A prospective evaluation of trochleoplasty for the treatment of patellofemoral dislocation and instability

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Trochlear dysplasia is a developmental condition characterised by an abnormally flat or dome-shaped trochlea and is an important contributory factor to patellofemoral instability and recurrent dislocation. We studied prospectively a series of 54 consecutive patients (59 knees) with patellofemoral instability secondary to trochlear dysplasia, who were treated by a trochleoplasty by a single surgeon between June 2002 and June 2007.

Pre- and post-operative scores were assessed by the patients and a satisfaction questionnaire was completed.

Of the 54 patients (59 knees) in the series, 39 (44 knees) were female and 15 (15 knees) were male. Their mean age at surgery was 21 years and 6 months (14 years 4 months to 33 years 11 months). In 40 patients (42 knees) the mean follow-up was for 24 months (12 to 58). One patient was unable to attend for follow-up. An analysis of the results of those patients followed up for at least 12 months showed a statistically significant improvement in outcome (p < 0.001 for all scores). Overall, 50 patients (92.6%) were satisfied with the outcome of their procedure.

The early results of trochleoplasty are encouraging in this challenging group of patients.

Chronic patellofemoral instability is a disabling condition which occurs in young patients. Torsional and angular malalignment of the lower limb, patella alta, inadequate soft-tissue constraints and dysplasia of the femoral trochlear, all predispose to this condition.1 Normally, the trochlea is concave, its shape being dependent on both the bony contour and the depth of the overlying cartilage.2,3 The articular surface of the patella is usually convex with a complex geometry which provides a degree of constraint to the patellofemoral joint.4 The work of Dejour et al5 has emphasised the importance of patellofemoral dysplasia in patients with patellar instability. The dysplastic trochlea is flat or dome-shaped (Fig. 1) and as a result, the distal third of the patella is flattened where it articulates with the abnormal proximal trochlea (Fig. 2).

Trochleoplasty is a ‘blanket’ term used to describe the reshaping of the trochlea to improve patellofemoral instability secondary to trochlear dysplasia. This may or may not correct the underlying morphological abnormalities of the trochlea. Patellofemoral congruence may be improved by either elevating the lateral facet of the trochlea, as proposed by Albee,6 or by deepening the trochlear sulcus. However, lateral trochlear elevation fails to restore the normal anatomy, overloads the lateral structures and displaces the patella further anteriorly, potentially leading to osteoarthritis (OA).

Masse7 first described deepening the trochlear sulcus, by impacting the cartilage on to the subchondral bone without fixation. This technique was later modified by Dejour et al8 who performed an osteotomy of both femoral condyles to create a V-shaped trochlear groove. The procedure which most closely restores the anatomy of the trochlea to normality is that of von Knoch et al,9 known as the Bereiter technique, in which an osteochondral flap is raised from the trochlea and a bony sulcus is fashioned using a series of high-speed burrs. The chondral flap is then moulded into the new sulcus and secured by vicryl tape.

We have prospectively evaluated 54 patients (59 knees) who underwent a Bereiter-type trochleoplasty, comparing pre- and post-operative outcome scores, complications and patient satisfaction.

Patients and Methods
Between June 2002 and June 2007, 59 trochleoplasties were performed by the senior
author (JDJE) on 54 patients, of whom 39 (44 knees) were female and 15 (15 knees) were male. In 30 patients (56%) the left knee was treated and in 24 (44%) the right side, with five (9%) having bilateral procedures. The mean age at operation was 21 years and 6 months (14 years and 4 months to 33 years and 11 months). The mean duration of symptoms before the trochleoplasty was seven years (1 to 19) and 16 patients (16 knees) had a total of 23 previous operations, which included seven medialisations of the tibial tubercle, six diagnostic arthroscopies, five lateral releases, two medial reefing procedures, two medial patellofemoral ligament reconstructions using a hamstring graft and one Roux-Goldthwaite procedure.10

The indications for surgery were either patellofemoral instability or chronic dislocation associated with dysplasia of the femoral trochlea. The ideal candidate for trochleoplasty has symptomatic recurrent patellofemoral instability, severe trochlear dysplasia, no degenerative change in the patellofemoral joint and has failed to respond to conservative treatment. In our patients, the classification system of Dejour et al5 was unhelpful. We defined ‘severe’ as the presence of a domed chondral surface of the proximal trochlea rather than a flat or shallow surface. In patients over 30 years of age, the procedure tends to be technically more difficult because of sclerotic subchondral bone and less pliable cartilage. Open physes are a contraindication.

Pre-operative evaluation. All the patients were assessed clinically by the senior author and had plain radiographs and MR studies. The axial T2-weighted fat-suppression images were used to delineate the osteocartilaginous anatomy of the trochlea and patella and to demonstrate chondral defects as well as the offset of the tibial tuberosity from the trochlear groove. Sagittal images were used to measure the patellar height. Following clinical and radiological assessment, interventions in addition to the trochleoplasty were then planned. These included distalisation of the tibial tubercle for functional patella alta if, after the trochleoplasty, in full extension the distal pole of the patella remained proximal to the most proximal portion of the trochlear groove,11 medialisation of the tibial tubercle when the offset of the tuberosity from the trochlear groove exceeded 18 mm and reconstruction of the medial patellofemoral ligament or medial soft-tissue reefing for persistent subluxation of the patella from the trochlear groove in spite of a normal tibial tuberosity. The final decision on any additional procedures to be performed was made intra-operatively after the trochleoplasty had been carried out.

Clinical assessment included the Oxford knee score12 the Western Ontario McMasters Osteoarthritis Index (WOMAC)13 and the International Knee Documentation...
Committee (IKDC)\textsuperscript{14} serves, as well as the outcome scores of Kujala et al\textsuperscript{15} and Lysholm and Gillquist.\textsuperscript{16}

**Operative technique.** Epidural anaesthesia was administered followed by general anaesthesia. A thigh tourniquet was used and inflated to 350 mm mercury. The knee was approached through a lateral parapatellar incision and an extrasynovial lateral release was performed. The synovium was incised after dissecting it free from the retinaculum. The patellofemoral articular surface was rated as either having a normal or abnormal surface. An osteochondral flap of the trochlea at an average minimum of 2 mm extending to the intercondylar notch was raised using a series of curved and straight osteotomes (Fig. 3). A trochlear groove was then fashioned in the subchondral bone using osteotomes and high-speed burrs. The anatomy of the patella was considered in the shaping of the new trochlear groove in which it is necessary to achieve a shallow broad unconstrained sulcus proximally which becomes deeper distally. As with patellofemoral replacement, the aim is to create a lateralised groove which allows the patella to become engaged. The deepening of the sulcus and often the lateral wall of the trochlea removes tension from the lateral retinacular structures allowing the patella to articulate within the new sulcus. Any remaining bone on the osteochondral flap of the trochlea was thinned so that it remained pliable enough to mould to the new shape of the trochlear groove. The osteochondral flap was secured to the subchondral bone by two 3 mm vicryl tapes (Ethicon, Norderstedt, Germany), passed through the subchondral flap and then tunnelled laterally where they were tied to the lateral femoral condyle (Fig. 4).

The synovium was re-attached to the margins of the articular cartilage with a no. 1 vicryl suture. Tracking of the patella was then assessed and supplementary procedures carried out if planned or required. Previously, we have observed that dysplasia of the patella affects primarily the distal third rather than the middle or proximal thirds.\textsuperscript{17} Therefore, an osteotomy of the patella was not performed since it would be expected to create incongruity of the patellofemoral articulation in flexion. Finally, the synovium was closed, followed by the fat and skin. No drains were used.

The first five patients were managed in a hinged brace with a 20° block to extension for the initial six weeks after operation to avoid shear on the flap, but in subsequent patients no brace was used, which reduced wasting of the quadriceps. Full movement of the knee was allowed immediately after surgery under the analgesia of the epidural anaesthetic. The latter was stopped after 24 to 48 hours. The patients were allowed to mobilise bearing full weight with crutches unless they had required a tibial tubercle osteotomy, in which case, they were kept partially weight-bearing on crutches for six weeks after the operation, then allowed to fully weight bear after six weeks, if the radiograph was satisfactory.

**Post-operative evaluation.** The patients were reviewed at two weeks, then at six weeks, three and six months, and then annually. The Oxford,\textsuperscript{12} WOMAC,\textsuperscript{13} IKDC,\textsuperscript{14} Kujala\textsuperscript{15} and Lysholm\textsuperscript{16} scores were completed after three months and at each subsequent annual follow-up. A patient satisfaction questionnaire comprising seven questions requiring ‘yes’ or ‘no’ responses was also used (Table I). Radiography was undertaken at three months and then annually (Fig. 5).

**Statistical analysis.** The data were entered onto a Microsoft Excel spreadsheet (Microsoft, Redmond, Washington). Pre- and post-operative scores were then compared by the Wilcoxon signed-rank test since the data were non-parametric and paired. The level of statistical significance was set at $p \leq 0.05$. 

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Fig. 4a

Intra-operative photographs showing a) a lateral view of the created trochlear groove held by 3 mm vicryl tape and b) a superior view of the created trochlear sulcus.

Fig. 4b
Results

The patellofemoral articular surface was considered to be macroscopically normal at the time of operation in 19 knees (17 patients) and abnormal in 37 knees (34 patients), with the most marked changes being in the distal third of the patella. In 12 of 59 knees (20%) abnormal trochlear cartilage was found predominantly affecting the proximal portion. All the patients were deemed to be suitable for the procedure at the time of surgery and did not have excessive damage to the trochlear articular cartilage. At the time of operation, 27 of 59 knees (46%) required additional procedures to stabilise the patella in the trochlear groove and to allow satisfactory patellofemoral tracking (Table II).

In 42 of the 59 trochleoplasties performed in 40 patients, the follow-up was for 12 months or longer, with a mean of 24 months (12 to 58). One patient was too unwell to attend follow-up. Information obtained from his GP indicated that his knee had improved after trochleoplasty. The results before the 12-month follow-up were considered to be too premature for inclusion in the analysis of outcome. All the scoring systems indicated that there was a statistically significant improvement after operation (Table III). Most patients reported an improvement in their satisfaction questionnaire (Table I).

In two patients, a superficial wound infection occurred which responded to a single course of oral antibiotic. There were no cases of deep infection. One patient failed to receive any post-operative physiotherapy and required manipulation under anaesthesia two months after the initial procedure. Subsequently, she maintained a full range of movement. No patient required arthrolysis. One fell, sustaining a dislocation of the patella which was managed conservatively without further episodes of instability. No patient had recurrent patellofemoral instability. One developed an anaphylactic reaction after administration of prophylactic antibiotic on induction of anaesthesia. The anaesthesia was reversed without any procedure being performed and immunological investigations were performed. Trochleoplasty was finally undertaken one year later. There were no thromboembolic events and no patient developed chondrolysis or nonunion of the osteochondral flap.

Discussion

We describe the operative protocol and early results of a trochlear deepening trochleoplasty for recurrent patellofemoral instability or dislocation in the presence of trochlear dysplasia using assessments of satisfaction by the patients.

Our intention in patients with trochlear dysplasia was to recreate the anatomy to as nearly normal as possible. This required deepening of the elevated trochlear sulcus and the use of supplementary procedures based on the pre-operative anatomical analysis.18 Historically, attempts to solve patellofemoral instability by realignment procedures of the extensor mechanism have been unsatisfactory since the underlying anatomical abnormality was not addressed. The result has been an increased incidence of OA.19,20 Operations to elevate the lateral aspect of the trochlea, such as the Albee procedure,6 fail to address the underlying osteocartilaginous anatomy and anteriorise the patella, increasing the patellofemoral joint reaction force and risking the development of OA.21 The Dejour technique8 creates a proximal trochlear groove, but does not restore the normal anatomy of the sulcus as far as the intercondylar notch. The logical solution in the patient with patellofemoral instabil-

Table I. Details of the patient satisfaction questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you satisfied with the outcome of the operation?</td>
<td>50 92.5</td>
<td>4 7.4</td>
<td></td>
</tr>
<tr>
<td>Did the operation improve or abolish your symptoms?</td>
<td>50 92.5</td>
<td>4 7.4</td>
<td></td>
</tr>
<tr>
<td>Would you have the same procedure again?</td>
<td>50 92.5</td>
<td>4 7.4</td>
<td></td>
</tr>
<tr>
<td>Would you recommend this procedure to others?</td>
<td>51 94.4</td>
<td>3 5.6</td>
<td></td>
</tr>
<tr>
<td>Have you had a recurrence of your symptoms?</td>
<td>10 18.5</td>
<td>44 81.5</td>
<td></td>
</tr>
<tr>
<td>Have you resumed sport/maximal activities?</td>
<td>36 66.7</td>
<td>18 33.3</td>
<td></td>
</tr>
<tr>
<td>Do you have any residual symptoms</td>
<td>16 29.8</td>
<td>38 70.4</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5

Case 1. Post-operative 30° skyline patellar radiograph.
ity secondary to trochlear dysplasia is the creation of a new groove in the trochlea by deepening of the subchondral bone and the application of the articular cartilage to this new groove as described above. The viability of the re-attached osteochondral flap after trochleoplasty has been investigated by Schöttle et al.22 Histological examination showed a normal cartilaginous matrix and cell distribution with a normal lamellar pattern of the subchondral bone and healing of the flap.

It was difficult to determine which score would detect changes in our patients most sensitively and we therefore used several scores. The Kujala score15 was developed to assess the patellofemoral joint, but in our study, the difference in the mean pre- and post-operative scores was only 14 points. This failed to reflect the patient’s perception of the improvement after surgery probably because the score tends to measure pain rather than instability. Donell et al23 found that the mean Kujala score15 improved by 28 points after the use of their modified Dejour technique.5 They commented that this score did not reflect the patient’s perception of the improvement after surgery probably because the score tends to measure pain rather than instability. Donell et al23 found that the mean Kujala score15 improved by 28 points after the use of their modified Dejour technique.5 They commented that this score did not reflect the patient’s perception of the improvement after surgery probably because the score tends to measure pain rather than instability.

Table III. Pre- and post-operative outcome scores

<table>
<thead>
<tr>
<th>Score</th>
<th>Mean (range) pre-operative score</th>
<th>Mean (range) post-operative score</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxford knee score12</td>
<td>26 (12 to 43)</td>
<td>19 (12 to 44)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>WOMAC* score13</td>
<td>23 (12 to 35)</td>
<td>17 (12 to 34)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>International Knee Documentation Committee score14</td>
<td>54 (26 to 89)</td>
<td>72 (23 to 100)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Kujala score15</td>
<td>62 (29 to 92)</td>
<td>76 (26 to 100)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lysholm score16</td>
<td>57 (25 to 91)</td>
<td>78 (30 to 100)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

* WOMAC, Western Ontario and McMaster osteoarthritis index

The patients in our series presented a considerable challenge. They had severe dysplasia with recurrent or habitual dislocation. Just less than a third had previous surgery, often in different hospitals since our unit acted as a tertiary referral centre. They represent all the trochleoplasties performed by the senior author with no exclusions. After the procedure, 50 patients (92.6%) reported a subjective reduction in or abolition of their symptoms and none had instability. Comparison of our series with others is difficult since the surgical procedures and follow-up have varied and the numbers have often been small. Bereiter’s group9 described a series of 45 knees with a follow-up of 4 to 14 years after trochleoplasty. Their outcome measures were pain, which improved in 49% of knees and worsened in 8.8%, and radiological progression of OA, which occurred in 30%,9 but no clinical scoring systems were used. Donell et al23 reported 17 patients who had a modified Dejour trochleoplasty with a mean follow-up of three years. They found a mean reduction in the height of the trochlea of 7.5 mm, with 13 patients being satisfied or very satisfied. A further 18 operations were needed in this group, ten to remove screws, five for arthrolysis because of stiffness one for medial re-reefing, one for an autologous chondrocyte transplant and one a patellar chondroplasty. In our series only one patient had surgery after their trochleoplasty which was a manipulation for stiffness.

Of the 16 patients (29.6%) with residual symptoms, eight have ongoing pain, all of whom had painful instability rather than simply instability pre-operatively. However, all patients with ongoing pain had abnormalities of either the trochlear or patellar articular cartilage before the trochleoplasty. The other eight patients had continuing swelling or crepitation. There is currently no evidence to suggest that surgical stabilisation of the patellofemoral joint decreases the long-term risk of arthritis, despite improving short-term stability.

The Bereiter trochleoplasty9 technique was found to be successful in patients with symptomatic recurrent patellofemoral instability associated with trochlear dysplasia. The technique was used in conjunction with other procedures with an early favourable outcome.

Our study is a prospective evaluation of trochleoplasty using outcome measures assessed by the patients. It shows statistically significant post-operative improvement with all
the scoring systems used. The long-term outcome is not known and our patients will continue to be followed up.

We thank Suzanne Miller for her help in setting up the Bristol Knee Instability Database and providing administrative support. We also thank Alexia Karantana for her help with early data collection and Victoria Wyld for the statistical analysis.

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References