the MPFLRa group.

The average distance of the postoperative TT-TG for TTO+MPFLR was  $10.55 \pm 0.83$  mm (range, 10-12 mm) showing statistically significant improvement from the preoperative states of  $18.5 \pm 1.24$  mm (range, 17-20 mm;  $P < .001$ ). There was no difference between the TT-TG distance pre- and postoperatively for the MPFLRa group.

The functional outcomes were evaluated. A statistical difference between pre- and postoperative status was found for the Kujala, Lysholm, and IKDC scores. Contrary to our expectations, Tegner scores were worse postoperatively; however, this difference was not clinically significant (Table 3).

Comparing both groups, functional improvement (change in the score measured as the difference between postoperative score and preoperative score) favored TTO+MPFLR over MPFLRa for Kujala, the primary outcome, in addition to Lysholm and IKDC (Fig 2).

Patellofemoral physical examination parameters were also analyzed as secondary outcomes comparing both groups. Postoperative J sign classification was normal for all subjects in the TTO+MPFLR group, whereas 33% (8 of 24) of the subjects in the MPFLRa group were rated as improved (Table 4).

**Table 2.** Subject Information and Clinical Assessments

	TTO+MPFLR	MPFLRa	<i>P</i>
No. of subjects	18	24	
Age, mean ± SD	25.33 ± 7.5	28 ± 8.6	.3
Male/female	3/15	8/16	.22
Side, left/right	10/8	18/6	.18
Increased femoral anteversion, n (%)	1 (6)	6 (25)	.9
Follow-up, months, mean ± SD	41.33 ± 10.26	40.5 ± 11.63	.81
Caton-Deschamps index, mean ± SD	1.12 ± 0.14	1.12 ± 0.11	.97
Patella alta, Caton >1.2, n (%)	8 (44)	8 (33)	.46
Patella size defect, cm <sup>2</sup> , mean ± SD	1.12 ± 0.39	1.22 ± 0.49	.48
Cartilage lesion Outerbridge grade, n (%)			
1	2 (11)	1 (4)	.81
2	7 (39)	11 (46)	
3	6 (33)	7 (29)	
4	3 (17)	5 (21)	
Dysplasia (Dejour), n (%)			
None	1 (6)	3 (13)	.67
A	6 (33)	7 (29)	
B	6 (33)	6 (25)	
C	5 (28)	6 (25)	
D	0 (0)	2 (8)	
TT-TG distance preoperatively, mm, mean ± SD	18.5 ± 1.24	18.04 ± 1.12	.16

MPFLRa, medial patellofemoral ligament reconstruction alone; SD, standard deviation; TT-TG; tibial tuberosity–trochlear groove; TTO+MPFLR, tibial tubercle osteotomy combined with medial patellofemoral ligament reconstruction.

In addition, patella alta was a contributing factor for a postoperative residual abnormal J sign. Considering subjects with normal patellar height, only 12.5% (2 of 16) of the MPFLRa group patients presented with a residual abnormal J sign (2+). Otherwise, 75% (6 of 8) of subjects with patella alta submitted to MPFLRa showed a residual abnormal J sign (2+) postoperatively. This difference was statistically significant ( $P < .001$ ).

All patients had a positive apprehension test or a subluxatable patella at the patellar glide test rated as grade 4 before surgery. Four patients had subluxatable patella without apprehension. Postoperatively, none of the subjects had a positive apprehension test, and no subject reported recurrent subluxation or dislocation. One subject from the MPFLRa group required manipulation under anesthesia. Two subjects from the TTO+MPFLR group required tibial tubercle screws and washer removal owing to anterior discomfort at the implant site. Two subjects from the TTO+MPFLR group and 5 subjects from the MPFLRa group had the other

knee operated on as well, at least 8 months after the index surgery, but the data regarding the other knee were not included to avoid confounders and a minimum of 2 years of follow-up surgery. No patient was dissatisfied enough to change the procedure (TTO+MPFLR or MPFLRa) on the other operated knee, as long as the other knee fulfilled the requirements for each technique.

Two subjects were excluded owing to a Caton index >1.40, 1 subject from the TTO+MPFLR group was excluded owing to a patellar lesion of Outerbridge grade 4 involving the proximal region and the medial facet, and 2 subjects were excluded from the MPFLRa owing to absence of patellofemoral cartilage lesions. Four subjects were lost to follow-up: 2 from TTO+MPFLR and 2 from MPFLRa.

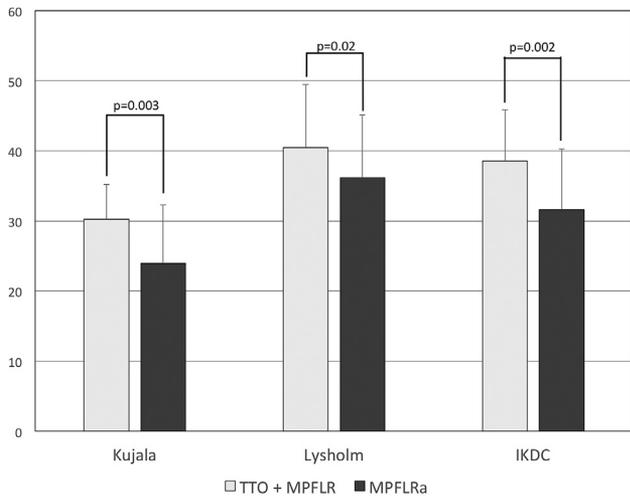
## Discussion

The most important findings of this study were the statistically and clinically significant functional Kujala improvement and the superior patellofemoral tracking

**Table 3.** Function Measured Preoperatively and Postoperatively

Score	TTO+MPFLR				<i>P</i>	MPFLRa				<i>P</i>
	Preoperative		Postoperative			Preoperative		Postoperative		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Kujala	57.27	4.94	87.55	5.44	.005	58.7	6.08	82.66	8.06	<.001
Lysholm	47.05	9.0	87.55	7.96	.006	49.41	6.7	85.62	7.4	.004
IKDC	49.83	8.4	88.42	5.19	.006	49.21	4.59	80.85	8.69	<.001
Tegner	5.22	1.26	5.11	1.36	.52	5.45	1.21	5.2	1.31	.55

IKDC, International Knee Documentation Committee; MPFLRa, medial patellofemoral ligament reconstruction alone; SD, standard deviation; TTO+MPFLR, tibial tubercle osteotomy combined with medial patellofemoral ligament reconstruction.



**Fig 2.** Comparison of the functional improvements (change in the score measured as the difference between postoperative score and preoperative score) between tibial tubercle osteotomy combined with medial patellofemoral ligament reconstruction and medial patellofemoral ligament reconstruction alone.

favoring the TTO+MPFLR group over the MPFLRa group. This demonstrates a beneficial influence of combined TTO as opposed to MPFLRa in the treatment of RPI patients with a TT-TG of 17 to 20 mm. This finding is an important contribution to understanding patellar instability, and it confirms the theoretical and mechanical advantages conferred by TTO.<sup>16,34,35</sup>

Despite MPFL being the most important medial stabilizer, it functions just as a restraint preventing lateral dislocation of the patella.<sup>1,2,36,37</sup> Its reconstruction alone does not considerably improve patellar tracking or kinematics, mainly in TT-TG >15 mm patients with severe trochlear dysplasia.<sup>4,7,11,38</sup> In this scenario, TTO addresses patellofemoral maltracking much more efficiently, as shown by the present study. J sign postoperative severity was lower in TTO+MPFLR than in MPFLRa, but there was no preoperative difference.

The introduction of patellofemoral tracking evaluation by grading the J sign from 1 to 4+ is an important parameter to be added to patellofemoral physical disorder examinations. Considering that the J sign can have a broad spectrum of manifestations, rating its severity can improve patellofemoral understanding and its outcomes analysis.<sup>28,39</sup> A large J sign is related to a delayed entrance of the patella into the trochlea, but its fundamental causes are not yet defined.<sup>26,40,41</sup> It can be associated with patella alta, as in the current study, with trochlear dysplasia, or with both.<sup>40</sup> In addition, as inferred from the data presented, it is related to a lateralized tibial tubercle and can be improved by TTO, as all TTO+MPFLR subjects were rated postoperatively as normal, whereas 34% of the MPFLRa remained abnormal. As such, it can have a role in decision making and choice of surgery: J sign severity can be an indication for more extensive surgical procedure.

Some studies on MPFLR described no correlation between greater TT-TG and worse outcomes; however, their sample sizes were small and presented no direct comparisons.<sup>3,6</sup> Matsushita et al.,<sup>5</sup> despite finding no Kujala differences comparing a TT-TG ≥20 mm and a control group with a TT-TG <20 mm, described positive postoperative apprehension tests in 4 knees in the greater TT-TG group and just 1 in the control group, in addition to abnormal patellar movements in a patient with a TT-TG of 27 mm. Yet some MPFLR studies with a large number of patients reported worse outcomes involving greater TT-TG.<sup>4,7</sup> Despite the report of a previous comparative study regarding the combined TTO+MPFLR and MPFLRa, which differs from the present study, no other reports compared the effects of these distinctive treatments in the same population and the presence of increased TT-TG or patella alta in the combined procedure, which results in a biased assessment.<sup>36</sup> Nevertheless, these studies reported no significant differences for the Kujala score or complications in comparison with the MPFLRa group, encouraging the use of combined procedures in the

**Table 4.** Patellofemoral Physical Examination Parameters

	TTO+MPFLR	MPFLRa	P	TTO+MPFLR	MPFLRa	P
J sign classification, grade, n (%)						
I (normal)	0 (0)	0 (0)	.17	18 (100)	16 (67)	.007
II	4 (22)	3 (13)		0 (0)	8 (34)	
III	4 (22)	12 (50)		0 (0)	0 (0)	
IV	10 (56)	9 (37)		0 (0)	0 (0)	
Patellar glide grade, n (%)						
I	0 (0)	0 (0)	.99	15 (83)	19 (79)	.56
II	0 (0)	0 (0)		3 (17)	5 (21)	
III	0 (0)	0 (0)		0 (0)	0 (0)	
IV	18 (100)	24 (100)		0 (0)	0 (0)	
Apprehension, n (%)	18 (100)	24 (100)		0 (0)	0 (0)	

MPFLRa, medial patellofemoral ligament reconstruction alone; TTO+MPFLR, tibial tubercle osteotomy combined with medial patellofemoral ligament reconstruction.

presence of increased TT-TG or patella alta.<sup>36</sup> Interestingly, a recent randomized controlled trial compared a combined TTO+MPFLR to TTO alone and showed better patient satisfaction and fewer episodes of instability or functional failures, which favors the combined procedure, somewhat similar to the present study; however, there was no Kujala difference.<sup>14</sup>

Kujala improvement from baseline, favoring TTO+MPFLR over MPFLRa, can be related to the improved patellofemoral tracking achieved by the TTO medialization or the biomechanical advantages added by coupled TTO anteriorization and medialization. The anteromedialization TTO was used instead of the medialization TTO because it has a similar complication rate and it offers some biomechanical advantages, increasing the lever arm of the extensor mechanism, lowering the patella-femoral contact pressure at the first 30°, decompressing the lateral facet from 0 to 30°, decompressing the distal articular surface of the patella, optimizing load sharing between lateral and medial facet after 30°, and also improving patellofemoral tracking.<sup>16,34,35,42</sup> In addition, patellar cartilage lesion locations, mainly at the lateral facet, followed by the distal portion of the ridge, can be related to the better outcome of the combined procedure because they are associated with improved anteromedialization TTO results over other topographies.<sup>35</sup> It is also important to note that all subjects with a patella alta (Caton index >1.2) had a TTO distalization added to the anteromedialization at TTO+MPFLR, whereas subjects with a Caton index >1.2 in the MPFLRa group had no patellar height correction. Because the correction of patella alta improves patellofemoral kinematics and patella-trochlear engagement, this could have also contributed to a better Kujala improvement favoring TTO+MPFLR.<sup>1,2,12,15,22,28,35,36,42-47</sup>

Since statistically significant research may not be clinically important, a minimum clinically important difference (MCID) was also applied. Comparing both groups, only the Kujala questionnaire showed an MCID, reported as at least 8 to 10 points or 10% of improvement. Improvement of the Kujala score in subjects submitted to TTO+MPFLR was 30% superior compared with subjects submitted to MPFLRa. Interestingly, Lysholm and IKDC scores did not show any clinically significant differences.<sup>27,48</sup> The Kujala score was designed to document pain in the patellofemoral compartment, and achieving MCID is likely a reflection of the specific pathology treated in this study. Despite the fact that it probably does not fully capture the subjective difficulties of RPI patients, it is still the most used questionnaire for RPI, and its improvement was the primary outcome of this study.<sup>8,28,29</sup>

Although there were no statistical differences regarding any complications between both groups, the addition of TTO supposedly increases the chances for

tibial fracture and reoperation due to symptomatic hardware removal. Maybe the complication rate was statistically similar between both groups because the number of patients involved was not large, especially if we consider only the TTO+MPFLR group. Similarly, the addition of TTO supposedly decreases the chances of functional failures; however, there were none in any group. This may also be related to the number of patients involved. Nevertheless, the recruitment took 5 years to complete, and the sample size is similar to the majority of studies regarding the same topic.<sup>7,9,12,13,15,16,28,34,36,37,45,49-51</sup>

This prospective comparative study was developed in response a previous failure in trying to conduct a randomized clinical trial. The majority of recruited patients for the first trial declined to participate, complaining they wanted to choose which procedure to participate in. The study was discontinued, and this prospective comparative study was developed.

### Limitations

Unfortunately, this type of study creates an opportunity for selection bias between the 2 groups, which can lead to an unanticipated factor leading to improvement of the TTO+MPFLR group that cannot be identified by the authors. However, considering that there is no controlled clinical trial comparing the outcomes of MPFLRa with those of a combined TTO+MPFLR to treat RPI, this study presents the best evidence, so far, to address this topic.

### Conclusions

TTO+MPFLR resulted in better functional outcome scores and patellar kinematics compared with MPFLRa in the surgical treatment of RPI in patients with a TT-TG distance of 17 to 20 mm.

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