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Medial patellofemoral ligament reconstruction with an extensor hallucis longus allograft: a retrospective study of 45 cases

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Reconstruction of the Medial Patellofemoral Ligament (MPFL) has become the procedure of choice in patients with patellar instability. The type of graft used for reconstruction is controversial. The purpose of this study was to analyze and describe the clinical and radiological results achieved with a MPFL reconstruction performed using an extensor hallucis longus allograft.

This work is a retrospective study of 41 patients (45 knees) who underwent MPFL reconstruction using an extensor hallucis longus allograft. The patellar apprehension test, Kujala scale, and EQ-5D European quality of life scale were evaluated preoperatively and postoperatively at 24 months. Complications, recurrence rate, time to return to sports, and satisfaction with the procedure were also assessed.

Statistically significant differences were observed between pre- and postoperative variables on the Kujala scale ($p < .001$) and the EQ-5D ($p < .001$). The isolated MPFL presented an increase on the Kujala scale of 41.9 ± 13.4, in contrast to the reconstruction with tibial tubercle osteotomy with an increase of 29.4 ± 16.6 ($p = 0.031$).

MPFL reconstruction with an extensor hallucis longus allograft is a suitable alternative in patients with patellofemoral instability because it offers clinically and radiologically satisfactory results. MPFL reconstruction combined with a tibial tubercle osteotomy can offer inferior functional outcomes to the isolated reconstruction.

Keywords: Patellofemoral joint, patellar dislocation, medial patellofemoral ligament reconstruction, allografts, extensor hallucis longus.

INTRODUCTION

Patellofemoral instability is more common among young patients and is multifactorial in origin. Advances in knowledge of anatomy and physiopathology have allowed for refining treatment techniques, which are evolving towards the use of soft tissue procedures such as medial patellofemoral ligament reconstruction (MPFL). The MPFL, considered the principle medial stabilizer of the patella, originates distally from the adductor tubercle and posteriorly from the medial epicondyle. It inserts into the superior and medial border of the patella[1-3].

Since 2005, a progressive increase in the number of MPFL reconstructions in patients with patellofemoral instability has been observed. In 2014, it accounted for 75% of patellar stabilization surgeries performed, and it has now become the procedure of choice. Although it is not free of complications, it leads to better results than those seen in other patellar stabilization procedures and with conservative management[4].

The type of graft used for reconstruction is the subject of controversy. Autografts have been widely used in MPFL reconstruction with optimal results[5]. Richter et al.[6,7] proposed MPFL reconstruction with an autologous internal gracilis tendon, in contrast to Wang et al.[8,9], who suggested the use of a monofascicular peroneus longus hemitendon allograft. Peter et al.[10] obtained satisfactory results after two years of follow-up with an autograft from the quadriceps tendon.

Though the use of an autograft offers multiple advantages, it also has some disadvantages, notably donor site morbidity and a longer surgical time. In light of these possible pitfalls, MPFL reconstruction with an allograft is a suitable option as it offers results that are comparable to an autograft while avoiding the aforementioned disadvantages[11-13]. Among the advantages of using an allograft are a reduction in

surgical time. Hendawi et al.[14] noted that use of an autograft could increase surgical time by 32.7 minutes compared to reconstruction with an allograft, given that it entails extraction of the autologous tendon.

The purpose of this study is to evaluate the clinical and radiological results achieved with MPFL reconstruction with an allograft from the extensor hallucis longus of the foot in patients with patellofemoral instability, with a minimum follow-up time of 24 months.

MATERIALS AND METHODS

All patients provided their consent to participate in this study. This work has been approved by the local ethics committee.

This work is a retrospective study that includes 41 patients with patellofemoral instability who underwent MPFL reconstruction with an allograft of the extensor hallucis longus (four patients required bilateral reconstruction and thus there were a total of 45 procedures) in the Virgen de la Victoria University Hospital in Málaga, Spain, between January 2014 and December 2017. Of the 41 patients included in the study, three of those who underwent a unilateral reconstruction did not complete the minimum follow-up time of 24 months because they moved to another autonomous community. Therefore, the final analysis included 38 patients (42 knees).

Eligibility criteria

The inclusion criteria were the following:

– Having presented with at least two episodes of patellar dislocation.

– Having had a first episode of patellar dislocation with persistence of instability and a positive apprehension test.

The exclusion criteria were the following:

– Not providing consent for participation in the study.

– Patients with patellar dislocation with traumatic origin.

– Patients with minor patellar instability – that is, patients who have not had any episodes of frank dislocation – who have presented with a sensation of instability and a positive apprehension test.

– Being younger than 14 years of age, as our hospital does not treat pediatric patients.

– In order to reduce the heterogeneity of the results, we excluded patients who, as an additional procedure, required cartilage treatment motivated by a chondral or osteochondral lesion or trochleoplasty, due to trochlear dysplasia was the main factor of instability.

– Having undergone a previous surgery in the affected or contralateral knee.

– Patients who present with hypermobility of congenital origin (Marfan syndrome, Down syndrome, etc.).

Surgical technique

All procedures were performed by an attending physician who belongs to our hospital's knee unit. Reconstruction was carried out on its own or combined with a tibial tubercle osteotomy, when necessary.

In all cases, general anesthesia was given, an ischemia cuff was used, and a prophylactic antibiotic was administered one hour before beginning surgery, as per our hospital's established protocol.

MPFL reconstruction was performed with a fresh-frozen allograft from the extensor hallucis longus tendon of the foot that had a minimum length of 21 centimeters. The allograft came from donors in cardiorespiratory arrest who are less than 55 years old, without the presence of an active infection, with the prior consent of the family. At the time of extraction, which was performed under strict aseptic conditions, samples were collected for microbiological study (aerobic and anaerobic bacteria and fungi). The graft was stored in a freezer at - 80 degrees for a period of less than 5 years.

Regarding the surgical approach, a 3-cm incision was made to expose the superior and medial border of the patella. Then, a 4.5-mm V-shaped double tunnel was drilled with the vertex in the anterior cortical bone of the patella. The femoral insertion point of the MPFL was located through palpation of the described anatomical reference points (medial epicondyle and adductor tubercle) with fluoroscopic guidance using the references proposed by Schöttle et al.[15]. A 2-cm incision was made at this location and then a blind-ended transosseous tunnel that had a mean diameter of 7 mm, as determined by the thickness of the tendon, was drilled. The tendon was slid through the double tunnel in the patella, with the two ends passing between the synovial and muscular plane, until it reached the blind-ended tunnel made in the patellar area. In this location, considered an isometric point, an interference screw measuring 1 mm thicker than the tunnel made in the femur was fixed with knee flexion of 60 degrees. The described surgical technique can be observed in Figure 1.

In patients with a Caton-Deschamps index greater than 1.2, an osteotomy was also performed, with a subsequent reduction in the ATT. Likewise, when a

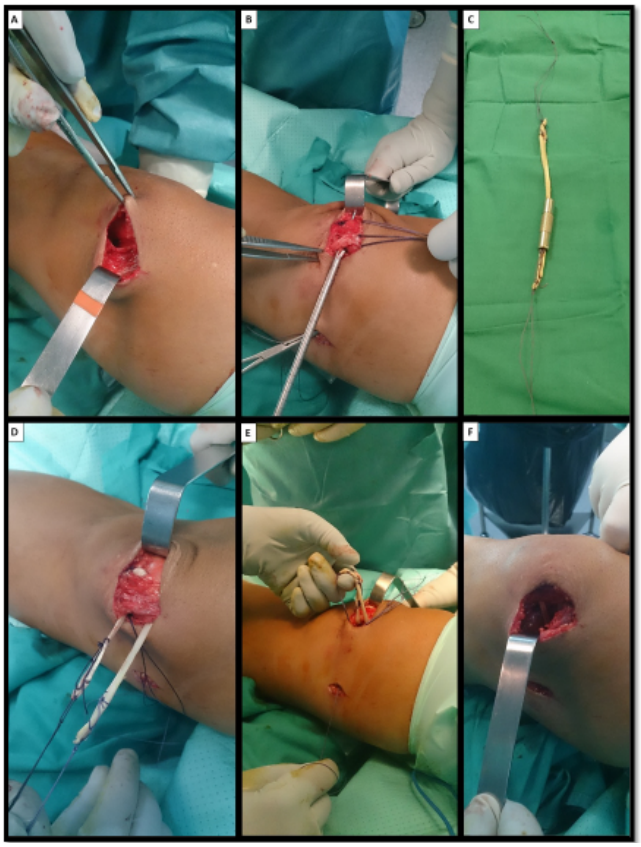

Figure 1. — MPFL reconstruction with an extensor hallucis longus allograft. A) Incision in the superior and medial border of the patella. B) Drilling of a double tunnel in the patella. C) Measurement of tendon graft thickness. D) Passage of the tendon graft through the double tunnel in the patella. E) Sliding of the tendon graft between the synovial and muscular plane towards the femoral tunnel. F) Image of the double fascicle after finishing the reconstruction.

TT-TG distance greater than 20 mm was observed, medialization was carried out. The ATT osteotomy was fixed with two 4-mm cortical screws with interfragmentary compression.

Postoperative rehabilitation

Patients began to walk with crutches and partial loading from the first day following surgery, with passive and active mobilization of between 0 and 90 degrees of the knee that was operated on. All patients performed isometric exercises from the beginning. At four weeks following surgery, they were allowed to walk with full loading on the limb that was operated on, progressively ceasing to use the crutches. Likewise, from that moment, passive and active mobilization was performed without restriction of knee flexion.

Clinical evaluation

All patients were evaluated pre- and postoperatively (24 months) using the patellar apprehension test (subjective patellar instability)[16], the Kujala scale[17], and the EQ-5D European quality of life scale[18]. The surgical time necessary for isolated MPFL reconstruction was also recorded, not including the time spent on tibial tubercle osteotomy in cases where it was necessary.

During the postoperative period, major and minor complications related to the procedure, recurrence rate, time to return to sports, and degree of satisfaction with the procedure were assessed.

Radiographic evaluation

In the pre- and postoperative periods, all patients had an anteroposterior, lateral, and axial x-ray of both patellas at 30 degrees of flexion. Likewise, before the surgery, all patients had a CT scan. All radiological measurements were carried out by two expert radiologists with a Picture Archiving and Communication System (PACS).

Preoperatively, the following radiological variables were gathered: patellar height (Caton-Deschamps index)[19,20], TT-TG distance[20,21] (evaluated via a pre-operative CT scan), sulcus angle[22-24], congruence angle (CA)[22-24], lateral patellar displacement (LPD)[22-24], lateral patellofemoral angle (patellar tilt angle)[22-24], presence of trochlear dysplasia (Dejour classification)[25] and patellar shape according to Wiberg classification[26].

In the postoperative period, the following variables were evaluated: patellar height (Caton-Deschamps index), CA, LPD, and patellar tilt angle.

Statistical analysis

The data collected were entered into an Excel database and analyzed with Statistical Package for Social Scientists (SPSS 23.0, IBM) software. In the descriptive analysis, quantitative variables are expressed with measures of central tendency (arithmetic mean, median, and mode) and through measures of dispersion (range and standard deviation). Qualitative variables are expressed in percentages. The data are shown graphically in order to facilitate reading and interpreting the analyzed variables.

Considering the sample size, the normality of variables was evaluated using the Shapiro-Wilk test. A contrast of the hypothesis was carried out for related samples using the Wilcoxon signed-rank test for quantitative variables and McNemar's test for dichotomous qualitative variables. Furthermore, Student's t-test was used for independent samples in order to conduct an analysis according to subgroups of the main outcome variable (dependent variable) based on various normally distributed independent variables.

RESULTS

MPFL reconstruction with an allograft was performed in 41 patients (45 knees). Three patients did not complete the minimum follow-up time, established at 24 months. Therefore, the final analysis included 38 patients (42 knees). The mean follow-up time was 57 (24-72) months. Patients' demographic characteristics are shown in Table I.

On the preoperative examination, the patellar apprehension test was positive in 39 cases (93%) versus 0 on the postoperative examination ($p < .001$). In regard to the Kujala scale, a preoperative value of 49.6 ± 8.6 (30-65) and a postoperative value, at 24 months, of 86.6 ± 13.7 (55-100) were found: an increase of 36.9 ± 14.7 (10-70). These differences observed between pre- and postoperative Kujala scale values were statistically significant ($p < 0.001$). The increase on the Kujala scale, considered the main outcome value, was analyzed according to patient subgroups based on the variables of age at surgery, sex, BMI, affected side, TT-TG distance, SA, patellar shape, patellar height, patellar tilt angle and isolated MPFL versus reconstruction with tibial tubercle osteotomy. No statistically significant differences were observed for most of the variables ($p > 0.05$), except for concurrent procedures. The isolated MPFL presented an increase on the Kujala scale of 41.9 ± 13.4, in contrast to the reconstruction with tibial tubercle osteotomy with an increase of 29.4 ± 16.6 ($p = 0.031$) (Table II).

The pre- and postoperative EQ-5D values were also collected and analyzed (Table III); statistically significant differences were found ($p < 0.001$). The mean time to return to regular sports activity was 5.2 ± 4.5 (0-24) months.

The increase in VAS EQ-5D (difference between postoperative and preoperative VAS EQ-5D) for the overall sample was 57.2 +/- 20.5. Thus, the increase in VAS EQ-5D was higher among patients treated with isolated MPFL versus reconstruction with tibial tubercle osteotomy (63.1 +/- 15.4 vs. 50.4 +/- 23.9), however, this difference was not statistically significant

Table I. — Demographic data

Sex	Female	22 (52.4%)
	Male	20 (47.6%)
Affected side	Left knee	22 (52.4%)
	Right knee	20 (47.6%)
Age at surgery	28.7 ± 9.2 (range 15-44) years	
Weight	70.6 ± 11.6 (range 43-101) kilograms	
Height	166.4 ± 8.2 (range 157-189) centimeters	
Body mass index (BMI)	26 ± 5 (range 17 - 35)	

Table II. — Analysis by subgroups of the variable increase on the Kujala scale (comparison of means using Student's t-test for independent samples)

Variables	Subgroups	Significance (*p* value)
Age at surgery	≤ 30 years, > 30 years	0.854
Sex	Male, female	0.267
BMI	≤ 25 kg/m^2, > 25 kg/m^2	0.586
Affected side	Left, Right	0.228
TT-TG distance	< 20 mm, ≥ 20 mm	0.688
SA	≤ 145 degrees, > 145 degrees	0.915
Patellar shape (Wiberg classification)	Type 2 patella, type 3 patella	0.551
Patellar height (Caton-Deschamps)	≤ 1.2, > 1.2	0.850
Patellar tilt angle	≤ 4 degrees, > 4 degrees	0.671
Concurrent procedures	Isolated MPFL, reconstruction with tibial tubercle osteotomy	0.031

Table III. — Pre- and postoperative values on the EQ-5D scale

	Preoperative		Postoperative (24 months)	
Visual Analog Scale (VAS, Health status today, 0-100)	33.3 ± 14.4 (10-60)		88.5 ± 9.8 (70-100)	
	No problem	Some problems	No problem	Some problems
Mobility	5 (11.9%)	37 (88.1%)	42 (100%)	0 (0%)
Personal care	7 (16.7%)	35 (83.3%)	42 (100%)	0 (0%)
Daily activity	1 (2.4%)	41 (97.6%)	38 (90.5%)	4 (9.5%)
Pain/discomfort	3 (7.1%)	39 (92.9%)	35 (83.3%)	7 (16.7%)
Anxiety/depression	19 (45.2%)	23 (54.8%)	41 (97.6%)	1 (2.4%)

Table IV. — Concurrent procedures

Procedure	Frequency	Percent
Isolated MPFL	21	50%
MPFL + Tibial tubercle osteotomy with only distalization	7	16.7%
MPFL + Tibial tubercle osteotomy with distalization and medialization	14	33.3%

Table V. — Pre- and postoperative values of CA, LPD, and patellar tilt angle

	Preoperative	Postoperative (24 months)
CA	13.6 ± 8.8 (-18-43)	3.5 ± 5.9 (-18-16)
LPD	5.6 ± 3.7 (0-20)	2.3 ± 2.7 (0-16)
Patellar tilt angle	4.7 ± 3.8 (-10-15)	10.1 ± 2.8 (4-18)

($p = 0.110$). Regarding the different dimensions of the EQ-5D scale, the group treated with an isolated MPFL showed a higher percentage of patients with no problems in their activities of daily living (16 [100%] vs. 10 [71.4%], $p = 0.037$), however, no statistically significant differences were found for mobility, personal care, pain/discomfort and anxiety/depression ($p > 0.05$).

Preoperatively, a mean patellar height (Caton-Deschamps index) of 1.22 ± 0.18 (0.78-1.5) was observed. The Caton-Deschamps index was greater than 1.2 in 21 cases (50%) and therefore a reduction in ATT was performed. In the postoperative period, a mean Caton-Deschamps index of 1.01 ± 0.16 (0.7-1.39) was found. The difference between the pre- and postoperative patellar height was statistically significant ($p < 0.001$).

In the preoperative period, a mean TT-TG distance of 17.6 ± 4.5 (8-31) mm was observed. Fourteen cases (33.3%) presented with values greater than 20 mm and as such, ATT medialization was considered necessary.

In the preoperative period, the degree of trochlear dysplasia (Dejour classification) was recorded along with the ridge angle, which was 151.5 ± 7.4 (138-168). No signs of trochlear dysplasia were observed in 13 cases (31%), type A dysplasia was observed in 11 cases (26.2%), type B dysplasia in 8 cases (19%), type C dysplasia in 10 cases (23.8%).

The additional procedures described are shown in Table IV.

Patella type (Wiberg classification) was also recorded in the preoperative period. Type 2 patella was observed in 26 cases (61.9%) and type 3 patella in 16 (38.1%). In this regard, no differences were observed between the pre- and postoperative period, given that patellar shape was not altered during the surgical procedure.

The pre- and postoperative values of CA, LPD, and patellar tilt angle were measured and are shown in Table V. Statistically significant differences were found in all three radiological measurements ($p < 0.001$).

The mean surgical time for an isolated MPFL reconstruction, not including the time needed for addition procedures, was 45 ± 7 (35-71) minutes. In regard to procedure-related complications, 34 cases (80.1%) did not present with any complications, six cases (14.3%) had minor complications such as occasional discomfort in the anterior face of the knee or keloid scars, and two cases (4.8%) presented with major complications: a patellar fracture and a tear in the tendon graft. The tendon graft tear took place at five months and required another reconstruction due to recurrence of instability. The patellar fracture was treated with an open reduction and cerclage wiring fixation. No cases of infection or joint stiffness were

observed. Of the 42 cases, 39 (92.9%) reported they were satisfied with the procedure versus three (7.1%) who were not.

DISCUSSION

The main finding of our work was the excellent clinical and radiological outcomes achieved with MPFL reconstruction with an extensor hallucis longus allograft. Our results are similar to those described in the scientific literature on reconstruction with autografts, but without some of their disadvantages.

Different authors recommend the use of an allograft is an appropriate alternative for MPFL reconstruction precisely because it avoids donor site morbidity and reduces surgical time[27]. In this regard, in our study, the mean surgical time was 45 minutes. Van et al.[28] described the advantages of reconstruction with an allograft from the Achilles tendon with a bone plug. Similarly, Marcheggiani et al.[29] observed optimal results following reconstruction with a fascia lata tendon allograft. In our case series, the reconstruction was performed with fresh-frozen allograft from the extensor hallucis longus tendon of the foot, which offers the advantages of an allograft and, in addition, has a smaller diameter than other types of allografts. This fact allows smaller diameter tunnels to be made in the patella, which reduces the risk of fracture.

The use of an allograft has also been linked to certain disadvantages, such as greater risk of infection or increased costs. In our study, no cases of infection were found. In regard to the possible increase in the cost of the procedure, our hospital belongs to the same public healthcare network as the tissue bank and thus, use of an allograft does not entail an additional cost. In our region, for private centers which request an allograft from the extensor halluces longus tendon of the foot, the price has been set by the healthcare authorities at €486.10[30], however, the price in other regions and countries may be different. Depending on the costs of allografts, if we take into consideration the costs arising from increased surgical time and the possible morbidity at the donor site, use of an allograft could be more cost-effective than reconstruction with an autograft.

In accordance with what is described in the literature[5], in our series, statistically significant differences were noted between the pre- and postoperative Kujala scale values ($p < 0.001$), with a mean increase of 36.9 ± 14.7 (10-70). In this regard, an analysis of the Kujala scale increase conducted according to patient subgroups found no statistically significant differences, except for the subgroup of patients where a tibial tubercle osteotomy was performed as an additional procedure, which presented a smaller increase in the Kujala scale versus isolated reconstruction.

Bouras et al.[18] reported that MPFL reconstruction can improve quality of life of patients with recurring patellar displacement and they recommend using quality of life scales for evaluating postoperative outcomes. In our work, quality of life was evaluated before and after surgery by means of the EQ-5D scale. Statistically significant differences were found on all of its dimensions (mobility, personal care, daily activities, pain/discomfort, and anxiety/depression) and on the visual analog scale (health status today).

Despite the excellent results of MPFL reconstruction, various authors, such as Biesert et al.[31], affirm that many patients may not achieve normal function in the operated knee, a possibility that patients must be warned of before the procedure. It has been observed that around 88.5% of patients operated on can do regular sports activity, but only 69.6% of those reached their previous level of activity[32]. In our series, 92.9% returned to sports in 5.2 ± 4.5 month. The other 7.1% could not return to sports and thus they reported dissatisfaction with the procedure.

Graft fixation, especially in the patella, is the subject of controversy. Various works, such as that by Yoon et al.[33], report that both anchoring with sutures and the use of transosseous tunnels in the patella lead to optimal results[34]. In this work, patella fixation in all patients was carried out with a double transosseous tunnel, 4.5-mm in diameter, as it allows for more precisely restoring the native MPFL anatomy and has a complication rate that is lower than is what is described in a single tunnel reconstruction[35]. Nevertheless, it is not free of complications, including patella fractures, which in some studies occurred in up to 11% of patients[36]. In this regard, in our series, only one patella fracture was recorded (2.4%), which was treated with cerclage wiring fixation. The use of extensor hallucis longus allograft, with a lower thickness than other grafts, allows reducing the diameter of the tunnels in the patella, which could reduce the incidence of patella fractures.

Regarding the association between tunnel diameter and risk of patellar fracture, in the present study it could not be proved, because in all patients tunnels were made with the same diameter (4.5 mm). Nevertheless, in the scientific literature we find authors, such as Deasey et al.[37], who suggest the use of smaller diameter (3.2-mm), short, oblique tunnels for patellar fixation could reduce the risk of fracture, with an incidence of patellar

fracture similar to suture anchor techniques but at a lower cost.

In this study, graft fixation was carried out with 60-degree flexion, in line with what is suggested in the scientific literature[38]. Lorbach et al.[39] affirm that graft fixation must be done with 60-degree flexion because this angle allows for more precisely reproducing patellofemoral contact with the native knee. Another aspect analyzed in the literature is graft tension.

In our case, we decided to perform a double fascicle reconstruction as we considered that it reproduced the native patella fingerprint with greater precision than monofascicular reconstruction and offers greater resistance to having another episode of dislocation[40].

The complication rate described in our series is in line with what has been observed in previous publications. In the study conducted by Schiphouwer et al.[41], complications were reported in 39 patients (20.3%) out of a series of 179 patients (192 knees) who underwent MPFL reconstruction surgery with a double patellar tunnel. In 27 cases (14.7%), they were minor complications versus seven cases (3.6%) of patellar fracture without a traumatic antecedent, which was more frequent in males. We also recorded one case of patella fracture (2.4%), which occurred in a male patient after a fall on a patella that was probably weakened by the transosseous tunnel. In regard to the recurrence rate, the aforementioned authors described ten cases (5.1%) that presented with another episode of dislocation with positive apprehension sign versus one case (2.4%) in our series, already reported in the results, which was caused by a tendon graft tear.

Among the limitations of our work are its small sample size, which is justified in our opinion due to the low prevalence of major patellar instability. Other limitations are the lack of a comparator group that could be of interest for comparing results; the loss of three patients to follow-up; and conducting additional procedures when necessary, as this hinders the interpretation of results achieved with an isolated MPFL reconstruction. A randomized, double-blind clinical trial that would allow for drawing conclusions based on higher quality evidence is required.

CONCLUSION

MPFL reconstruction with an extensor hallucis longus allograft is a suitable alternative in patients with patellofemoral instability because it provides clinically and radiologically satisfactory results. The isolated reconstruction of the LPFM offers superior functional outcomes than the reconstruction combined with a tibial tubercle osteotomy.

REFERENCES

1. Best MJ, Cosgarea AJ. The Evolution of Patellofemoral Instability Surgery During the Past 25 Years. Sports Med Arthrosc Rev. 2018 Dec;26(4):157-159. doi:10.1097/JSA.0000000000000221. Available from: https://pubmed.ncbi.nlm.nih.gov/30395057/
2. Aframian A, Smith TO, Tennent TD, Cobb JP, Hing CB. Origin and insertion of the medial patellofemoral ligament: a systematic review of anatomy. Knee Surg Sports Traumatol Arthrosc. 2017 Dec;25(12):3755-3772. doi:10.1007/s00167-016-4272-1. Available from: https://pubmed.ncbi.nlm.nih.gov/27631645/
3. Fujino K, Tajima G, Yan J, et al. Morphology of the femoral insertion site of the medial patellofemoral ligament. Knee Surg Sports Traumatol Arthrosc. 2015 Apr;23(4):998-1003. doi: 10.1007/s00167-013-2797-0. Available from: https://pubmed.ncbi.nlm.nih.gov/24296991/
4. Gravesen KS, Kallemose T, Blønd L, Troelsen A, Barfod KW. Persistent morbidity after Medial Patellofemoral Ligament Reconstruction - A registry study with an eight-year follow-up on a nationwide cohort from 1996 to 2014. Knee. 2019Jan;26(1):20-25. doi: 10.1016/j.knee.2018.10.013. Available from: https://pubmed.ncbi.nlm.nih.gov/30502935/
5. Weinberger JM, Fabricant PD, Taylor SA, Mei JY, Jones KJ. Influence of graft source and configuration on revision rate and patient-reported outcomes after MPFL reconstruction: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2017 Aug;25(8):2511-2519. doi: 10.1007/s00167-016-4006-4. Available from: https://pubmed.ncbi.nlm.nih.gov/26856314/
6. Richter J, Mayer P, Immendörfer M, Schulz M, Schlumberger M, Schuster P. [Reconstruction of the medial patellofemoral ligament using autologous gracilis tendon in an implant-free technique on the patellar side]. Oper Orthop Traumatol. 2016 Feb;28(1):65-77. doi: 10.1007/s00064-015-0404-x. German. Available from: https://pubmed.ncbi.nlm.nih.gov/26162786/
7. Carnesecchi O, Neri T, Di Iorio A, Farizon F, Philippot R. Results of anatomic gracilis MPFL reconstruction with precise tensioning. Knee. 2015 Dec;22(6):580-4. doi: 10.1016/j.knee.2015.01.006. Available from: https://pubmed.ncbi.nlm.nih.gov/26021832/
8. Wang X, Wang P, Han X, Yu J, Yuan Y, Tan H. [Arthroscopic reconstruction of medial patellofemoral ligament combined with medial displacement of lateral hemitibial tuberosity for treatment of recurrent dislocation of patella]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2020 Jul 15;34(7):836-842. Chinese. doi: 10.7507/1002-1892.201912001. Available from: https://pubmed.ncbi.nlm.nih.gov/32666725/
9. Rimmke NA, Magnussen RA, Flanigan DC. Medial Patellofemoral Ligament Reconstruction Technique Utilizing Patellar Suture Anchors and a Peroneus Longus Tendon Allograft. J Surg Orthop Adv. 2019 Fall;28(3):166-174. Available from: https://pubmed.ncbi.nlm.nih.gov/31675292/
10. Peter G, Hoser C, Runer A, Abermann E, Wierer G, Fink C. Medial patellofemoral ligament (MPFL) reconstruction using quadriceps tendon autograft provides good clinical, functional and patient-reported outcome measurements (PROM): a 2-year prospective study. Knee Surg Sports Traumatol Arthrosc. 2019 Aug;27(8):2426-2432. doi: 10.1007/s00167-018-5226-6. Available from: https://pubmed.ncbi.nlm.nih.gov/30374571/
11. Calvo Rodríguez R, Figueroa Poblete D, Anastasiadis Le Roy Z, Etchegaray Bascur F, Vaisman Burucker A, Calvo Mena R. Reconstruction of the medial patellofemoral ligament:

Evaluation of the clinical results of autografts versus allografts. Rev Esp Cir Ortop Traumatol. 2015 Sep-Oct;59(5):348-53. doi: 10.1016/j.recot.2014.10.006. Available from: https://pubmed.ncbi.nlm.nih.gov/25481698/
12. Flanigan DC, Shemory S, Lundy N, Stitgen M, Long JM, Magnussen RA. Medial patellofemoral ligament reconstruction with allograft versus autograft tissue results in similar recurrent dislocation risk and patient-reported outcomes. Knee Surg Sports Traumatol Arthrosc. 2020 Jul;28(7):2099-2104. doi: 10.1007/s00167-020-05920-x. Available from: https://pubmed.ncbi.nlm.nih.gov/32185451/
13. Nha KW, Bae JH, Hwang SC, et al. Medial patellofemoral ligament reconstruction using an autograft or allograft for patellar dislocation: a systematic review. Knee Surg Relat Res. 2019 Aug 23;31(1):8. doi: 10.1186/s43019-019-0008-0. Available from: https://pubmed.ncbi.nlm.nih.gov/32660535/
14. Hendawi T, Godshaw B, Flowers C, Stephens I, Haber L, Waldron S. Autograft vs Allograft Comparison in Pediatric Medial Patellofemoral Ligament Reconstruction. Ochsner J. 2019 Summer;19(2):96-101. doi: 10.31486/toj.18.0081. Available from: https://pubmed.ncbi.nlm.nih.gov/31258420/
15. Schöttle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. Am J Sports Med. 2007 May;35(5):801-4. doi: 10.1177/0363546506296415. Available from: https://pubmed.ncbi.nlm.nih.gov/17267773/
16. Chrintz H, Appelquist E, Falster O. Evaluering af kliniske menisktest [Evaluation of clinical tests in meniscal injuries]. Ugeskr Laeger. 1989 Sep 18;151(38):2431-2. Danish. Available from: https://pubmed.ncbi.nlm.nih.gov/2800017/
17. Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. Arthroscopy. 1993;9(2):159-63. doi: 10.1016/s0749-8063(05)80366-4. Available from: https://pubmed.ncbi.nlm.nih.gov/8461073/
18. Bouras T, U E, Brown A, Gallacher P, Barnett A. Isolated medial patellofemoral ligament reconstruction significantly improved quality of life in patients with recurrent patella dislocation. Knee Surg Sports Traumatol Arthrosc. 2019 Nov;27(11):3513-3517. doi: 10.1007/s00167-019-05447-w. Available from: https://pubmed.ncbi.nlm.nih.gov/30820603/
19. Biedert RM, Tscholl PM. Patella Alta: A Comprehensive Review of Current Knowledge. Am J Orthop (Belle Mead NJ). 2017 Nov/Dec;46(6):290-300. Available from: https://pubmed.ncbi.nlm.nih.gov/29309446/
20. Arendt EA, England K, Agel J, Tompkins MA. An analysis of knee anatomic imaging factors associated with primary lateral patellar dislocations. Knee Surg Sports Traumatol Arthrosc. 2017 Oct;25(10):3099-3107. doi: 10.1007/s00167-016-4117-y. Available from: https://pubmed.ncbi.nlm.nih.gov/27145773/
21. Goutallier D, Bernageau J, Lecudonnec B. Mesure de l'écart tubérosité tibiale antérieure - gorge de la trochlée (T.A.-G.T.). Technique. Résultats. Intérêt [The measurement of the tibial tuberosity. Patella groove distanced technique and results (author's transl)]. Rev Chir Orthop Reparatrice Appar Mot. 1978 Jul-Aug;64(5):423-8. French. Available from: https://pubmed.ncbi.nlm.nih.gov/152950/
22. Laurin CA, Dussault R, Levesque HP. The tangential x-ray investigation of the patellofemoral joint: x-ray technique, diagnostic criteria and their interpretation. Clin Orthop Relat Res. 1979 Oct;(144):16-26. Available from: https://pubmed.ncbi.nlm.nih.gov/535219/
23. Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. J Bone Joint Surg Am. 1974 Oct;56(7):1391-6. Available from: https://pubmed.ncbi.nlm.nih.gov/4433362/
24. Kujala UM, Osterman K, Kormano M, Komu M, Schlenzka D. Patellar motion analyzed by magnetic resonance imaging. Acta Orthop Scand, 1989, 60: 13–16. Available from: https://pubmed.ncbi.nlm.nih.gov/2929285/
25. Kazley JM, Banerjee S. Classifications in Brief: The Dejour Classification of Trochlear Dysplasia. Clin Orthop Relat Res. 2019 Oct;477(10):2380-2386. doi: 10.1097/CORR.0000000000000886. Available from: https://pubmed.ncbi.nlm.nih.gov/31393338/
26. Panni AS, Cerciello S, Maffulli N, Di Cesare M, Servien E, Neyret P. Patellar shape can be a predisposing factor in patellar instability. Knee Surg Sports Traumatol Arthrosc. 2011 Apr;19(4):663-70. doi: 10.1007/s00167-010-1329-4. Available from: https://pubmed.ncbi.nlm.nih.gov/21153544/
27. Tang H, Xu YQ, Zheng TE, et al. [Anatomical double bundle reconstruction of medial patellofemoral ligament with allograft tendon in the treatment of patellar dislocations]. Zhongguo Gu Shang. 2015 Mar;28(3):252-5. Chinese. Available from: https://pubmed.ncbi.nlm.nih.gov/25936196/
28. Van Eck CF, Kharrazi FD. Medial Patellofemoral Ligament Reconstruction Using Achilles Tendon Allograft With Bone Block. Arthrosc Tech. 2019 Sep 19;8(10):e1131-e1135. doi: 10.1016/j.eats.2019.05.029. Available from: https://pubmed.ncbi.nlm.nih.gov/31921586/
29. Marcheggiani Muccioli GM, Lullini G, Grassi A, et al. Good results are reported at 60-month follow-up after medial patello-femoral ligament reconstruction with fascia lata allograft for recurrent patellar dislocation. Knee Surg Sports Traumatol Arthrosc. 2021 Apr;29(4):1191-1196. doi: 10.1007/s00167-020-06142-x. Available from: https://pubmed.ncbi.nlm.nih.gov/32651802/
30. Boletín Oficial de la Junta de Andalucía, 27 de octubre de 2005, núm. 210, pp. 80 a 83. Available from: https://www.juntadeandalucia.es/boja/2005/210/
31. Biesert M, Johansson A, Kostogiannis I, Roberts D. Self-reported and performance-based outcomes following medial patellofemoral ligament reconstruction indicate successful improvements in knee stability after surgery despite remaining limitations in knee function. Knee Surg Sports Traumatol Arthrosc. 2020 Mar;28(3):934-940. doi: 10.1007/s00167-019-05570-8. Available from: https://pubmed.ncbi.nlm.nih.gov/31236635/
32. Ambrožič B, Novak S. The influence of medial patellofemoral ligament reconstruction on clinical results and sports activity level. Phys Sportsmed. 2016;44(2):133-40. doi: 10.1080/00913847.2016.1148561. Available from: https://pubmed.ncbi.nlm.nih.gov/26837237/
33. Yoon KH, Kim EJ, Kwon YB, Hwang IU, Kim SG. Comparison of Clinical and Radiological Outcomes Between Transosseous Tunnel and Suture Anchor Patellar Fixation for Medial Patellofemoral Ligament Reconstruction: A Cohort Study With 2-Year Follow-up. Orthop J Sports Med. 2020 May 5;8(5):2325967120917660. doi: 10.1177/2325967120917660. Available from: https://pubmed.ncbi.nlm.nih.gov/32490024/
34. Ye M, Zhang H, Liang Q. Clinical Outcomes After Medial Patellofemoral Ligament Reconstruction Using Transosseous Sutures Versus Suture Anchors: A Prospective Nonrandomized Controlled Trial. Orthop J Sports Med. 2020 May 4;8(5):2325967120917112. doi: 10.1177/2325967120917112. Available from: https://pubmed.ncbi.nlm.nih.gov/32490023/
35. Mohammed R, Hunt N, Gibbon AJ. Patellar complications in single versus double tunnel medial patellofemoral ligament reconstruction. J Orthop Surg (Hong Kong). 2017 Jan;25(1):2309499017691007. doi: 10.1177/2309499017691007. Available from: https://pubmed.ncbi.nlm.nih.gov/28228051/
36. Placella G, Speziali A, Sebastiani E, Morello S, Tei MM, Cerulli G. Biomechanical evaluation of medial patello-femoral ligament reconstruction: comparison between a double-bundle converging tunnels technique versus a single-bundle technique.

Musculoskelet Surg. 2016 Aug;100(2):103-7. doi: 10.1007/s12306-016-0397-0. Available from: https://pubmed.ncbi.nlm.nih.gov/26873710/
37. Deasey, M. J., Moran, T. E., Lesevic, M., Burnett, Z. R., & Diduch, D. R. (2020). Small, Short, Oblique Patellar Tunnels for Patellar Fixation Do Not Increase Fracture Risk or Complications in MPFL Reconstruction: A Retrospective Cohort Study. Orthopaedic journal of sports medicine, 8(10), 2325967120954430. https://doi.org/10.1177/2325967120954430
38. Zuo YX, Ma ZP. [Reconstruction of medial patellofemoral ligament with Tightrope button fixation on the femoral side for the treatment of traumatic patellar dislocation]. Zhongguo Gu Shang. 2017 Nov 25;30(11):1039-1042. doi: 10.3969/j.issn.1003-0034.2017.11.014. Chinese. Available from: https://pubmed.ncbi.nlm.nih.gov/29457397/
39. Lorbach O, Zumbansen N, Kieb M, et al. Medial Patellofemoral Ligament Reconstruction: Impact of Knee Flexion Angle During Graft Fixation on Dynamic Patellofemoral Contact Pressure-A Biomechanical Study. Arthroscopy. 2018 Apr;34(4):1072-1082. doi: 10.1016/j.arthro.2017.09.047. Available from: https://pubmed.ncbi.nlm.nih.gov/29305291/
40. Wang Q, Huang W, Cai D, Huang H. Biomechanical comparison of single- and double-bundle medial patellofemoral ligament reconstruction. J Orthop Surg Res. 2017 Feb 13;12(1):29. doi: 10.1186/s13018-017-0530-2. Available from: https://pubmed.ncbi.nlm.nih.gov/28193295/
41. Schiphouwer L, Rood A, Tigchelaar S, Koëter S. Complications of medial patellofemoral ligament reconstruction using two transverse patellar tunnels. Knee Surg Sports Traumatol Arthrosc. 2017 Jan;25(1):245-250. doi: 10.1007/s00167-016-4245-4. Available from: https://pubmed.ncbi.nlm.nih.gov/27405577/