Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-015-3934-8

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Clinical and radiological outcomes after a quasi-anatomical reconstruction of medial patellofemoral ligament with gracilis tendon autograft

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Received: 7 July 2015 / Accepted: 9 December 2015

Abstract
Purpose To analyse the clinical and radiological outcomes of a quasi-anatomical reconstruction of the medial patellofemoral ligament (MPFL) with a gracilis tendon autograft.
Methods Patients with objective recurrent patellar instability that were operated on from 2006 to 2012 were included. A quasi-anatomical surgical technique was performed using a gracilis tendon autograft. It was anatomically attached at the patella, and the adductor magnus tendon was also used as a pulley for femoral fixation (non-anatomical reconstruction). The IKDC, Kujala and Lysholm scores as well as Tegner and VAS for pain were collected preoperatively and at final follow-up. Radiographic measurements of patellar position tilt and signs of osteoarthritis (OA) as well as trochlear dysplasia were also recorded.
Results Thirty-six patients were included. The mean age at surgery was 25.6 years. After a minimum 27 months of follow-up, all functional scores significantly improved ($p < 0.001$) with respect to the preoperative values. The VAS dropped from 6 (SD 2.48) to 2 (SD 1.58). No recurrence of dislocation was observed in this series. The apprehension sign was still apparent in one patient. The CT scan evaluation showed a significant decrease in patellar tilt ($p < 0.001$). On the Crosby and Insall grading scale, there were no changes in the radiological signs of OA.
Conclusion This specific MPFL reconstruction gives good clinical results and corrects patellar tilt. It did not affect the patellofemoral surfaces at the short term, as shown by the absence of radiological signs of OA in the CT scan. The procedure has been shown to be safe and suitable for the treatment of chronic patellar instability, including in adolescents with open physis. A new effective, inexpensive and easy-to-perform technique is described to reconstruct MPFL in the daily clinical practice.
Level of evidence Therapeutic case series, Level IV.

Keywords Patella · Medial patellofemoral ligament reconstruction · Patella dislocation · Patellofemoral joint

Introduction

More than one hundred techniques for patella stabilization, including transference of the tibial tuberosity (TT), patellar lateral release, *vastus medialis obliquus* advancement, trochleoplasty and derotational osteotomies have been described [1, 15]. Although an "à la carte" plan based on reconstructing anatomical disorders has been advocated, a standard surgical technique to treat recurrent patella dislocations remains undetermined [12].

The medial patellofemoral ligament (MPFL) is the primary passive restraint in pathologic lateral translation of the patella [2, 7, 13]. Consequently, it tears when the patella dislocates laterally [10, 19, 30]. The efficacy of MPFL reconstruction in the control of lateral patellar instability has already been demonstrated, and therefore, its reconstruction is currently one of the most widely used surgical

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Published online: 24 December 2015

techniques for the treatment of chronic patellar instability [18, 29].

Several methods of MPFL reconstruction have been described. They vary in terms of graft choice, patellar and femoral fixation and graft tension at the time of fixation. In general, it is thought that a non-anatomical graft tends to over-constrain the patellofemoral (PF) joint [9, 16, 31]. Theoretically, this pressure results in the loss of knee motion and increases PF osteoarthritis (OA) [9]. Conversely, in a biomechanical laboratory study using cadaver knees, a non-anatomical femoral attachment point in the adductor tubercle did not alter the pressures on the PF joint in comparison with an anatomical attachment [16]. Then again, controversy persists relative to defining the optimal attachment points for the MPFL graft.

The main objective of this study was to analyse the clinical and radiological outcomes in a series of patients with chronic patellar instability after a quasi-anatomical MPFL reconstruction using a gracilis tendon autograft. The hypothesis was that this type of reconstruction for recurrent patellar dislocation would provide good outcomes and would not cause degeneration of the patellofemoral joint.

In the present study, a new easy-to-perform technique to reconstruct MPFL is described.

Materials and methods

A longitudinal descriptive study was performed. Patients with objective recurrent patellar instability that were operated on from 2006 to 2012 were included. A double-bundle MPFL reconstruction with *gracilis tendon* (GT) autograft was performed in all cases, and therefore, no control group was available.

The preoperative and final follow-up clinical evaluation and data on knee scales were recorded. It included the International Knee Documentation Committee (IKDC) form, Kujala score, Tegner activity level scale, Lysholm functional score and the Visual Analogue Scale (VAS) for pain.

Radiological assessment included radiographs as well as CT scan imaging before and after surgery. Patellar height (in accordance with the Caton-Deschamps index [6]) was studied by means of plain radiographs in a lateral view at 30° of flexion. Patellar tilt and TT–TG distance were analysed in a CT scan. Data on preoperative trochlear dysplasia (based on the Dejour classification [6]) were also recorded. Finally, radiological signs of OA were graded in accordance with the Crosby and Insall grading system (three grades: none to mild, moderate and severe) [4].

Functional as well as radiographic evaluations were carried out by two independent observers.

Data on complications and/or surgical reoperations were also documented.

Surgical technique

The homolateral GT autograft was always the graft of choice. The tendon was sized and stored in gauze soaked in vancomycin [22]. A 2-cm vertical skin incision was then made over the superior medial border of the patella to expose its proximal third. Two convergent drill holes (usually 4.5 mm in size) of approximately 10 mm depth are created leaving a bone bridge of 10 mm, obtaining a V-shaped tunnel (Fig. 1). Another 2- to 3-cm skin incision was made along the *adductor magnus* (AM) tendon slightly proximal to the medial femoral epicondyle. The tendon of the AM was identified and dissected so as to be used as a pulley for the graft (Fig. 1). The graft was then passed through the patella, then under the fascia and finally looped around the AM tendon back to the patella. The knee was cycled several times through full range of motion while keeping the graft under slight tension. Finally, both graft ends were sutured together at 30° of flexion with No. 0 high-resistance non-absorbable sutures. Tension was calculated on the basis that the patella could still be manually lateralized some 10 mm to avoid over-constraint. The lower limb was finally immobilized in a brace locked at full extension.

No lateral retinacular release was performed in the present series. Distal realignment was associated in cases of a preoperative TT–TG distance exceeding 20 mm. Patella lowering was concomitantly performed in those cases in which patella supera was observed, as defined by a Caton-Deschamps index of more than 1.2.

IRB approval

The study was approved by the local ethics committee (ICATME—Institut Universitari Dexeus, 2/2014).

Statistical analysis

Categorical variables are presented as frequencies and percentages. Mean and range (or the 25–75 percentiles) were calculated for each continuous variable.

The Wilcoxon test was used to compare the pre- and postoperative results of different knee tests. In other cases, the Chi-square test was used to compare the results of different groups of patients. No sample size calculation was performed because of the descriptive purpose of the present study without any control group. Statistical analysis was performed using the SPSS 19 (SPSS Inc., Chicago, Illinois, USA) statistical package. The significance level was set at $p < 0.05$.

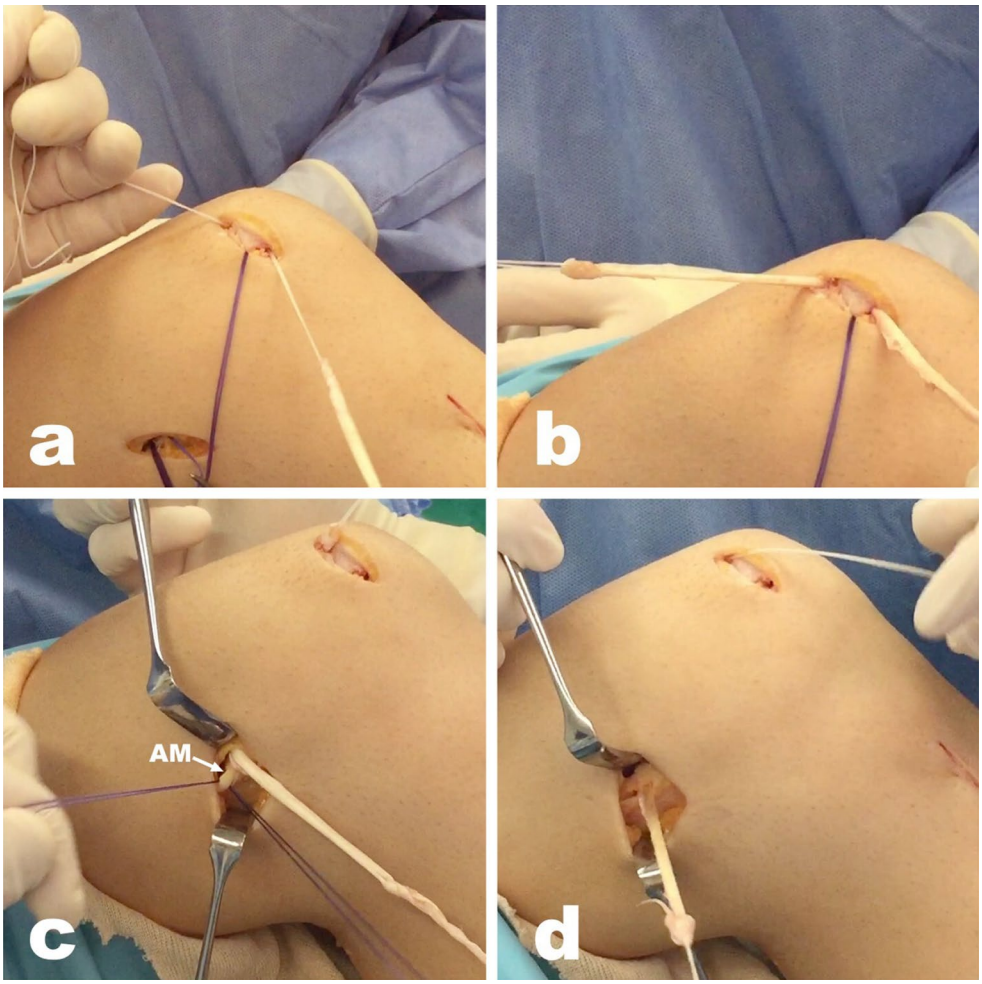

Fig. 1 Different steps of the surgical technique. **a** A *V*-shaped tunnel is drilled in the medial aspect of the patella; **b** the gracilis tendon is introduced in the patellar tunnel; **c** the adductor magnus (AM) tendon is identified; **d** the gracilis tendon is then looped around the AM tendon

Table 1 Differences between knee functional scores before and after surgery

Knee scale	Pre-op Med [P_{25}–P_{75}]	Post-op Med [P_{25}–P_{75}]	Change Med [P_{25}–P_{75}]	*p* value (*)
Lysholm	53 [41–65]	95 [85–99]	39 [20–50]	<0.001
Kujala	63 [49–70]	90 [79–98]	25 [22–37]	<0.001
IKDC	51 [39–72]	85 [78–96]	32 [20–41]	<0.001
Tegner	4 [3–4]	5 [3–7]	1 [0–3]	<0.001
VAS	6 [5–7]	2 [0–3]	5 [4–6] (neg.)	<0.001

(*) Assessed with the nonparametric Wilcoxon signed-rank test

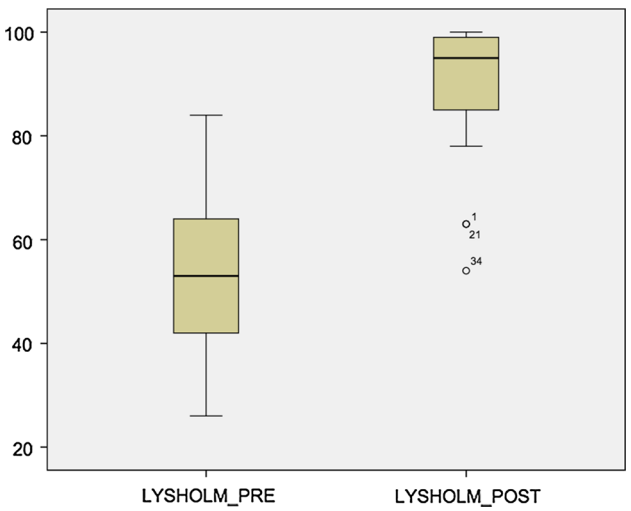

Fig. 2 Pre- and postoperative Lysholm scores ($p < 0.001$)

Results

Thirty-six knees (thirty-five patients) were included. No patient was lost during follow-up. The number of previous dislocations ranged from 3 to 15. The mean follow-up time

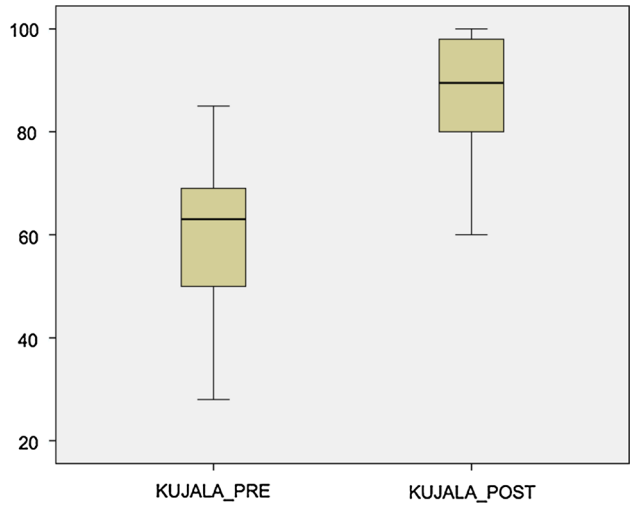

Fig. 3 Pre- and postoperative Kujala scores ($p < 0.001$)

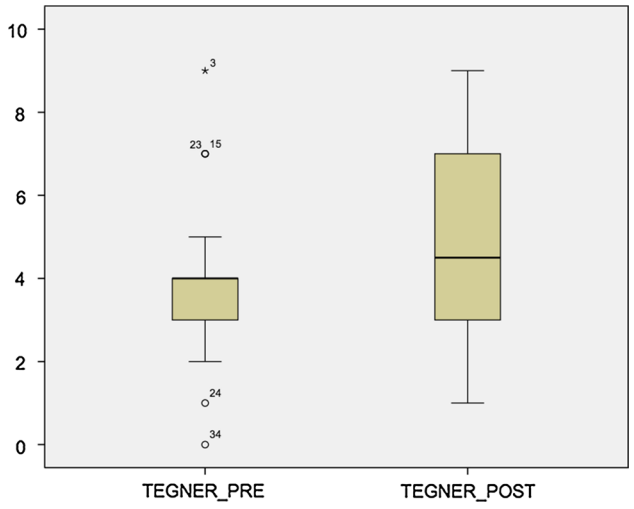

Fig. 5 Pre- and postoperative Tegner scores ($p < 0.001$)

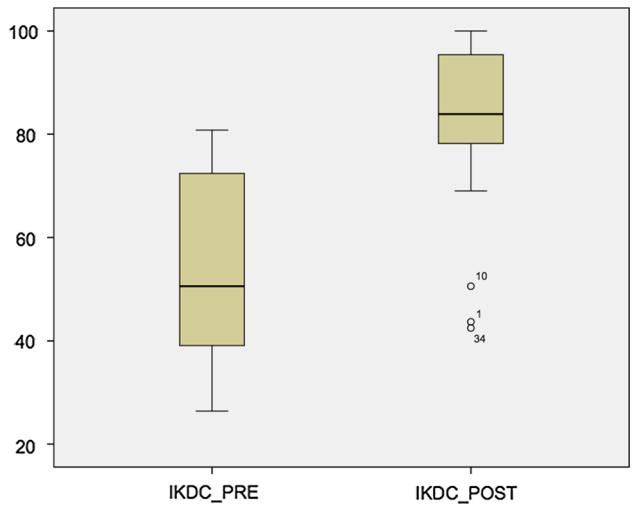

Fig. 4 Pre- and postoperative IKDC scores ($p < 0.001$)

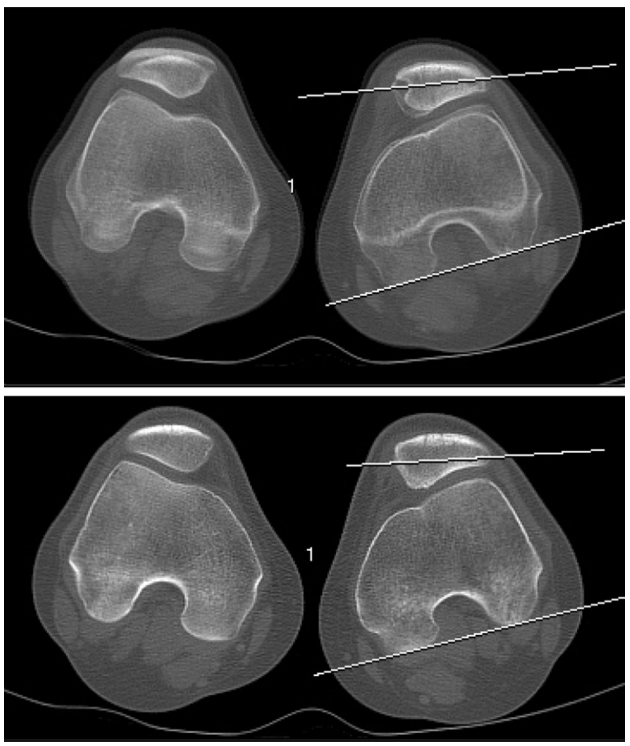

Fig. 6 Preoperative CT scan and final follow-up

was 37.6 months (SD 18.1 months). There were 19 female (52.8 %) and 17 male (47.2 %) patients with a mean age of 25.6 years (SD 9.4 years). The right side was involved in 23 (63.9 %) patients and the left in 13 (39.1 %) patients. The MPFL was solely reconstructed in 16 knees (44.4 %), while an associated distal realignment procedure was performed in 20 cases (55.6 %).

No patient experienced recurrent patellar dislocation in this series although one patient complained while having an apprehension test. All the functional scores showed a significant improvement (Table 1). The mean Lysholm, Kujala and IKDC scores improved significantly ($p < 0.001$) in all cases (Figs. 2, 3, 4). A significant improvement ($p < 0.001$) was also seen in the Tegner scale (Fig. 5). The preoperative VAS was a mean of 6 points (SD 2.5) and dropped to a mean of 2 points (SD 1.6) at final follow-up ($p < 0.001$).

No significant changes were found in patellar height. The mean preoperative Caton-Deschamps index was 1.2 (SD 0.2), while it was 1.1 (SD 0.1) at the last follow-up (n.s.). The average preoperative patellar tilt of 20.4° (SD 9.7°) improved to 14.9° (SD 8.0°) (Fig. 6) at the last follow-up ($p < 0.001$). The preoperative TT–TG distance of

Table 2 Differences between clinical outcomes in patients with isolated MPFL reconstruction versus MPFL reconstruction associated with other surgical procedures

Variable	Surgery	Pre-op Med [P_{25}–P_{75}]	Post-op Med [P_{25}–P_{75}]	Change Med [P_{25}–P_{75}]	*p* value (*)
Lysholm	LPFM (Alo)	56 [43–71]	95 [94–100]	40 [25–52]	n.s.
	LPFM + Otr.	52 [35–62]	93 [85–95]	39 [19–50]	
Kujala	LPFM (Alo)	64 [54–78]	90 [88–100]	26 [21–40]	n.s.
	LPFM + Otr.	62 [45–65]	89 [75–97]	25 [22–35]	
IKDC	LPFM (Alo)	52 [49–73]	91 [81–97]	31 [23–46]	n.s.
	LPFM + Otr.	51 [39–72]	80 [72–89]	32 [17–40]	
Tegner	LPFM (Alo)	4 [3–4]	6 [4–7]	1 [0–3]	n.s.
	LPFM + Otr.	4 [2–4]	4 [3–7]	1 [0–2]	
VAS	LPFM (Alo)	7 [4–7]	1 [0–2]	5 [4–6] (neg.)	n.s.
	LPFM + Otr.	6 [5–8]	2 [1–3]	5 [2–6] (neg.)	

(*) Assessed based on the change between groups with the nonparametric Mann–Whitney *U* test

16.6 mm (SD 5.1 mm) remained unchanged with a mean 15.2 mm (SD 5.2 mm) at the final follow-up evaluation (n.s.).

Using the Crosby and Insall [4] criteria, all the patients were graded as none to mild OA at the preoperative assessment. No radiological progression of PF OA was seen in any case at the final follow-up evaluation.

When comparing the clinical and radiological results in the isolated MPFL reconstructions or when this procedure was combined with bony distal realignment techniques, no differences were seen in any of the evaluated parameters (Table 2).

Few complications were observed in the present series. Two cases (5.8 %) showed reduced ROM (flexion deficit of 25°) during the rehabilitation period. Both of them were successfully treated. While full ROM was restored in one of the patients after mobilization under anaesthesia, the other patient required arthroscopic arthrolysis. Another patient with an associated distal realignment required hardware removal from the osteotomy site. These three patients (5.8 %) were the only cases that needed to return to the operating room for additional procedures. Six additional knees (16.7 %) developed a painless hypertrophic wound scar that was considered a minor complication. No patellar fractures were seen in this series.

Discussion

The most important finding of the present investigation is that postoperative patellar instability was not observed in any case. Additionally, all the functional scores improved. Regardless of the non-anatomical type of reconstruction, no signs of OA were observed, which suggests that no harm to the patellofemoral joint was caused, at least during this short-term follow-up period. Therefore, the hypothesis has been confirmed.

Despite the good results generally obtained with MPFL reconstruction, several surgical aspects are still controversial. Some authors have recommended the use of the semitendinous tendon as a graft to reconstruct the MPFL [5, 8, 24]. However, the GT was used in this study. The native MPFL was found to have a mean tensile strength of 208 N [17]. The mean maximum load for one strand of a GT was found to be 837 ± 138 N and two strands of the same tendon had approximately twice the strength and stiffness as one strand [11]. Therefore, the GT appears to be long and strong enough to duplicate MPFL function.

The location of the femoral attachment of the MPFL has been widely debated. According to some authors, the native femoral attachment is centred approximately 10 mm distal to the adductor tubercle [19, 20, 24]. The MPFL is a non-isometric ligament intended to restrain lateral patellar mobility. In cases of patella supera, further anisometry of the MPFL can arise, as has been recently shown [31]. Shifting the femoral attachment site more proximally will increase the distance between the attachment points of the ligament during flexion and increases its tension and, theoretically, will increase the force and pressure applied to the medial aspect of the patellofemoral joint [9]. In the current work, the AM tendon, which is proximal to the MPFL's original attachment, was used instead as a femoral attachment. Interestingly enough, no clinical signs of PF overload or radiological OA were observed during the follow-up period. Melegari et al. [16] conducted a biomechanical study using cadaveric knees with a non-anatomical femoral attachment point in the *adductor tubercle*. They also found no alterations in PF joint pressures when comparing this type of non-anatomical MPFL reconstruction to an anatomical MPFL reconstruction [16]. These non-anatomical reconstructions may exhibit quasi-isometric behaviour that prevents over-constraint of the patellofemoral joint as suggested by Panagopoulos et al. [21]. A possible explanation might be the very limited changes in length during

knee flexion from 0° to 90° seen in the MPFL, which was calculated to be of only 1.1 mm [28]. In addition, it might also be possible that the elastic nature of the adductor pulley may be able to adapt itself to a small potential length mismatch, which occurs throughout the knee's ROM [23].

Excellent results have often been reported at short- and mid-term follow-up, regardless of the type of MPFL reconstruction, even in the presence of degenerative conditions [3, 5, 8, 24, 25, 28, 29]. In the present series, the outcomes were also good in terms of the functional scores analysed, which favourably compares with the more anatomical types of reconstruction [14, 25, 27, 28]. In a recent review, Shah et al. [26] found an overall rate of complications after MPFL reconstruction of 26.1 %. More specifically, the percentage of patients with a recurrence of patellar instability was found to be 3.7 % of the 629 patients included in the review. Conversely, the complications reported with the current technique were lower than the aforementioned rates. The isolated case of apprehension and no cases of recurrence of dislocation and the considerably lower rate of reinterventions seen in the present study positively compare to the current results with those previously published works [3, 5, 26, 29].

Patellar tilt reflects the soft tissue imbalance associated with lateral patellar dislocation [9]. As a significant decrease in the patellar tilt was achieved with the proposed non-anatomical type of reconstruction, it is likely that the tension developed in the reconstructed MPFL positively influences the tilt moment as well as patellar tracking.

The surgical technique presented here showed some advantages. It is simple, safe, inexpensive and reproducible. It turns into a simple soft tissue procedure in which the femoral physeal plate is not affected as no tunnel needs to be drilled and no hardware to fix the graft to the bone needs to be used. Additionally, there is no need to use intraoperative fluoroscopy. This technique entered into use in 2005 in a short series of adolescents with symptomatic recurrent patellar instability. Following the good results obtained in this series of skeletally immature patients, it came to be indicated in adult patients.

The present investigation has several limitations. Although the design was prospective, this is a single surgeon work with the absence of a control group. The cohort may be considered small, and the follow-up is rather short, particularly in terms of PF OA. In addition, some patients included had not only a MPFL reconstruction but also a distal realignment procedure. However, this also made it possible observe the outcomes of surgical techniques performed concomitantly, which is something commonly seen in patellofemoral instability surgeries. Although no OA changes were observed in any case, a longer follow-up period is needed to better assess this specific outcome.

Patellar tilt improvement and the absence of clinical symptoms of medial patellar overload and signs of OA seem to prove that this procedure does not have any deleterious effect on the PF joint. Hence, it seems that the anatomical placement of the MPFL graft is not essential to the preservation of knee function after MPFL reconstruction.

The present technique might be of clinical relevance. This technique is easy to perform, safe and inexpensive. It is particularly useful in children and adolescents, as drilling holes near the femoral growth line are no longer needed.

Conclusion

This specific MPFL reconstruction gave good clinical results and corrected patellar tilt. It did not affect the patellofemoral surfaces at short term as shown by the absence of radiological signs of OA in the CT scan. The procedure has proven to be safe and adequate for the treatment of recurrent patellar instability, including in adolescents with an open physis.

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