Original article

Medial patellofemoral ligament reconstruction: Clinical and radiographic results in a series of 90 cases

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\begin{abstract}
Introduction: Among the numerous techniques available, medial patellofemoral ligament (MPFL) reconstruction is increasingly used for the surgical treatment of objective patellar instability. The main objective of the present study was to assess efficacy in preventing recurrence of patellar dislocation and in correcting radiographic patellar tilt. The study hypothesis was that MPFL reconstruction, isolated or with associated bone surgery, by restoring “favorable” graft anisometry, provides a good trade-off between patellar stability and absence of postoperative stiffness.

Materials and methods: Eighty-seven patients (90 reconstructions) presenting with objective patellar instability were prospectively included. The standardized procedure comprised MPFL reconstruction using the gracilis tendon. Femoral fixation used an interference screw in a blind tunnel between the adductor magnus tubercle and the medial epicondyly; patellar fixation used 2 anchors. Complementary distal bone graft was associated in 21 patients due to a preoperative tibial tubercle-trochlear groove (TT-TG) distance exceeding 20 mm or to patella alta. Functional IKDC and Kujala scores and radiographic measurement of patellar tilt and femoral tunnel position were assessed preoperatively and at end of follow-up.

Results: Mean follow-up was 24.3 months (range, 6–49 months). Three patients showed recurrence of patellar dislocation. Mean Kujala score rose from 53.88 preoperatively to 86.24 postoperatively, and mean real IKDC score from 45.15 to 73.92 (P<0.001). Patellar tilt decreased significantly between pre- and postoperative X-ray (P<0.001).

Discussion: MPFL gracilis reconstruction provides good clinical results and good radiologic correction of patellar tilt, making it a technique of choice in the treatment of objective patellar instability.

Level of evidence: Level IV. Retrospective case series study.

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\end{abstract}

1. Introduction

The medial patellofemoral ligament (MPFL) is the primary stabilizer of lateral patellar translation and is the structure most frequently affected by patellar dislocation [1–3]. Numerous repair techniques have been described, using a variety of transplants and fixation methods [4]. These studies concerned small series, but reported good clinical results, especially in the short term. No one technique emerges as better than the others, and larger series with longer follow-up are needed [4–6]. The technique described here is founded on anatomic and biomechanical requirements emerging from previous cadaver studies [7].

The principal objective of the present study was to assess the efficacy of MPFL reconstruction in preventing recurrence of patellar dislocation; the secondary objectives were to assess efficacy in terms of symptoms associated with patellofemoral instability and of radiologic correction of patellar tilt.

The hypothesis was that restoring favorable graft anisometry, with tension peaking at 30° knee flexion and relaxing in extension, would achieve a good trade-off between patellar stability and absence of postoperative stiffness [8,9].

2. Material and methods

2.1. Population

The continuous prospective multi-surgeon study included all patients receiving MPFL gracilis reconstruction between December...
2007 and June 2013, whether or not associated to bone surgery. Indication for surgery was at least 1 episode or radiologic sequela of confirmed patellar dislocation.

2.2. Surgical technique

The femoral fixation point was located from the native MPFL insertion as determined on cadaver studies [10,11]: 10 mm distally to the adductor magnus tubercle and 10 mm behind the medial femoral condyle (Fig. 1).

Patellar fixation used 2 resorbable anchors; femoral fixation used an interference screw.

Graft tension was adjusted by simply positioning the transplant without traction with the knee in 30° flexion [10,12].

Following the algorithm drawn up by Servien et al. [13], complementary tibial tunnel (TT) medialization bone surgery was associated if the tibial tubercle-trochlear groove (TT-TG) distance exceeded 20 mm. TT lowering was only performed in case of severe patella alta (Caton-Deschamps index > 1.60 for TT lowering without medialization or > 1.40 with medialization).

Trochlear and patellar dysplasia was ignored; no trochlear or patellar bone surgery was performed.

2.3. Clinical and radiological assessment

Clinical and functional assessment of the knee was performed preoperatively and at end of follow-up on two subjective scores: International Knee Documentation Committee (IKDC) and Kujala scores [14]. Range of motion and patellar tracking were assessed. Apprehension of patellar dislocation on Smillie test and recurrence of dislocation were recorded.

Radiologic assessment was performed preoperatively and at 6 months. Patellar height and tilt (Laurin angle, Merchant angle, Maldague classification) were assessed on plain X-ray [15]. Femoral tunnel position was assessed on the criteria formulated by Schöttle et al. [16]. TT-TG distance was measured on preoperative CT scan.

2.4. Statistical analysis

Data were entered on a secure Microsoft Excel® spreadsheet (Microsoft Corp., Redmond, WA, USA) and analyzed on SAS®
software (Statistical Analysis System, SAS Institute, Cary, NC, USA). The significance threshold was set at P<0.01. Pre- versus postoperative qualitative variables were compared on Chi² test, or Fisher exact test as appropriate, and quantitative variables on Student t-test, comparing mean differences against zero.

3. Results

3.1. Study population

Eighty-seven patients receiving MPFL gracilis reconstruction were included. Three patients had bilateral procedures. There was no loss to follow-up.

Mean age was 22.7 years (range, 11–38 years). Etiology was traumatic in 47 cases and non-traumatic in 43. Mean follow-up was 24.3 months (range, 6–49 months). Mean interval between primary dislocation and surgery was 70 months (range, 1–363 months). Twenty-one patients received medialization of the TT, 3 of which associated to lowering; only 1 patient underwent lowering of the TT without medialization.

3.2. Clinical results

Three patients showed recurrence of patellar dislocation, all 3 due to iterative high-energy trauma: 2 road accidents and 1 3-meter fall (Table 1).

IKDC and Kujala scores improved significantly from preoperative values to end of follow-up (P<0.001).

At end of follow-up, 5 patients showed persistent quadriceps atrophy at 1 year. Six showed stiffness in flexion, including 1 requiring surgical revision. Mean flexion was unchanged (P=0.71).

Twenty-eight of the 31 patients with initial joint effusion had no swelling at end of follow-up (P<0.001). Eighty-two patients had positive Smillie apprehension tests preoperatively, and none postoperatively.

3.3. Radiologic results

Mean patellar height on Caton-Deschamps index was 1.14 (range, 0.81–1.64) preoperatively versus 1.10 (0.79–1.52) at end of follow-up (P=0.007). In all 4 cases with TT lowering, Caton-Deschamps index showed correction. Patellar tilt decreased significantly between pre- and postoperative values (P<0.001), whether assessed as Laurin and Merchant angles (Table 2) or on the Maldague classification (P<0.001) (Fig. 2), and worsened in no cases.

On the Schöttle criteria, 72 femoral tunnels were well-positioned, 1 was proximal, 12 anterior, 1 anterior and distal and 3 anterior and proximal, the last 3 causing stiffness in flexion.

Table 1 Pre- and postoperative functional scores.

<table>
<thead>
<tr>
<th>Score</th>
<th>Preoperative</th>
<th>End of FU</th>
<th>Difference</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean raw IKDC</td>
<td>57.28</td>
<td>82.31</td>
<td>+25.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean real IKDC</td>
<td>45.15</td>
<td>73.92</td>
<td>+28.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean Kujala</td>
<td>53.88</td>
<td>86.24</td>
<td>+32.36</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

IKDC: International Knee Documentation Committee; FU: follow up.

Table 2 Radiologic assessment of patellar tilt.

<table>
<thead>
<tr>
<th>Angle</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Difference</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Laurin</td>
<td>3.30 [-6, 16]</td>
<td>-0.5 [-8, 10]</td>
<td>-3.80</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean Merchant</td>
<td>12.79 [-4, 28]</td>
<td>3.37 [-16, 18]</td>
<td>-9.42</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

3.4. Complications and surgical revision

There were no intraoperative complications. One patient showed deep venous thrombosis of the groin fold, and 3 showed type-1 complex regional pain syndrome.

Eight revision surgeries were performed. The 3 patients with recurrence of patellar dislocation underwent repeat MPFL reconstruction using the semitendinosus, and were free of further recurrence at last follow-up. One case of stiffness in flexion, due to poor femoral tunnel positioning, was fully corrected by arthroscopic arthrolysis with medial structure release. Two patients had iatrogenic pain caused by protruding patellar anchors; these were ablated at 10 months, relieving pain without recurrent dislocation. One patient underwent revision of a painful chloïd scar. One tibial tubercle fracture after medialization of the TT required osteosynthesis.

4. Discussion

With low recurrence rate, significant functional improvement, low complications rate and radiologic correction of patellar tilt, the present results match those of the literature (Table 3).

Radiologic analysis demonstrated correction of patellar tilt, but which in many cases was incomplete. This defect did not correlate with recurrence of dislocation and may, as Beck et al. argue, prevent medial femoropatellar compartment hyperpressure [26]. Patellar tilt correction is hard to determine from plain radiographs: CT analysis would be better adapted.

The principle of the technique lay in respecting native MPFL function. To reproduce the physiological balance between patellar stability and knee mobility, favorable graft anisometry, as defined by Servien et al. [13] and Thaunat and Erasmus [8], was sought, taking several parameters into account.

Femoral tunnel positioning should be as anatomic as possible. Despite improved knowledge of native MPFL anatomy and the radiologic landmarks defined by Schöttle, this remains a tricky step [10,16]. The impact of non-anatomic tunnel positioning is variable according to the literature (Table 4). The present series included 3 cases of stiffness in flexion, 1 of which required surgical revision. In all 3 cases, excessively proximal or anterior femoral tunnel positioning was implicated. However, the other positioning defects (in 21% of tunnels) in the present series were not associated with unfavorable clinical results.

To reproduce anatomic femoral insertion, femoral fixation must be solid. Techniques involving dynamic plastic using quadriceps [30] or adductor magnus tendon [31], and thus not respecting MPFL insertion anatomy, are associated with higher recurrence rates. In the present series, with femoral fixation by interference screw, as...
Table 3
Literature Review.

<table>
<thead>
<tr>
<th>Authors</th>
<th>n</th>
<th>Mean FU (mo)</th>
<th>Graft</th>
<th>Femoral fixation</th>
<th>Patellar fixation</th>
<th>Postop Kujala</th>
<th>Recurrence of dislocation</th>
<th>Stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Csintalan et al. [17]</td>
<td>56</td>
<td>51.6</td>
<td>Gra</td>
<td>Interference screw</td>
<td>Tunnel</td>
<td>Abs</td>
<td>Abs</td>
<td></td>
</tr>
<tr>
<td>Schottle et al. [18]</td>
<td>15</td>
<td>47.5</td>
<td>ST</td>
<td>Interference screw</td>
<td>2 anchors</td>
<td>85.67</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Thaunat et al. [19]</td>
<td>23</td>
<td>28</td>
<td>Gra</td>
<td>Anchors</td>
<td>Tunnel</td>
<td>93</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Matthews and Schranz [20]</td>
<td>25</td>
<td>31</td>
<td>Gra-ST</td>
<td>Interference screw</td>
<td>Tunnel</td>
<td>87</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Christiansen et al. [21]</td>
<td>44</td>
<td>22</td>
<td>Gra</td>
<td>Interference screw</td>
<td>Tunnel</td>
<td>84</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nomura and Inoue [22]</td>
<td>27</td>
<td>72</td>
<td>Artificial ligament</td>
<td>Staple</td>
<td>Tunnel</td>
<td>Abs</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Howells et al. [23]</td>
<td>211</td>
<td>16</td>
<td>ST</td>
<td>Endobutton</td>
<td>Tunnel</td>
<td>81.69</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Deit et al. [24]</td>
<td>46</td>
<td>114</td>
<td>ST</td>
<td>Passage in MCL</td>
<td>Tunnel</td>
<td>93</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chassaing and Trémoulet  [25]</td>
<td>145</td>
<td>20</td>
<td>Gra</td>
<td>Hooking of medial patellar wing</td>
<td>Interference screw</td>
<td>2 anchors</td>
<td>86.24</td>
<td>3</td>
</tr>
</tbody>
</table>

MPFL: medial patellofemoral ligament; ST: semitendinosus; Gra: gracilis; MCL: medial collateral ligament; abs: absent; Postop: postoperative; FU: follow-up; mo: month.

Table 4
Incidence of femoral tunnel positioning defect.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Positioning defect</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stephen et al. [27]</td>
<td>Frontal</td>
<td>Altered graft isometry</td>
</tr>
<tr>
<td>Anteroposterior</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Bicos et al. [28]</td>
<td>Too proximal</td>
<td>Medial patellofemoral compartment hyperpressure</td>
</tr>
<tr>
<td>Too distal</td>
<td>Excessive graft tension in extension</td>
<td></td>
</tr>
<tr>
<td>Elias and Cosgarea [29]</td>
<td>Too anterior</td>
<td>Medial patellofemoral compartment hyperpressure</td>
</tr>
<tr>
<td>Present series</td>
<td>Too anterior and proximal</td>
<td>Stiffness in flexion</td>
</tr>
</tbody>
</table>

in the series of Fithian et al. [17] and Schottle et al. [32], there were no cases of disinsertion or screw-related pain.

Patellar fixation used 2 resorbable anchors, following Schottle et al. [32]. Despite Mountney et al. [33] and Amis et al.'s [3] findings of stronger patellar fixation with patellar tunnels, in the present series there were no cases of postoperative breakage. Anchors avoid the non-negligible risk of weakening or even fracturing the patella associated with patellar tunnels [8].

Concerning graft tension, we followed Teitge and Torga-Spak [12] in positioning the graft and adjusting tension in 30° flexion. To minimize tension, it is preferable to simply position the graft, with the knee in 30° flexion. Elias and Melegari et al. demonstrated that tension exceeding 10 N can induce pain, stiffness and early medial patellofemoral osteoarthritis [27,29,34].

5. Conclusion

In the light of the present good long-term clinical results with good correction of patellar tilt, MPFL reconstruction founded on the biomechanical principle of favorable anisometry and effective fixation techniques is an attitude of choice in the management of objective patellar instability.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References
