Original article

Sulcus deepening trochleoplasty for patellofemoral instability: A series of 34 cases after 15 years postoperative follow-up

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A R T I C L E   I N F O

Article history:
Received 8 April 2014
Accepted 26 January 2015

Keywords:
Trochleoplasty
Patellofemoral instability
Trochlear dysplasia

A B S T R A C T

Introduction: Trochlear dysplasia is one of the main elements of patellofemoral instability. Although correction by trochleoplasty seems logical, the long-term outcome of this procedure is unknown and the progression to osteoarthritis has not been clarified. Thus, we performed a retrospective study of a series of sulcus deepening trochleoplasties with a 15-year follow-up whose goal was to (1) evaluate the long-term clinical outcome and radiological rate of osteoarthritis, and (2) define the results in relation to the type of instability and the grade of dysplasia.

Hypothesis: Sulcus deepening trochleoplasty is an effective procedure to stabilize the patellofemoral joint that does not increase the risk of osteoarthritis.

Patients and methods: This retrospective study analyzed 34 sulcus deepening trochleoplasties based on clinical scores (IKS, Lille, Kujala and Oxford scores) and radiological results (stage of osteoarthritis according to the Iwano score) after a mean follow-up of 15 years (12–19 years). An Insall procedure was systematically associated with an anterior tibial tubercle transfer in 17 cases (7 prior tibial transfers).

Results: No recurrent objective instability was observed. Seven knees had additional surgery after a mean follow-up of 7 years (2–16): 7 underwent conversion to total knee arthroplasty because of progression of osteoarthritis and one knee had tibial tubercle transfer for pain and episodes of the knee giving way. The mean Lille, Kujala and IKS scores increased from 53.3 (30–92) to 75 (25–95) to 61.5 (25–93), 76 (51–94) and 152.4 (66–200) respectively between preoperative and follow-up assessment (P<0.05) (revisions included). Functional outcome was significantly better for dysplasia with supratrochlear spurs (IKS score 168 [127–200] versus 153 [98–198] and Kujala score 81.5 [51–98] versus 76 [51–94] (P<0.05). Patients were satisfied in 65% of the cases and the total mean Oxford score was 24.1/60 (12–49 points). Occasional pain was present in 53% of the cases. The trochlear prominence decreased from 49 mm (3–9 mm) to −1.2 mm (−7–4 mm). Ten cases of preoperative patellofemoral osteoarthritis were identified, but none with > Iwano 2, while osteoarthritis was present in 33/34 cases at the final follow-up with 20 cases > Iwano 2 (65%).

Discussion: Sulcus deepening trochleoplasty corrects patellofemoral stability even in patients with severe dysplasia and the long-term functional outcome is better in this group. It does not prevent patellofemoral osteoarthritis. It should be limited to severe dysplasia with supratrochlear spurs and associated with procedures to realign the extensor apparatus.

Level of evidence: IV, retrospective cohort study.

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1. Introduction

Patellofemoral instability was described by Henri Dejour who identified trochlear dysplasia as the fundamental element of this disease. [1,2]. To correct this anomaly, trochleoplasties have been described by bone graft wedge by Albee [3]; then sulcus deepening trochleoplasty, which was introduced by Masse and Dejour [4,5]. Sulcus deepening trochleoplasty includes an osteotomy of the
two femoral condyles to deepen the trochlea. Other authors have proposed a trochleoplasty that remodels the subchondral bone to recreate the trochlear groove [6,7], while others have described an arthroscopic procedure [8]. Finally, Goutallier et al. [9] described a recession wedge trochleoplasty whose results were published by Thaunat et al. [10]. The postoperative progression of osteoarthritis and the functional outcome following trochleoplasties have not been clarified in any long-term studies, in particular in relation to the severity of dysplasia, as no studies have been published with a mean postoperative follow-up of more than 10 years. The goal of this retrospective study of a series of sulcus deepening trochleoplasties after a follow-up of 15 years was (1) to evaluate the clinical and radiological outcome, in particular the rate of osteoarthritis, and (2) to define the results in relation to the type of instability and the grade of dysplasia. The hypothesis was that sulcus deepening trochleoplasty effectively restored patellofemoral stability without increasing the risk of osteoarthritis.

2. Materials and methods

2.1. Patients

This retrospective study evaluated a consecutive single-surgeon (FG) series of sulcus deepening trochleoplasties performed between 1992 and 1998. Patients were included who presented with objective (patellofemoral dislocations) or subjective (apprehension without dislocation) patellofemoral instability associated with trochlear dysplasia according to Dejour and Lecoultre [11]. Exclusion criteria included adolescents with open growth plates, painful patellar syndromes without clinical instability, and Iwano et al.’s stage ≥ 2 patellofemoral osteoarthritis [12]. Forty-five consecutive patients were operated on by sulcus deepening trochleoplasty. Eleven patients were lost to follow-up and 34 patients were seen at the final follow-up and evaluated by the same surgeon after a mean 15.3 years (12–19 years) (Table 1). Thirteen patients presented with a history of knee surgery including 7 tibial tubercle transfers, 3 lateral retinacular resections, 5 cases of arthroscopic lavage and one ablation of an intra-articular foreign body by open surgery.

The preoperative radiological work-up included 19 cases of dysplasia with supratrochlear spurs (grades B and D), 15 cases of dysplasia without spurs (grades A and C) and 10 knees with Iwano stage 1 osteoarthritis [12] (Fig. 1).

2.2. Surgical technique

Sulcus deepening trochleoplasty was performed according to Masse [4], to reorient the trochlear groove and reduce the trochlear prominence. If trochlear dysplasia was associated with a supratrochlear spur, additional deepening was performed in this area before the current trochleoplasty. Other risk factors of patellofemoral instability were treated during the same procedure. Seventeen tibial tubercle transfers were associated with the trochleoplasty. Medialization was performed if the tibial tubercle trochlear groove (TTTG) distance was greater than 20 mm and TT lowering was performed if the Caton-Deschamps index was above 1.2 [13,14]. An Insall procedure was systematic, transferring the vastus medialis oblique muscle at the anterior aspect of the patella [15]. Immediate weight bearing was allowed after surgery with two crutches and the knee in extension in a brace for 45 days. Recovery of range of motion was immediate without restriction unless a tibial tubercle transfer had been performed, in which case flexion was limited to 90° for six weeks. Return to sports was not allowed for six months.

2.3. Clinical evaluation

The objective preoperative evaluation included the functional Lille score (Appendix 1) [16], IKS score [17], Kujala score [18], and the number of episodes of dislocation, apprehension and knee range of motion. The subjective assessment included the presence of pain or a feeling of instability.

The follow-up assessment included subjective data (satisfaction, pain, instability, the Oxford score [19]) as well as objective data (apprehension, range of motion, the functional Lille score, IKS and Kujala scores [16–18]). All patients who underwent a revision procedure including arthroplasty or bone surgery were considered failures.

2.4. Radiological assessment

The preoperative and postoperative radiographic assessment included a unipodal AP X-ray of the knee in extension, a Schuss view, a strictly lateral view at 10° and 30° flexion, and a patellofemoral axial view at 30° flexion. The preoperative assessment included the grade of dysplasia according to Dejour and Lecoultre criteria [11], the trochlear prominence, the height of the patella according to the Caton-Deschamps index [13], tibiofemoral osteoarthritis according to Kellgren and Lawrence [20] and patellofemoral osteoarthritis according to Iwano et al. [12]. The TTTG distance was determined by CT-scan [14]. Postoperative X-rays were performed to assess the trochlear groove, height of the patella and tibiofemoral and patellofemoral osteoarthritis.

![Fig. 1. Progression of patello femoral osteoarthritis according to Iwano et al. [12].](image)

0: no damage. 1: remodelling of the subchondral bone surfaces with no significant narrowing (Iwano 1). 2: joint space width narrowing thickness > 3 mm (Iwano 2). 3: joint space width narrowing with < 3 mm (Iwano 3). 4: bone surfaces in contact (Iwano 4).

<table>
<thead>
<tr>
<th>Table 1 Description of the series.</th>
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<tbody>
<tr>
<td>Patients (n)</td>
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<tr>
<td>Woman (n)</td>
</tr>
<tr>
<td>Age at surgery (years)</td>
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<tr>
<td>Mean number of dislocations per patient (n)</td>
</tr>
<tr>
<td>Objective instability (n)</td>
</tr>
<tr>
<td>Severe preoperative pain (n)</td>
</tr>
<tr>
<td>Former knee surgery (n)</td>
</tr>
<tr>
<td>Type of dysplasia by Dejour and Lecoultre [11]</td>
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<tr>
<td>Dysplasia grade A (n)</td>
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<tr>
<td>Dysplasia grade B (n)</td>
</tr>
<tr>
<td>Dysplasia grade C (n)</td>
</tr>
<tr>
<td>Dysplasia grade D (n)</td>
</tr>
<tr>
<td>Mean trochlear prominence (mm)</td>
</tr>
<tr>
<td>Mean Caton-Deschamps Index [13]</td>
</tr>
<tr>
<td>Mean TTTG distance (mm)</td>
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</tbody>
</table>

TTTG: tibial tubercle trochlear groove.
Table 2
Preoperative and final follow-up results.

<table>
<thead>
<tr>
<th>Objective instability (recurrent dislocation) (n)</th>
<th>Preoperative</th>
<th>Final follow-up</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smillie apprehension (n)</td>
<td>34</td>
<td>4</td>
<td>s</td>
</tr>
<tr>
<td>Severe pain (n)</td>
<td>16</td>
<td>8</td>
<td>ns</td>
</tr>
<tr>
<td>Mean Lille score (points/100) [16]</td>
<td>53.3 (30–92)</td>
<td>61.5 (25–93)</td>
<td>s</td>
</tr>
<tr>
<td>Mean IKS score (points/200) [17]</td>
<td>127.3 (54–184)</td>
<td>152.4 (66–200)</td>
<td>s</td>
</tr>
<tr>
<td>Mean Kujala score (points/100) [18]</td>
<td>55 (13–75)</td>
<td>76 (51–94)</td>
<td>ns</td>
</tr>
<tr>
<td>Mean trochlear prominence (mm)</td>
<td>4.9 (3–9)</td>
<td>−1.2 (−7–4)</td>
<td>s</td>
</tr>
<tr>
<td>Mean Caton-Deschamps Index [13]</td>
<td>1.16 (0.8–2)</td>
<td>1.12 (0.7–1.2)</td>
<td>ns</td>
</tr>
<tr>
<td>Iwano stage ≥ 2 (n) [12]</td>
<td>0</td>
<td>22 (65%)</td>
<td>s</td>
</tr>
</tbody>
</table>

s: significant difference, ns: non-significant difference.

2.5. Statistical analysis

All data were analyzed by a statistician from the biostatistics department of the University hospital of Lille. Quantitative values were compared by the Mann-Whitney test with Yates correction for small groups and the Fischer exact test for qualitative variables. The alpha value was 5%.

3. Results

Seven patients (20%) were considered failures. Six underwent revision arthroplasty (3 total knee arthroplasties and 3 patellofemoral arthroplasties for pain and Iwano stage 4 patellofemoral osteoarthritis.) These revision procedures were performed 2 years (n = 1), 5 years (n = 2), 8 years (n = 1), 12 years (n = 1) and 16 years (n = 1), postoperatively. Finally, one patient underwent revision surgery by TTA transfer due to pain and because the knee frequently gave out at 3 years. None of the patients presented with recurrent patellofemoral dislocation.

The functional outcome of patients before revision surgery is presented in Table 2. All functional scores (IKS, Kujala and Lille) were significantly improved. Functional scores were significantly better in patients operated for severe dysplasia (grades B and D) (P < 0.005) and in patients with objective instability (Tables 3 and 4). The rate of failure with revision surgery was not different in relation to the severity of dysplasia or the type of instability (Tables 3 and 4).

Among the 27 patients without revision, 22 (81%) were satisfied or very satisfied and the mean Oxford score was 24.1/60 points (12–45). The apprehension test was negative in 24 cases (89%). Ten patients reported occasional instability (37%). Eighteen patients (66%) did not report any pain or only occasional pain. Only one patient (4%) presented with significant pain. Mean preoperative flexion was 132° (110–150) and 131° (105–140) at follow-up. At follow-up, the mean functional Lille score was 70.4 (36–93) or 48% of good and very good results (score > 80/100), and 7% of poor results (score < 50).

4. Discussion

This study shows that sulcus deepening trochleoplasty effectively corrects patellofemoral stability because there was no recurrent dislocation in this series. Trochleoplasty corrected the trochlear prominence in all cases, and successfully removed the trochlear spur, which is a major factor of instability. However, the hypothesis was not confirmed because osteoarthritis worsened after a mean postoperative follow-up of 15 years. Although this single-surgeon series has limitations because 11 patients were lost-to-follow-up; this study with long-term follow-up provides a reliable estimation of the progression of osteoarthritis. Trochleoplasty was not performed alone, making it difficult to evaluate the exact role of this procedure, but correction was performed on a case by case basis, with the goal of correcting all the factors of instability.

As in other series, the main result of sulcus deepening trochleoplasty in this study is the absence of recurrent dislocation (Table 5). Only Utting et al. [21] reported trauma-related recurrent dislocation. Besides the longer follow-up, this series identifies prognostic factors for this strategy because the best results were observed in cases of severe dysplasia with spurs and pre-existing objective instability. The study by Verdonk et al. [22] did not find that the severity of dysplasia or the type of instability influenced the final functional score. The short-term results of recession wedge trochleoplasty (34 months) were identical to those of sulcus deepening trochleoplasty with a mean Kujala score of 80 and 2/19 cases of recurrent instability, but it is technically much simpler [10].
Recurrent instability seems to be much more frequent in cases of isolated tibial tubercle transfer [23,24], moreover, in the current study, 7 prior transfers did not correct instability. The results of stability after medial patellofemoral ligament (MPFL) reconstruction have been shown to be better, but postoperative follow-up of these procedures is much shorter and they were usually used in low grade dysplasia [25,26]. The results of isolated MPFL reconstruction for patellofemoral instability in severe high grade dysplasia are not as good [26,27].

The rate of knee pain after trochleoplasty varied because in this series, 44% of patients report moderate or severe pain. Von Knoch et al. [7] describe improvement in 49% of the cases but worsening in 33% after 8 years of follow-up. Sulcus deepening trochleoplasty results in stiffening and required a manipulation procedure in 23% of the cases in the current series which is comparable to 27% for Verdonk et al. [22] and 29% for Donnell et al. [28].

None of the patients in this series presented with a trochlear prominence of more than 5 mm at follow-up. Most authors had similar results with correction of the crossing sign, the prominence, the depth of the trochleal groove and of patellar tilt [7,28], confirming that sulcus deepening trochleoplasty does create a track for the patella. Sulcus deepening trochleoplasty often requires additional procedures during the same operation to optimize patellar tracking [7,21,28]. Ntagiopoulos et al. [29] observed significant correction of all criteria of trochlear dysplasia as well as improvement in the TTG1 distance and the Caton–Deschamps index following sulcus deepening trochleoplasty even in patients who did not undergo tibial tubercle transfer. Thaunat et al. [10] did not find any difference in the correction of patellar tilt with or without MPFL associated with a recession trochleoplasty. The latter results suggest that certain additional procedures may no longer be necessary.

The rate of osteoarthritis in our series at the final follow-up was 97% but 65% with Iwano grade > 2. Von Knoch et al. [7] only reported a rate of 30% of patellofemoral osteoarthritis, however, after a mean follow-up of only 8 years. After a comparable postoperative follow-up, isolated tibial tubercle transfers result in a rate of patellofemoral osteoarthritis similar to our series: 69% after 13 years for Nakagawa et al. [24]. For Mulford et al. [30], there is no proof that surgical stabilization of the patellofemoral joint results in a long-term decrease in the development of osteoarthritis. The development of osteoarthritis may be associated with patellofemoral incongruence caused by the sulcus deepening trochleoplasty itself because a flat, dysplastic patella tracks in a newly deepened trochlear groove. Recession trochleoplasty may reduce the risk of osteoarthritis because it respects patellofemoral congruence suggesting that long-term results should be evaluated.

5. Conclusion

The long-term results of sulcus deepening trochleoplasty are reliable for the treatment of patellofemoral instability secondary to trochlear dysplasia by correcting the main bone deformities of this form of instability. Results are better for objective instability (recurrent dislocation instead of apprehension accidents) and for grade B or D dysplasia with bone spurs. This technique does not prevent the development of patellofemoral osteoarthritis, even if the relative tolerance to this event did not influence the objective and subjective long-term clinical results of the patients in this series. This procedure should be limited to severe grade B or D dysplasia with supratrochlear bone spurs.

Disclosure of interest

Henri Migaud and Gilles Pasquier have no direct conflicts of interest to declare in relation to this study, but are occasional research and education consultants for Zimmer. Henri Migaud is a research consultant for Tornier.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jsot.2015.01.017.

References