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Combined reconstruction of the medial patellofemoral and medial patellotibial ligaments: outcomes and prognostic factors

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Abstract

Purpose To report outcomes after combined medial patellofemoral ligament (MPFL) and medial patellotibial ligament (MPTL) reconstruction and test associations between prognostic factors and clinical outcomes. It was hypothesised that combined MPFL and MPTL reconstruction would result in significant improvement in function, and that outcomes would be associated with age, sex, Beighton score, concomitant articular lesions, and preoperative function.

Methods All combined reconstructions of MPFL and MPTL were reviewed. Inclusion criterion was minimum 2-year follow-up. Exclusion criteria were age at surgery ≥ 35 years and concomitant osteotomies. Kujala, Tegner and Marx scores were completed prospectively. Patients were evaluated at a minimum 2-year follow-up. Associations between potential prognostic factors and Kujala and Tegner scores were tested using bivariate analyses followed by multivariate regression models.

Results Of 22 patients (26 knees), 19 (23 knees) met inclusion criteria, and 16 (20 knees) were available for follow-up. Mean age at surgery was 18 years (range 14.5–23). Mean follow-up was 43 months (range 24–73). Postoperative Kujala score significantly improved compared to before surgery (86.4 ± 12.5 vs. 54.9 ± 15.2, $p < 0.01$). Postoperative Tegner score was nonsignificantly higher compared to before surgery (4.8 ± 2.4 vs. 4 ± 3, p = ns) and lower compared to before first patella dislocation (4.8 ± 2.4 vs. 5.9 ± 1.2, $p < 0.01$). Postoperative Kujala score was associated with male sex ($p = 0.02$), with medial patellofemoral chondral lesions ($p = 0.01$) and with preoperative Kujala score ($p = 0.05$). Postoperative Tegner score was associated with male sex ($p < 0.01$), with preoperative Tegner level ($p < 0.01$), and with Beighton score ($p < 0.01$). Patella apprehension was recorded in two knees (10%) in two patients.

Conclusion Combined MPFL and MPTL reconstruction in young adults results in significant improvement in subjective knee function with minimal risks, although preinjury activity levels are not consistently restored. Associated factors of improved outcome include higher preoperative knee scores and activity levels, medial patellofemoral chondral lesions, decreased Beighton scores, and male sex. This supports the advisability of the procedure and can also assist in setting realistic goals for specific groups of patients.

Level of evidence Case series, Level IV.

Keywords MPFL · MPTL · Gracilis · Beighton · Tegner · Marx

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Introduction

The medial patellofemoral ligament (MPFL) is the primary passive restraint to lateral patellar translation. It contributes more than 50% of the restraining force when the knee is between 0 and 30° flexion before the patella engages in the trochlea [6, 10, 24, 28]. Multiple surgical techniques were, therefore, developed to address recurrent lateral patellar instability by reconstructing this ligament [5]. The medial patellotibial ligament (MPTL) is a secondary passive restraint. It contributes 20% of the restraining force to lateral patellar translation in the extended knee, but becomes more fundamental beyond 30° flexion and resists lateral patellar tilt beyond 45° flexion with increasing contribution in further knee flexion [24]. The combined restraining action of both ligaments, working on a continuum of knee range of motion, may, therefore, better resist lateral patellar maltracking compared to isolated MPFL reconstruction. This may be further advantageous in cases which involve dysmorphism (i.e., shallow trochlea, increased patellar height, increased external tibial torsion or femoral anteversion), in which bony congruency may be inadequate at higher flexion angles for enabling the patella to settle in the trochlear groove. Accordingly, certain investigators suggested combined reconstruction of both MPFL and MPTL in cases of recurrent lateral patellar instability to enhance a more physiological patellar tracking through a wider range of knee motion [2, 4, 7–9, 11, 30]. While good clinical outcomes and high success rates were reported in general in these techniques [2, 5, 7, 8, 29, 30], a recent systematic review of MPFL reconstructions highlighted complications in up to one quartile of the cases [29], ranging from clinical instability on postoperative examination, pain, and superficial wound infections, to severe complications such as patellar fractures. Viewing the extensive literature on MPFL reconstruction [5] and the limited reports on the outcomes following combined MPFL and MPTL reconstruction, it is difficult to determine a preferred surgical procedure. Moreover, previous reports were focused on outcomes per se, while information about prognostic factors in these cases was limited. The purpose of this study was, therefore, to add to the body of literature mid-term outcomes after combined MPFL and MPTL reconstruction in young adults which could be incorporated in future meta-analyses of outcomes aiming to determine a preferred technique, and to test inter-relationships between potential prognostic factors and the clinical outcomes observed. It was hypothesised that combined MPFL and MPTL reconstruction in young adults would result in significant improvement in function with minimal failure rates, and that intrinsic factors such as age, sex, BMI, and Beighton score, and extrinsic factors such as symptoms' duration, preoperative activity levels, and concomitant patellofemoral chondral lesions would be associated with knee function and activity levels at mid-term follow-up.

Materials and methods

All primary combined MPFL and MPTL reconstructions performed between 2008 and 2016 in a single sports medicine injury clinic were identified. Indications for performing the procedure were: (1) history of recurrent lateral patellar instability, (2) physis closure, and (3) patella which could be dislocated laterally under anaesthesia at the beginning of surgery. Inclusion criteria for the cohort of this study were: (1) a minimum of 2-year follow-up. Exclusion criteria were: (1) age at surgery ≥ 35 years; and (2) concomitant osteotomy. Twenty-two patients (26 knees) fulfilled the initial inclusion criteria for this study (Fig. 1). Six patients (six knees) were not included in the final study cohort for the following reasons: two patients (two knees) aged 35 years or older, one patient (one knee) had concomitant tibial tubercle osteotomy because TT-TG was 25 mm and a prominent J-sign was observed, one patient (one knee) could not be reached due to moving to another continent after surgery, and two patients (two knees) were unwilling to volunteer for personal reasons not related to the operation. Thus, 20 operated knees in 16 patients comprised the study cohort, corresponding to 84% follow-up (16 of 19 patients). In this series, TT-TG was in the range 10–18 mm, and there were no cases of significant trochlea dysplasia (i.e., type B, C, or D, according to the Dejour classification) [17] or patella alta (Insall–Salvati and Caton–Deschamps ratios were in the range 0.95–1.20 and 1.0–1.17, respectively).

Surgical technique

Principles of the procedure included: (1) using a hamstring tendon (gracilis was used generally, unless it was exceptionally thin, and in that case the semitendinosus could be used) which was left attached at the tibia insertion (pes anserinus) and whip-stitched with a #1 Vicryl suture; (2) preparing a 4.0-mm-diameter longitudinal tunnel at the medial third of the patella. An ACL aimer device could be used for easier aiming (Fig. 2). The proximal aperture of this tunnel was located just lateral to the upper medial corner of the patella and the distal aperture was just medial to the medial margin of the patellar tendon insertion on the distal patellar pole; (3) passing the hamstring tendon from distal to proximal and through the patellar tunnel (Fig. 3); (4) preparing a 3-cm-long incision over the medial femoral epicondyle area and passing the hamstring tendon just over the joint capsule, as a second layer in accordance with anatomical studies [25], towards the medial epicondyle; (5) using a 5.5-mm double-loaded Bio-Corkscrew FT anchor (Arthrex, Naples, FL, USA) at a mid-point between the medial epicondyle and the adductor tubercle; (6) with the knee held at 45° flexion, slack was removed from both distal and proximal limbs of the tendon, followed by a single suture around the graft at the femoral insertion point and the knot was then firmly held with a suture clamp. Desired stability and tracking of the patella was then confirmed through knee range of motion from 90° flexion to full extension, aiming to achieve lateral passive translation of the patella of less than one-half the patellar width in full extension. This is in accordance with anatomical investigation supporting maximum MPTL tension at 90° and maximum MPFL tension closer to knee extension [24]. Adjustments of graft tension were

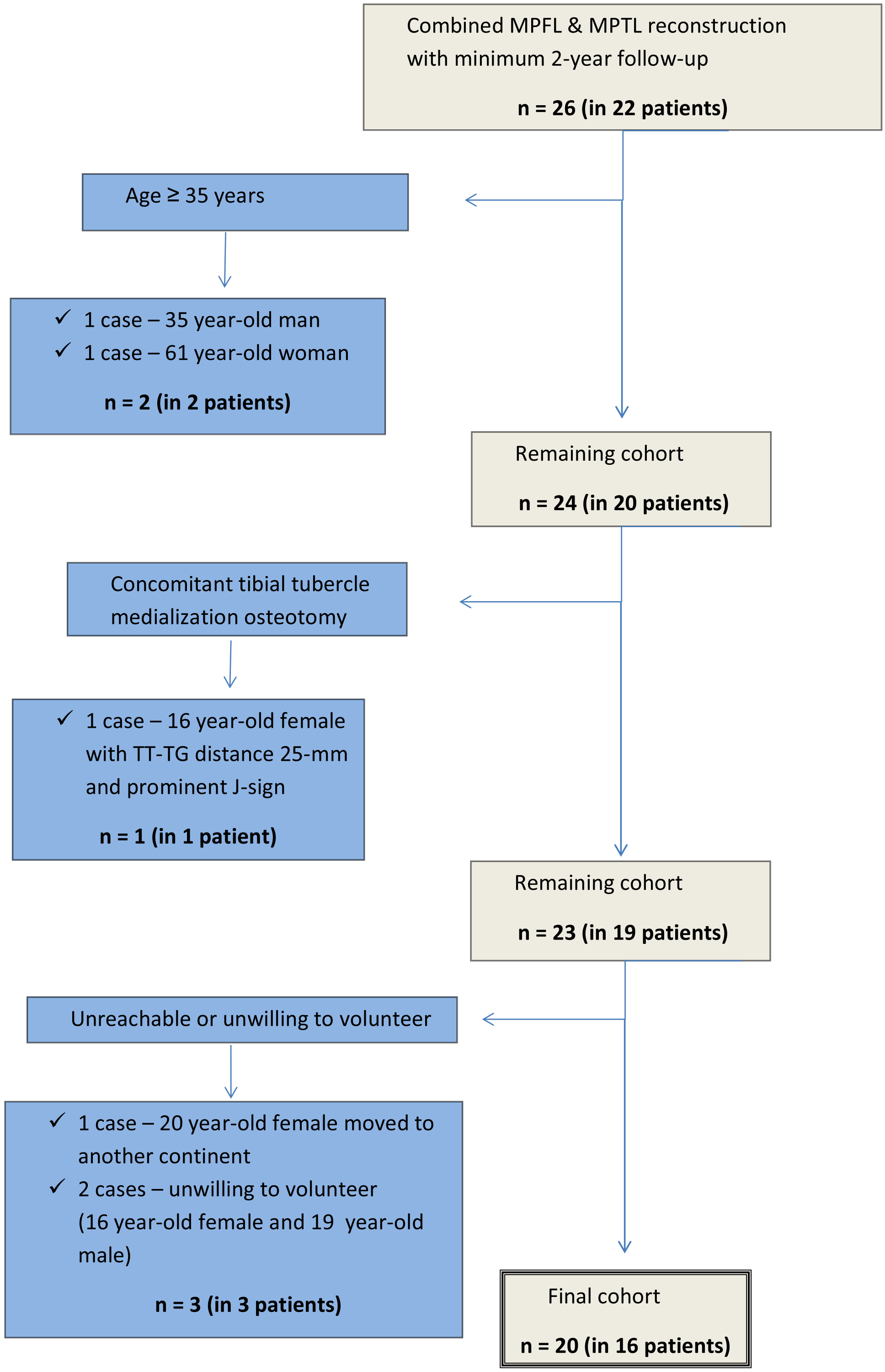

Fig. 1 Study cohort flow-chart

performed as needed until tension was optimal. Consecutive knots were then tied over the graft at the femoral insertion (Fig. 4); (7) remaining distal tip of the tendon beyond anchor fixation was looped back towards the patella and tied over itself with #1 Vicryl suture. The postoperative protocol included using a knee range of motion brace for 6 weeks with immediate full weight bearing with crutches and isometric quadricep strengthening. Range of knee motion was restricted to 0°–30° for the first 2 weeks, 0°–60° for the third and fourth weeks, and 0°–90° for the fifth and sixth weeks. After 6 weeks, the brace was removed and increase in range of knee motion was allowed without restrictions. Return

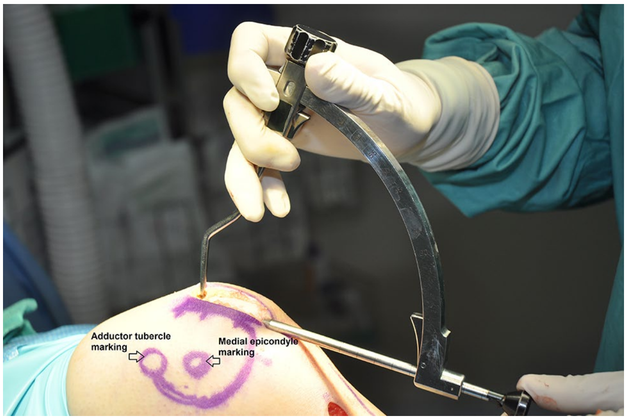

Fig. 2 Left knee. ACL aimer device assists for preparing a longitudinal tunnel at the medial third of the patella

Fig. 3 Left knee. The hamstring tendon left intact at the tibia insertion and then passed through the patellar tunnel

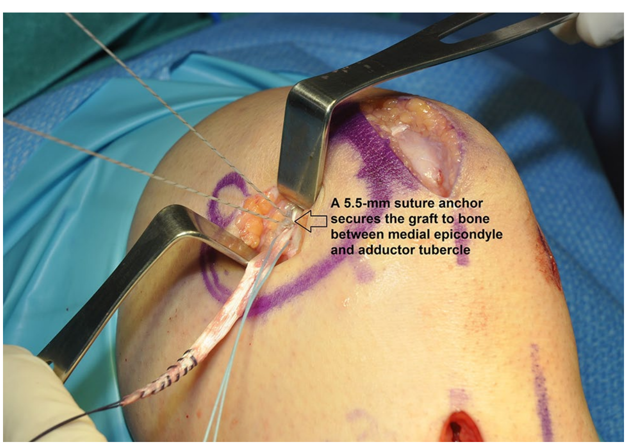

Fig. 4 Left knee. Knots tied over the graft at the femoral insertion

to unrestricted sports activity was basically allowed when painless full range of knee motion and quadricep strength and control were regained. This was usually at 4–5 months postoperatively, which is roughly in accordance with previous protocols after such procedures [7, 32].

Patients were contacted for a follow-up evaluation in the clinic at 2–6 years after surgery. Office charts and operative reports were reviewed. Demographic variables included sex, age at operation, BMI, symptoms duration before surgery, and follow-up time. Physical examination included Beighton score which is a simple scoring system on a scale between 0 and 9 to quantify joint laxity and hypermobility [3]. Higher score indicates greater laxity. Nine joints are tested, and each positive exam adds 1 point. This includes little finger passive dorsiflexion beyond 90° (right and left, 1 point each), thumb passive dorsiflexion to the flexor aspect of the forearm (right and left, 1 point each), elbow hyperextension beyond 10° (right and left, 1 point each), knee hyperextension beyond 10° (right and left, 1 point each), and foreword flexion of trunk with knees extended and palms resting flat on the floor (1 point). Other tests included patella apprehension test, patellofemoral grinding test for pain, standard knee physical examination of all knee ligaments and range of motion. Prospectively collected data included Kujala score [15], Tegner [31] and Marx [20] activity level scores. The International Knee Documentation Committee (IKDC)-subjective score [1] was recorded at follow-up.

The Institutional Review Board (Meir General Hospital, Kfar Saba, Israel) approved the study protocol (approval I.D 0216-13-MMC) and all participants signed informed consent.

Statistical analysis

The planned sample size was based on the largest previous series of combined MPFL and MPTL reconstruction [2, 7, 8, 30] or on systematic reviews of MPFL reconstruction alone [5, 27] which reported significant clinical improvements in series of 14–27 knees after ligament reconstruction without concomitant osteotomies. The Student *t* test was used for comparing mean values between variables with normal distribution. The Mann–Whitney non-parametric test was used for comparing variables where the assumption of normality was rejected. Nominal variables were analysed with the chi-square or the Fisher's exact tests. Associations between function at latest follow-up (Kujala and Tegner scores) and potential prognostic factors were tested. Chi-square test was used for nominal variables which included sex (male vs. female), history of medial plication surgery performed after the first lateral patella dislocation event ("yes" vs. "no"), and co-existing Outerbridge grade 3–4 patellofemoral lesions identified at surgery ("yes" vs. "no") [22], whereas Pearson product–moment correlation coefficient was used for continuous variables which included BMI, duration of instability symptoms from the first dislocation to ligament reconstruction surgery (years), Beighton score, age at surgery (years), follow-up time (years), preoperative Kujala score, Tegner and Marx activity level scores before the first event of patella dislocation, and preoperative Tegner and Marx activity level scores. Multivariate stepwise linear regression models were used to evaluate the relationships between latest postoperative Kujala and Tegner scores and independent variables which were significantly associated with these outcome measures in the bivariate analyses. Minimal clinically important difference (MCID) was defined as one-half the standard deviation of the change in pre- vs. postoperative Kujala outcome score, which is an accepted formula in orthopaedic surgery as well as specifically following knee ligament reconstruction [21]. Post hoc power analysis with $\alpha = 0.05$ was calculated for any prospectively collected outcome measure showing nonsignificant change at follow-up compared to before surgery. Twenty operated knees were included in the final study cohort in accordance with the planned sample size. Level of statistical significance was set at 0.05. Statistical analyses were performed using IBM SPSS-22 software package (Armonk, NY, USA).

Results

Table 1 presents patient demographics and injury characteristics. Of 20 operated knees, 14 were females (10 patients) and 6 were males (6 patients). Ten patients (63%) were involved in Soccer, Basketball, or Dancing. Three knees in three patients (15%) had history of MPFL repair early after the first dislocation, but due to recurrent instability episodes they underwent combined MPFL and MPTL reconstruction. Six knees (30%) had high-grade patellofemoral lesions (Outerbridge grade 3–4) observed at the time of the combined MPFL and MPTL reconstruction. These six cases were observed to have 10–15-mm medial patellar facet lesions of which three had reciprocating far-lateral LFC lesions.

Table 2 presents outcome scores. Kujala score indicated significant improvements in patellofemoral function at follow-up. Also, Kujala score at follow-up, as a specific measure of patellofemoral function, demonstrated strong correlation with overall knee function at follow-up represented by the IKDC-subjective score. MCID of Kujala score was 7.0 points. Eighteen of the 20 operated knees (90%) obtained improvement in function greater than MCID. Tegner activity level was 5.9 ± 1.2 before the first dislocation event, dropped significantly to 4 ± 3 preoperatively and demonstrated nonsignificant increase at latest follow-up. A similar trend was observed in Marx activity level score. While the study was adequately powered to show significant increase from pre- to postoperative Kujala score and significant decrease from preinjury to preoperative Tegner score, it appeared underpowered to detect significant increase from preoperative to postoperative Tegner and Marx scores ($\beta < 50\%$).

Tests of potential prognostic factors of postoperative Kujala score and Tegner activity level are presented in Table 3. Postoperative Kujala score was positively associated with male sex, with high-grade compared to low-grade patellofemoral chondral lesions identified during surgery, with preoperative Kujala score, and with preoperative Marx score. Postoperative Tegner activity level was negatively associated with Beighton score and positively with male

Table 1 Patient demographics and injury characteristics

Variables	
Female vs. male (n. knees)	14 vs. 6
Type of sports practiced before injury (n. patients)	
Soccer—professional level (Tegner = 10)	3
Soccer—recreational level (Tegner = 7)	3
Basketball—professional level (Tegner = 9)	1
Dancing—professional level (Tegner = 6)	2
Dancing—recreational level (Tegner = 5)	1
No specific sports except jogging, etc. (Tegner = 3–5)	6
Age at operation, years (mean) (range)	18 ± 2 (14.5–23)
BMI (mean) (range)	22.3 ± 1.9 (18–25)
MPFL repair after first dislocation (n. knees) (%)	3 (15%)
Symptoms' duration before surgery[a], years (mean) (range)	2.5 ± 1.7 (0.5–6)
Beighton score (median) (range)	6 (0–9)
Outerbridge grade 3–4 patellofemoral lesions (n. knees) (%)	6 (30%)
Follow-up time, months (mean) (range)	43 ± 17 (24–73)

n. number of cases, *BMI* body mass index

[a]Interval from first lateral patella dislocation event until combined MPFL and MPTL reconstruction was performed

Table 2 Outcome scores and inter-relationships between outcome scales

	Score (mean ± SD)	*p* value
Outcome scale		
Kujala postop vs. preop	86.4 ± 12.5 vs. 54.9 ± 15.2	< 0.01
IKDC-subjective postop	75.7 ± 18.1	
Tegner bi vs. preop vs. postop	5.9 ± 1.2 vs. 4 ± 3 vs. 4.8 ± 2.4	$< 0.01^{\text{bi-preop}}$; $\text{n.s.}^{\text{preop–postop}}$
Marx bi vs. preop vs. postop	7.4 ± 5.9 vs. 3.9 ± 6.8 vs. 4.4 ± 6.1	$< 0.01^{\text{bi-preop}}$; $\text{n.s.}^{\text{preop–postop}}$
Inter-relationships between scales		
Kujala postop vs. IKDC-subjective postop	*r* = 0.963	< 0.01
Kujala postop vs. Tegner postop	*r* = 0.495	0.03
Kujala postop vs. Marx postop	*r* = 0.537	0.02
Tegner postop vs. Marx postop	*r* = 0.934	< 0.01
Tegner postop vs. IKDC-subjective postop	*r* = 0.579	< 0.01
Marx postop vs. IKDC-subjective postop	*r* = 0.603	< 0.01

SD standard deviation, *preop* preoperative, *postop* postoperative, *bi* before injury (before first event of lateral patella dislocation), *IKDC* International Knee Documentation Committee, *n.s.* nonsignificant

Table 3 Kujala score and Tegner activity level vs. each potential prognostic factor

Prognostic factor tested	Kujala at follow-up	Tegner at follow-up
Sex ("male" vs. "female")	96 ± 4 vs. 82 ± 13 ***p* = 0.02**	7.8 ± 1.8 vs. 3.4 ± 1.0 ***p* < 0.01**
BMI	*r* = − 0.053, *p* = n.s.	*r* = 0.336, *p* = n.s.
MPFL repair surgery immediately after first lateral patellar dislocation ("yes" vs. "no")	86 ± 15 vs. 86 ± 13 *p* = n.s.	3.3 ± 1.5 vs. 5 ± 2.5 *p* = n.s.
Time interval between first lateral patella dislocation event until MPFL and MPTL reconstruction	*r* = − 0.157, *p* = n.s.	*r* = 0.239, *p* = n.s.
Beighton score	*r* = − 0.315, *p* = n.s.	*r* = − 0.830, ***p* < 0.01**
Age at surgery	*r* = 0.228, *p* = n.s.	*r* = 0.144, *p* = n.s.
Patellofemoral Grade 3–4 chondral lesions ("yes" vs. "no")	97 ± 4 vs. 82 ± 12 ***p* = 0.01**	6 ± 2.8 vs. 4.2 ± 2.1 *p* = n.s.
Follow-up time	*r* = − 0.001, *p* = n.s.	*r* = 0.340, *p* = n.s.
Kujala preoperative	*r* = 0.444, ***p* = 0.05**	*r* = 0.632, ***p* < 0.01**
Tegner activity level before injury	*r* = 0.286, *p* = n.s.	*r* = 0.627, ***p* < 0.01**
Tegner activity level preoperative	*r* = 0.260, *p* = n.s.	*r* = 0.759, ***p* < 0.01**
Marx activity score before injury	*r* = 0.232, *p* = n.s.	*r* = 0.482, ***p* = 0.04**
Marx activity score preoperative	*r* = 0.445, ***p* = 0.05**	*r* = 0.680, ***p* < 0.01**

Significant *p* values appear in bold

BMI body mass index, *n.s.* nonsignificant, *bi* before injury (before first event of lateral patella dislocation)

sex, with preoperative Kujala score, with Tegner level before injury and preoperatively, and with Marx score before injury and preoperatively.

A stepwise multivariate regression model for latest postoperative Kujala score vs. the three associated prognostic factors that appeared in the bivariate analyses, which were patellofemoral high-grade lesions, Kujala preoperative score, and sex, revealed that patellofemoral lesions had the most substantial contribution, accounting for 27% of the variance (adjusted $r^2 = 0.27$, p = n.s.), while the addition of preoperative Kujala score and sex to the regression model had only 6% additional contribution (adjusted $r^2 = 0.33$ for all three factors, p = n.s. for all three factors). The stepwise multivariate regression model for latest postoperative Tegner level vs. the three associated prognostic factors that appeared in the bivariate analyses, which were sex, preoperative Tegner level, and Beighton score, revealed that when Tegner preoperative level and sex were combined in the model, both accounted together for 81% contribution (adjusted $r^2 = 0.81$) to this outcome measure with significant associations ($p = 0.02$ for preoperative Tegner level, and $p < 0.01$ for sex), but when all three variables were included in the model, this accounted for 85% contribution (adjusted $r^2 = 0.85$) to the outcome measure, while sex had nonsignificant contribution ($p =$ n.s.), as opposed to preoperative Tegner level which remained significantly associated with the outcome measure ($p < 0.01$). To further explore the observation that sex had nonsignificant contribution to both Kujala and Tegner scores at follow-up in the multivariate regression models as opposed to its apparent significant contribution to both outcome measures in the bivariate analyses, comparisons were made between males and females in relation to the other three impactful factors, i.e., high-grade patellofemoral lesions, Beighton score, and preoperative Tegner level. These comparisons revealed significant differences between males vs. females in all three measures (66.7% vs. 14.3%, $p = 0.04$; 1.7 ± 2.0 vs. 6.6 ± 1.2, $p < 0.01$; and 6.8 ± 4.0 vs. 2.8 ± 1.3, $p = 0.05$ or < 0.01, for prevalence of patellofemoral lesions, for Beighton score, and for preoperative Tegner level, respectively), supportive that sex per se may have not been the critical prognostic factor, but rather those other three factors which were inter-related with sex had likely by themselves a more fundamental contribution to the functional outcomes and activity levels at follow-up.

Complications included two knees in two patients (10%) who had positive patella apprehension sign at follow-up and two knees in two patients (10%) who had tenderness on skin palpation at the medial femoral anchor area which was likely the consequence of bulky knots of the nonabsorbable anchor sutures. None of the cases underwent revision ligament reconstruction.

Discussion

The most important finding of the present study was that combined reconstruction of the MPFL and MPTL resulted in significant improvement in subjective knee function. Ninety percent of the operations demonstrated improvement in postoperative Kujala score greater than the MCID. The improvement from preoperative condition to postoperative period as reflected by Kujala patellofemoral score and the Kujala and IKDC-subjective scores at the postoperative period is in accordance with previous reports of MPFL and MPTL reconstruction [2, 7, 8, 30] or reports of isolated MPFL reconstruction [5, 27]. This seems to point out that either reconstruction technique is an advisable procedure in this respect because it leads to substantial improvement in patellofemoral joint function and knee function as a whole. More challenging, however, would be to expect a knee ligament reconstruction procedure to restore preinjury activity level and intensity of sports participation. In this series, despite the convincing improvement in Kujala score and the favourable postoperative IKDC-subjective scores, Tegner and Marx activity scores did not support the restoration of mean preinjury levels but only the maintenance of preoperative levels. Only one study, to the best of our knowledge, reported Tegner activity levels after combined MPFL and MPTL reconstruction [7]. In that study, mean Tegner level was 6.8 at the preinjury condition and 6.7 at the postoperative evaluation with 11 of 15 operated patients regaining preinjury activity levels [7]. This seems to have a higher success compared to the current series where mean postoperative Tegner level was 4.8 and substantially lower than the preinjury level. Whereas the current series and the previous study [7] demonstrated similarly high Kujala scores at follow-up, the discrepancy between the reports in terms of restoring activity levels may be attributed to the differences in patients' demographics. In the previous study [7], 10 of 15 patients (67%) had preinjury Tegner levels of 7–10 as opposed to the current series where only 7 of 16 patients (44%) had preinjury Tegner levels of 7–10, and only 6 patients (7 knees, 35% of all operations) in this series were involved before the injury in professional sports including soccer, basketball, and dancing. The higher preinjury Tegner levels in the previous study [7], representing a more active population, may have accounted for higher motivation to return to high-demand sports. Few studies reported Tegner levels after isolated MPFL reconstruction. In one study, despite the significant improvements in mean Kujala score from 66 preoperatively to 87 postoperatively, only half the patients returned to their preinjury sports levels and mean Tegner score dropped from 4.5 preoperatively to 4.0 postoperatively ($p < 0.01$) while mean Marx score dropped from 6.0 preoperatively to 3.0 postoperatively ($p < 0.01$) [18]. A recent systematic review and meta-analysis found that only a small proportion of studies of isolated MPFL reconstruction reported activity levels before and after the reconstruction [27]. Among the limited number of studies addressing this measure and included in that review, postoperative Tegner scores were between 4.4 and 7.7 (mean 5.7 of all pooled data), whereas preinjury or preoperative scores (some reports indicated only preoperative scores and not preinjury scores) were between 3.0 and 6.1 (mean 4.5 of all pooled data). The discrepancy between the significant improvement in Kujala score as opposed to only mild improvement in activity level score in the current series and in some of the previous reports is likely to be multifactorial but could be attributed to reasons such as fear of reinjury, lack of interest in returning to sports, and unwillingness to "pay a price" with continuing cutting and pivoting activities, particularly in non-professional populations with lower motivation for returning to sports. Another important point in this regard was that patients in the current series sustained their first lateral patellar dislocation at a young age, while waiting between 6 months and 6 years until ligament reconstruction took place. While this is not necessarily unusual in this type of injury and was reported by other investigators as well [7], the lengthy time from the first injury until the ligament reconstruction surgery may have driven patients to modify their activities, and consequently they may have been reluctant later to return to intense activity. Overall, based on previous reports and the current series, the goal of restoring preinjury activity levels (Tegner scale) and preinjury activity intensities (Marx scale) in these cases, even when substantial improvements in subjective perceptions of patellofemoral joint function and knee function as whole are obtained, seems challenging and should meet reasonable patient expectations.

Among the prognostic factors, higher postoperative Kujala scores were associated with higher preoperative scores, with male sex, and with high-grade medial patellofemoral chondral lesions observed during surgery. A regression model revealed that the presence of high-grade medial patellofemoral lesions remained the most influential factor associated with higher Kujala scores. A possible explanation for this finding could be that lower-grade lesions represent patients who are prone to less favourable outcomes as a result of inherent subtle passive or dynamic lack of patellofemoral stability. From a practical standpoint this means that Outerbridge grade 3–4 medial patellofemoral chondral lesions should at least not discourage from performing medial patellofemoral ligament reconstructive surgery due to a concern of unfavourable outcomes. Higher postoperative Tegner activity level was associated with higher preoperative Tegner level, with male sex, and with Beighton laxity score. In a regression model, preoperative Tegner level remained the most influential factor on this outcome measure, whereas sex had nonsignificant contribution in the model. The positive relationship between preoperative and postoperative levels of sports participation is not surprising and is supported by previous investigators [18]. As to the negative impact of generalised joint laxity on this outcome measure, some similarities were seen in young patients after ACL reconstruction [16, 19]. This could be related to poor landing mechanics [22], or to other factors of ligament tissue quality, but it may also reflect the end result of a complex multifactorial process that is affected by biological and mechanical factors which are inter-related.

Age and BMI were not prognostic factors in this series. However, this should be seen in view of the homogeneity of the series with regard to these factors since only young non-obese adults were included.

Minor complications included positive apprehension sign in two knees of two patients (10%), which was noted in previous descriptions as a relatively common complication among the complications observed after medial patellofemoral ligament reconstruction [18, 26, 27, 29], and subcutaneous sensitivity around nonabsorbable suture knots over the medial anchor in two cases (10%), one of which also had a positive apprehension sign. Sensitivity around the medial femoral hardware in these procedures is in accordance with previous reports that drew attention to the increased sensitivity over this specific area around the knee after surgery [29] and, therefore, care should be taken to avoid prominent hardware at this location. No major complications were recorded such as infection or patella fracture. In fact, patella fracture was reported previously only following isolated MPFL reconstruction techniques, where transverse patellar tunnels were used [23, 26, 27, 29]. In this respect, the longitudinal medial patellar tunnel used in this series may be protective to prevent this complication.

From the anatomical perspective, it should be noted that while the technique presented closely follows MPFL insertions to the patella and femur [12, 14, 25], it follows MPTL anatomical insertion to the patella [12, 13] but is not consistent with the insertion of the MPTL to the tibia [12, 13]. This is because the native MPTL inserts on the proximal medial tibia at 15-mm distal to the joint line and not at the pes anserinus area as in this technique. Whether this apparently non-anatomical MPTL limb reconstruction needs to be modified for mechanical reasons of patella tracking could be a basis for future research.

Limitations of this study included the relatively limited size of the series which may have resulted in type II errors, and not controlling for other potential prognostic factors such as core muscle function with gluteal strength and balance before surgery and at follow-up.

Conclusion

Combined MPFL and MPTL reconstruction in young adults results in significant improvement in subjective knee function with minimal risks, although preinjury activity levels are not consistently restored. Associated factors of improved outcome include higher preoperative knee scores and activity levels, medial patellofemoral chondral lesions, decreased Beighton scores, and male sex. This supports the advisability of the procedure and can also assist in setting realistic goals for specific groups of patients.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval The local Institutional Review Board (Meir General Hospital, Kfar Saba, Israel) approved the study protocol (I.D. 0216-13-MMC).

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