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Femoral Tunnel Enlargement After Medial Patellofemoral Ligament Reconstruction

Prevalence, Risk Factors, and Clinical Effect

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Investigation performed at Hôpital de la Croix-Rousse, Lyon, France

Background: In recent years, significantly more attention has been focused on the role of the medial patellofemoral ligament (MPFL) in patellar stability, and MPFL reconstruction has become a mainstay of surgical treatment of episodic patellar dislocations. Although previously described in detail after reconstruction of the anterior cruciate ligament, tunnel enlargement has not been investigated after MPFL reconstruction.

Hypotheses: (1) Femoral tunnel enlargement occurs after MPFL reconstruction. (2) Patella alta, trochlear dysplasia, and tunnel malposition are risk factors for tunnel enlargement. (3) The presence of tunnel enlargement is not associated with recurrent dislocations or poorer patient-reported outcome scores after MPFL reconstruction.

Study Design: Case-control study; Level of evidence, 3.

Methods: Fifty-five of 59 knees treated for episodic patellar dislocations with MPFL reconstruction between 2005 and 2010 were evaluated at 1 year postoperatively for the presence of tunnel enlargement on lateral radiographs. Tunnel enlargement was defined as a tunnel area greater than 2 times that of the original tunnel. Knees with tunnel enlargement at 1 year were compared with those without tunnel enlargement. Patients were assessed for recurrent subluxations or dislocations at a mean of 3 years postoperatively, and patient-reported outcome scores were assessed in a subset of patients at a mean of 3.7 years postoperatively.

Results: Tunnel enlargement was noted in 23 knees (41.8%). No differences in patient age or body mass index were noted between the 2 groups. The mean patellar height was significantly higher in the enlarged tunnel group ($P = .03$). A higher prevalence of trochlear dysplasia or tunnel malposition was not demonstrated in the enlarged tunnel group. Patient-reported outcome scores and the risk of recurrent patellar instability were equal in the 2 groups.

Conclusion: Femoral tunnel enlargement after MPFL reconstruction is common, with patients with patella alta at an increased risk. The influence of tunnel malposition and trochlear dysplasia on this condition requires further research. Recurrent instability and patient-reported outcome scores are not affected by tunnel enlargement.

Keywords: medial patellofemoral ligament; reconstruction; tunnel enlargement; outcome; prevalence

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Cases of episodic patellar dislocations generally require surgical management to restore stability.¹ A variety of surgical procedures have been described, including those that address bony structures (trochleoplasty, tibial tubercle osteotomy) as well as procedures that address soft tissue restraints (medial patellofemoral ligament [MPFL] reconstruction, lateral release, vastus medialis plasty).¹ The classic approach to the management of episodic patellar dislocations includes a careful assessment of anatomic risk factors for recurrent dislocations, followed by a selection of the surgical procedure(s) to address the specific risk factors noted in each patient (the so-called menu à la carte).⁵

In recent years, significantly more attention has been focused on the role of the MPFL in preventing patellar

dislocations.¹⁰ The MPFL is taut near full knee extension, where it functions to resist lateral patellar translation. In higher degrees of flexion (beyond 20°-30°), the MPFL is lax, with bony congruence between the patella and trochlea contributing more to patellar stability.¹⁰ The MPFL is virtually always torn with patellar dislocations, and reconstruction of the MPFL has become a mainstay of surgical treatment of episodic patellar dislocations either in isolation or in combination with bony procedures.¹

The goal of MPFL reconstruction is to provide a medial restraint near knee extension while avoiding excessive tightening in flexion that could limit range of motion. While many techniques have been described, the use of an interference screw at the femoral attachment site is common in the majority of techniques.¹⁵

This technique is occasionally associated with enlargement of the femoral tunnel, which is evident on lateral radiographs. The prevalence, cause, and significance of this finding have not been described in the literature; however, the phenomenon has been extensively documented after anterior cruciate ligament (ACL) reconstruction.^{7-9,13,20} After ACL reconstruction, increased tunnel enlargement has been associated with earlier postoperative motion,⁷ the use of cortical fixation,⁹ increased force exerted on the bone tunnel by the graft,⁸ and tunnel malposition.^{13,20} It is unknown whether these same risk factors extend to MPFL reconstruction.

We hypothesized that (1) femoral tunnel enlargement would occur after MPFL reconstruction; (2) patella alta, trochlear dysplasia, and tunnel malposition would be risk factors for tunnel enlargement; and (3) the presence of tunnel enlargement would not be associated with recurrent dislocations or poorer patient-reported outcome scores after MPFL reconstruction.

MATERIALS AND METHODS

Patients

Between 2005 and 2010, 66 patients underwent MPFL reconstruction for episodic patellar dislocations at our institution. All patients had a positive patellar apprehension sign preoperatively. Eleven patients were excluded from this analysis because they were revision cases, cases in which an associated procedure other than a tibial tubercle osteotomy was performed, or cases in which patellar instability was secondary to a neurological cause. Of the remaining 55 patients, 4 underwent bilateral surgery, yielding 59 knees eligible for inclusion in the study. All data were obtained through chart review and telephone interviews. This study was exempt from institutional review board approval.

Preoperative Analysis

Demographic information including age, sex, and body mass index (BMI) was obtained for each patient. Preoperative anteroposterior (AP), lateral, and axial plain radiographs along with computed tomography (CT) scans in

full knee extension were obtained of each knee. Patellar height was assessed on lateral radiographs by determining the Caton-Deschamps index.² The CT scan of each knee was utilized to measure the tibial tubercle–trochlear groove distance⁶ and assess the degree of trochlear dysplasia according to the Dejour classification.⁴

Surgical Technique

Arthroscopic surgery was performed in each case to evaluate and treat associated cartilage injuries and evaluate patellar tracking. In knees in which the Caton-Deschamps index exceeded 1.2, tibial tubercle distalization was performed as described by Caton et al³ in the same operative session and before MPFL reconstruction to obtain a Caton-Deschamps index of 1.0. In cases in which the tibial tubercle–trochlear groove distance exceeded 20 mm, tibial tubercle medialization was performed according to the Elmslie-Trillat technique^{11,17} to obtain a tibial tubercle–trochlear groove distance of 12 mm.

Reconstruction of the MPFL then proceeded with a gracilis tendon autograft. The medial patella was exposed, and the appropriate layer deep to the medial retinaculum for graft placement was identified. In the proximal half of the patella, 2 tunnels, 4.5 mm in diameter, were created from the medial border to its anterior surface. A femoral socket, 7 mm in diameter and 25 to 30 mm in depth, was created between the adductor tubercle and medial epicondyle with fluoroscopic guidance. The gracilis graft was folded in half, pulled into the femoral tunnel, and secured with a 7-mm Habis bioabsorbable interference screw (Phusis, Saint-Ismier, France). The free ends of the graft were passed through the appropriate layer up to the patella. Each end was passed through one of the patellar tunnels and sutured to itself using a surgeon's knot backed up with 3 alternating half-hitches with the knee in 30° of flexion. Care was taken to avoid excessive tension on the graft, so the graft served as a checkrein to lateral patellar dislocations without hindering knee motion. The final construct is shown in Figure 1. Postoperatively, full range of motion was allowed immediately. Weightbearing was allowed immediately with a knee brace locked in extension and crutches for balance. The brace and crutches were discontinued upon sufficient recovery of quadriceps control and strength as determined by the physical therapist.

Postoperative Analysis

Patients were evaluated at 45 days, 6 months, and 1 year postoperatively and subsequently at variable times. At the 1-year postoperative visit, AP and lateral radiographs were obtained, and patellar apprehension was assessed by physical examination. The position and area of the femoral tunnel were measured on the lateral radiographs. Each femoral tunnel was classified as well positioned or malpositioned as described by Servien et al.¹⁴ Malpositioned tunnels were defined as those in which the center of the tunnel was located greater than 7 mm from the anatomic femoral origin of the MPFL as defined radiographically by Schottle et al.¹² At the last clinical visit, patients

Figure 1. (A) Anterior, (B) medial, and (C) axial drawings of a right knee after medial patellofemoral ligament reconstruction. Reproduced with permission from Demey G, Servien E, Debarge R, Lustig S, Ait Si Selmi T, Neyret P. Prise en charge actuelle des luxations episodiques de la rotule (place de la reconstruction du ligament femoro-patellaire medial). *Maitrise Orthopedique*. 2009;189. Available at: <http://www.maitrise-orthop.com/viewPage.do?id=1111>

were also questioned as to whether they had suffered ≥ 1 recurrent patellar dislocations or subluxations and whether they had undergone repeat ipsilateral knee surgery. Subjective International Knee Documentation Committee (IKDC) scores were obtained in some patients at their final follow-up visits, but this was not consistently done. Efforts were made to contact the remaining patients to complete the subjective IKDC questionnaire by telephone.

The area of the femoral tunnel was measured on lateral radiographs obtained at 1 year postoperatively using a picture archiving and communication system (PACS) digital viewer with markup tools. Two measurements were taken of each tunnel: the radius of the tunnel measured parallel to the axis of the femoral diaphysis and the radius of the tunnel measured perpendicular to the axis of the femoral diaphysis (Figure 2). The area of the tunnel was then calculated by multiplying the 2 radii together and multiplying by π (3.14). Tunnel enlargement was defined as any tunnel with an area greater than 2 times the original area of the tunnel. The original tunnel area was calculated as the original radius (3.5 mm) squared and multiplied by π (original area = 38.5 mm²). Thus, any tunnel with an area greater than 77 mm² was classified as enlarged.

Statistical Analysis

After each tunnel's classification as normal or enlarged, characteristics of the 2 groups of tunnels were compared. Continuous variables (patient age, BMI, and patellar height) were compared using unpaired *t* tests. Categorical variables (patient sex, trochlear dysplasia type, and prevalence of associated tibial tubercle osteotomy) were

Figure 2. Lateral radiograph of a knee 1 year after medial patellofemoral ligament reconstruction, demonstrating the technique for measurement of the tunnel size. The radius of the tunnel was measured both parallel (solid black line) and perpendicular (dashed black line) to the long axis of the femur (marked with a long, thin black line). The 2 radii were multiplied together and then by 3.14 to obtain the tunnel's cross-sectional area.

compared using the Fisher exact test. Statistical significance was defined as $P \leq .05$.

RESULTS

Of the 55 patients eligible for inclusion, 4 who underwent unilateral procedures were lost to follow-up. One-year radiographic follow-up was thus available for 55 of 59 knees (93.2%). The same 55 knees (93.2%) were available for clinical follow-up at a mean of 3.0 years (range, 1.0-6.0 years) after reconstruction. Patient-reported outcome scores (subjective IKDC) were available in 60% of knees at a mean of 3.7 years (range, 1.8-6.0 years) after reconstruction. The series included 37 women and 14 men and 26 left knees and 29 right knees. The mean age at surgery was 24.2 years, and the mean BMI was 22.5 kg/m². Patella alta (Caton-Deschamps index >1.2) was noted in 21 knees (38.2%). Trochlear dysplasia was noted in 52 knees (94.5%) and was distributed as the following: 14 type A, 22 type B,

TABLE 1
Comparison of Patients by Tunnel Enlargement^a

	No Tunnel Enlargement (n = 32)	Tunnel Enlargement (n = 23)	P Value
BMI, mean $\pm$ SD, kg/m ²	21.8 $\pm$ 2.3	23.2 $\pm$ 4.2	.12
Age, mean $\pm$ SD, y	24.5 $\pm$ 9.7	24.4 $\pm$ 8.0	.97
Trochlear dysplasia, %			.14
None	6.2	4.3	
Type A	34.3	13.0	
Type B	37.5	43.5	
Type C	21.8	26.1	
Type D	0	13.0	
Patella alta present (C-D index >1.2), %	28.2	52.2	.09
C-D index, mean $\pm$ SD	1.08 $\pm$ 0.15	1.17 $\pm$ 0.19	.03
Femoral tunnel malpositioned, %	34.4	43.5	.58
Increased TT-TG distance (at least 20 mm), %	9.4	8.7	.69
TT-TG distance, mean $\pm$ SD, mm	15.4 $\pm$ 6.1	16.2 $\pm$ 3.5	.57
TTO performed, %	21.9	39.1	.23
Recurrent subluxation, n (%)	1 (6.2)	1 (4.3)	1.0
Recurrent dislocation, n (%)	1 (3.1)	0	1.0
Subjective IKDC score, ^b mean $\pm$ SD	83.0 $\pm$ 17.4	82.6 $\pm$ 14.6	.93

^aBMI, body mass index; C-D, Caton-Deschamps; IKDC, International Knee Documentation Committee; TTO, tibial tubercle osteotomy; TT-TG, tibial tubercle–trochlear groove. Bolded *P* value indicates significance.

^bIKDC scores were available for 33 of 55 patients (60%).

13 type C, and 3 type D. Isolated MPFL reconstructions were performed in 39 knees (70.9%), while MPFL reconstructions and associated tibial tubercle transfers were performed in the remaining 16 knees (29.1%). Overall, 21 tunnels (38.2%) were noted to be malpositioned.

Tunnel enlargement was noted in 23 knees (41.8%) at 1 year postoperatively. The mean cross-sectional area of the tunnel in the nonenlarged group was 57.9 ± 11.5 mm² (range, 38.5–75.4 mm²) as compared with 105.0 ± 20.4 mm² (range, 78.5–153.9 mm²) in the enlarged group ($P < .001$). No differences in patient age or BMI were noted between the 2 groups. The distributions of patella alta and trochlear dysplasia in the 2 groups are reported in Table 1. The mean patellar height was significantly higher in the enlarged tunnel group (1.17) than in the nonenlarged group (1.08) ($P = .03$). A higher prevalence of trochlear dysplasia or tunnel malposition was not demonstrated in the enlarged tunnel group. The prevalence of an increased tibial tubercle–trochlear groove distance and performance of tibial tubercle osteotomy were not different between the 2 groups. There was no difference in the risk of a positive patellar apprehension test result or recurrent dislocations between the 2 groups at a mean of 3 years postoperatively (range, 1–6 years). No significant difference in subjective IKDC scores was noted between the enlarged group (82.6) and the nonenlarged group (83.0) ($P = .93$).

DISCUSSION

The most important findings of this study are that while femoral tunnel enlargement is seen in over 40% of patients treated with MPFL reconstruction with an absorbable interference screw, clinical results are not adversely affected at 3 years postoperatively. No recurrent

dislocations were noted in the group either with or without tunnel enlargement, and the risk of recurrent subluxations was equal between the 2 groups.

Increased patellar height (more proximal patellar position) was associated with an increased risk of tunnel enlargement. While this study does not provide evidence as to the reason for this association, there are several potential causes. First, it is possible that patients with patella alta put more stress on the reconstructed MPFL, potentially causing micromotion of the graft and screw and subsequent tunnel enlargement. Previous studies have demonstrated that patella alta is associated with an increased risk of recurrent dislocations after MPFL reconstruction.¹⁶ Another possibility is that the presence of patella alta leads to increased graft anisometry, again potentially placing more stress on the graft and leading to tunnel enlargement. However, the finding was present in spite of concurrent distalization of the tibial tubercle, which could mitigate this effect. More research into possible causes for this association is needed. Under this theory, tunnel malpositioning would also be expected to correlate with tunnel enlargement. The results did not demonstrate this finding, but the study is underpowered to detect such a difference.

The concurrent performance of tibial tubercle osteotomy was not associated with an increased risk of tunnel enlargement, but again, the study is underpowered to detect such a difference. The study lacks sufficient numbers to assess whether the performance of tibial tubercle distalization mitigates the increased risk of tunnel enlargement in cases of patella alta.

Other limitations exist in the current study. First, the length of radiographic follow-up was only 1 year. It is unknown whether tunnel enlargement will continue beyond this time or if existing tunnel enlargement could

become symptomatic with the passage of time. However, clinical follow-up of over 3 years revealed no clinical differences in the recurrence risk or, when available, IKDC scores between the enlarged and nonenlarged groups. In addition, tunnel enlargement was defined rather arbitrarily as twice the original diameter of the tunnel. It is unknown at what point tunnel enlargement becomes clinically significant. Further, the prevalence of tunnel enlargement is likely related to the choice of interference screw utilized in the femur. The use of an absorbable screw may contribute to this risk. Use of such screws also precludes an analysis of screw divergence that may contribute to tunnel widening. Further studies utilizing different hardware are required to determine how generalizable the findings of this study are. The study lacks sufficient power to detect the effect of tunnel malpositioning on tunnel enlargement or to break down the effects of malpositioning in different directions. Further, the causes of tunnel malpositioning in the series are unknown. Finally, plain radiographs rather than CT was used to assess tunnel enlargement. The accuracy and reproducibility of this technique have not been formally examined for MPFL tunnels but have been confirmed when evaluating femoral tunnels for ACL reconstruction, especially when assessing large changes in tunnel size.^{18,19}

CONCLUSION

Femoral tunnel enlargement after MPFL reconstruction is common. Patients with patella alta are at an increased risk for tunnel enlargement. The influence of tunnel malpositioning and trochlear dysplasia on this condition requires further research. The risk of recurrent instability at 1 year is not affected by tunnel enlargement.

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