Deepening Trochleoplasty for Distal Femoral Dysplasia in Patellar Instability

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ABSTRACT
Awareness of the importance of the shape of the femoral sulcus as a component of patellar instability has gained acceptance over the last 15 years. As a result, operations to correct the abnormality by deepening the sulcus have been introduced. The main drive for this has been from Europe, but is still only performed in a few specialist centers. The indications, technique, rehabilitation, and evaluation of results are therefore still being systematized and clarified. In this report, I describe the technique of deepening by removing excess distal cancellous bone and creating 2 triangular-shaped osteochondral flaps which are then anchored with bioabsorbable screws placed into the femoral condyles. The procedure requires an appreciation of the abnormal geometry, but is not difficult to master, and the early results are encouraging. Deepening of the femoral sulcus for those patients with a significant dysplasia and symptomatic patellar instability is an operation that will become more common in the future.

Keywords: trochleoplasty, dysplasia, patellar instability, surgical technique

HISTORICAL PERSPECTIVE
The importance of a shallow femoral sulcus as a component of patellar instability has been recognized since the 1890s. Elevation of the lateral trochlear facet was first described by Albbee1 in 1915, but this fell out of favor because of subsequent patellofemoral osteoarthritis (OA). In 1966, Masse2 described removing subchondral bone and impacting the articular cartilage with a punch. This technique was further developed by Henri Dejour in Lyon, France, in the late 1980s.3,4 Dejour also classified trochlear dysplasia on the lateral plain radiograph and developed the indications for his trochleoplasty.5 The original Dejour technique uses a burr with a feeler gauge attached. The gauge is placed on the chondral surface, and the burr removes subchondral bone at a set depth giving a fixed-depth osteochondral flap. The new groove is created by cutting the flap with an osteotome along the desired line, impacting the 2 resulting flaps and anchoring them with staples. He noted that the best results were in those patients with instability and no pain where the trochleoplasty was part of the primary procedure.

INDICATIONS/CONTRAINDICATIONS
The main indication for deepening trochleoplasty is symptomatic patellar instability which has failed conservative therapy and which has a significant dysplasia with a trochlear boss on lateral radiograph. It is not required for the majority of patients with patellar instability. The Dejour method for measuring the boss height is shown in Figure 1 and requires a lateral radiograph with the posterior condyles strictly overlapping. A simpler method uses a line drawn along the anterior cortex of the femur and then measures a line dropped perpendicular to this from the most anterior part of the femoral groove.

The history should establish significant functional disability from patellar instability in a patient prepared to undergo a major operation to control this. At least one third of patients decline trochleoplasty during the consent procedure. However, about half of these return because of significant ongoing symptoms. The birth and family history is important. Half the patients have affected family members. Collagen disorders may be present (eg, Marfan and Ehlers-Danlos syndromes), and this may affect the anesthetic or operative procedure.

Physical examination should include an assessment for hypermobility syndrome. This is present to some degree in more than half the patients and is associated with a positive family history. The torsional alignment of the lower limb is also important, noting hip version and tibial torsion. From time to time, rotational osteotomies may be needed to reorientate the extensor mechanism over the distal femur. Trochleoplasty alone will not do this.

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Patellar tracking should be noted. With a dome-shaped boss greater than 10 mm, the patella may show a “bayonet” tracking. When the knee is fully flexed, the boss can be palpated directly through the quadriceps tendon.

Many patients in whom trochleoplasty is indicated have had multiple previous procedures. The resulting scars can be a problem if narrow skin bridges are created. Advice from a plastic surgeon may be needed.

Tightness of the quadriceps muscle may be present, especially if there is a patella alta. Quadriceps dysplasia with absence of the vastus medialis obliquus is almost universal and can affect the postoperative course. Without decent quadriceps function, the symptoms of instability will persist.

**PREOPERATIVE PLANNING**

Standard plain radiographs including a strict lateral and skyline (tangential patella) are essential. The lateral radiographs allow assessment of the degree of dysplasia. The boss height should be measured (Fig. 2). Although a height greater than 6 mm suggests suitability for trochleoplasty, consideration should be given to the size of the patient. In a small female, this would represent a greater dysplasia than a tall male. In the former, 4 mm would be adequate to consider the procedure.

Further imaging with computed tomography (CT) scan, or better, magnetic resonance imaging scan, helps assess the shape of the groove in the first 20 degrees of flexion. The CT scan shows the subchondral bone contour; the magnetic resonance imaging scan, the chondral shape. The scan can be taken with the knee in extension and the quadriceps relaxed. Coronal cuts through the distal femoral shaft down to the distal end of the tibial tubercle are ideal. The groove can be classified according to the Dejour method (Fig. 3), with C and D being suitable for deepening trochleoplasty. The scans can also be used to assess the patellar tilt angle and tibial tubercle–trochlear groove distance. Correcting patellar maltracking is an important part of the procedure and may require distal or proximal realignment operations according to the surgeon’s preference.

**SURGICAL TECHNIQUE**

The operation is performed under epidural analgesia, which is also used for postoperative pain relief. A light general anesthetic is usually added. Postoperative pain control is critical otherwise early full motion cannot be achieved and stiffness may result.

A single dose of a third-generation cephalosporin is administered intravenously at induction, for example, 1.5 g cefuroxime. Chemical thromboprophylaxis is not routinely given. A calf stimulator is applied to the opposite leg during the operation. Cross-matching blood for transfusion is not needed.

The patient is placed supine with the knee flexed at 90 degrees, held with foot bolster and thigh support. A preliminary arthroscopy through anterolateral and suprolateral portals is useful for assessing patellar tracking and confirming that the tibiofemoral joint is normal. Any loose bodies may be removed. An open arthrotomy is performed through a midline longitudinal incision commencing just medial to the patellar tendon at the level of the tibiofemoral joint line progressing proximally and slightly laterally to the middle of the quadriceps tendon. The proximal extent depends on the thickness of the subcutaneous fat. A routine medial parapatellar arthrotomy is performed. The incision is deepened through the subcutaneous and prepatellar fascial layers.
in the line of the incision and should pass onto the med- dial part of the patella. This will allow double-breasting medial reefing at the end or a medial patellofemoral ligament reconstruction should it be needed. Skin flaps are not developed. The approach continues through the quadriceps tendon and medial retinaculum. Care should be taken to avoid incising the articular cartilage. The patella is inverted and inspected. Any medial ossicle is removed, and any articular damage addressed. The patella is then reverted and retracted into the lateral gutter.

The trochlea is then inspected, and the dysplasia confirmed (Fig. 4). The synovium attached to the distal...
femoral articular cartilage, along with the supracondylar fat pad, is stripped off the bone using sharp dissection and a small periosteal elevator. It is important to expose the anterior cortex of the distal shaft of the femur (Fig. 5). This defines how much bone is to be removed. The object is to create a groove at the level of the anterior femoral cortex. The synovium is held retracted with stay sutures.

Following this, the osteochondral flaps are marked forming 2 triangles (Fig. 6). The objective is to obtain a lateral buttress with a depressed medial flap. This is achieved by marking the lateral flap with an acute line, and the medial flap with a more obtuse one. The groove line should pass more laterally than the original. This helps patellar tracking and reduces the trochlear groove part of the tibial tubercle–trochlear groove distance. It is important that the lateral flap is wide enough to take a countersunk 3.5-mm screw. The apex of the flaps should be close to the roof of the intercondylar notch. This allows the whole length of the groove to be deepened.

The distal femoral cortex is then removed between the marked flaps with an osteotome. This is shaped in a triangular fashion with a more marked slope laterally (Fig. 7). The horizontal component runs along the edge of the chondral margin. The proximal cancellous bone can be removed at the same time. Any bone removed during the procedure should be saved, as it will be used as graft at the end of the procedure to plug any defects under the flaps.

A trench is then formed in the shape of a rhomboid, which matches the marked flaps. This is most easily achieved using a 4.5-mm drill passed in a fanlike manner down to the apex. The index finger is placed at this point, and the drill is passed until it is felt just under the cartilage (Fig. 8). Broaching the articular cartilage is not a significant problem and can be ignored. Any bone between the passes of the 4.5-mm drill is then removed with rongeurs. A large rhomboid osteochondral flap is now formed.

The new trochlear groove will be produced by cutting along the marked groove line with an osteotome. If the flaps are now depressed, the cartilage will crack open along the flap lines. The flaps are therefore

FIGURE 6. The flaps marked out, seen from lateral side.

FIGURE 7. The distal femoral cortex is cut with an osteotome in a V shape, seen from above.

FIGURE 8. A 4.5-mm drill is passed to the apex of the marked flaps to produce a subchondral trench, seen from lateral side.
undermined with a drill and/or burr. This can be visualized directly by using the arthroscope. The flap lines are also transilluminated, confirming that adequate bone has been removed. Slots are also made at the proximal ends of each flap line with a rongeur. This allows the flaps to fold down (Fig. 9).

To cut the groove, place an instrument such as the rongeurs under the flap, and then cut with an osteotome. The instrument will avoid inadvertent complete detachment of a flap by its sudden collapse (Fig. 10). To obtain the correct position with the 2 flaps making a smooth groove, further targeted undermining of the subchondral or cortical bone may be necessary, again aided by direct visualization with the arthroscope. If a flap is unstable (typically, the medial flap), it should be placed in the correct position, and bone graft packed under it. The flap should be checked to be stable, otherwise it will displace when using the tap for the absorbable anchoring screw. Getting the tap through the subchondral bone requires significant force, which easily displaces an unstable flap.

Once each flap position is satisfactory, each one is secured with a countersunk 3.5 000D7 35-mm

FIGURE 9. To allow the flap to be depressed, a gap is fashioned with rongeurs along the flap edge until only the distal flat part is left.

FIGURE 10. The new groove is cut with an osteotome. The rongeurs have been placed to protect the osteochondral flaps from inadvertent displacement. The view is from the medial side.

FIGURE 11. The flaps have been depressed and fixed with absorbable screws, seen from above. Note that the proximal groove widens.

FIGURE 12. Before and after the trochleoplasty, seen looking toward the hip.
SmartScrew (Linvatec, Finland). This screw is bioabsorbable and can be trimmed with a scalpel if an edge is prominent. The screws need to be placed at the midpoint of the flap and directed into their respective femoral condyles (Fig. 11). If placed too distal, the proximal end of the flap will not be secure. If placed too proximal, the distal end of the flap may rotate, causing incongruency in the new groove. The new profile should show a lateral flare (Fig. 12).

Any gaps under the flaps are packed with bone graft. The proximal groove may also be packed but not above the level of the subchondral bone plate. Any exposed cancellous bone proximal to the articular surface is sealed with bone wax. The synovium and suprapatellar fat pad are reattached to the articular edge using interrupted 2-0 Vicryl sutures (Fig. 13).

Patellar tracking should now be assessed. Any maltracking should be corrected using the surgeon’s preferred method. Unless the dysplasia is severe, a lateral release is not typically needed, and closure with a double-breasted medial reefing is often sufficient. In severe cases, a formal medial patellofemoral ligament reconstruction may be necessary.

Closure of the wound should include, if possible, closure of the synovium with a continuous layer of 2-0 Vicryl. The extensor mechanism is repaired with interrupted 2-0 Vicryl along the medial border of the patella and the distal quadriceps tendon. The whole of the medial retinaculum and quadriceps tendon is then closed with a continuous 2-0 Vicryl. A double-breasting technique may be used if appropriate.

If possible, the preretinacular fascia should be closed with continuous 2-0 Vicryl, and the skin with subcuticular 3-0 Vicryl and SteriStrap. No drain is used.

The wound is then covered with a clear waterproof dressing, wool, and crepe bandage.

### RESULTS

Trochleoplasty is in its infancy. My current series is more than 55 patients over 13 years, with 18 performed in 2006. The referral base is national. The early results of this technique have been reported. In 15 patients with 17 knees treated and an average 3-year (range, 1–9 years) follow-up, the boss height was reduced from an average 7.5 mm (range, 6–10 mm) to 0.7 mm (range, −1 to 3 mm). Normal tracking was achieved in 11 knees, the rest having slight J-shaped tracking. Mild residual apprehension was present in 7 knees. Seven patients were very satisfied, including two who played soccer and described their knees as normal. Six were satisfied, and 2 were disappointed. The average Kujala score improved from 48 (range, 13–75) to 75 (range, 51–98). The disappointed patients had pain as a feature both preoperatively and postoperatively, including one who had presented late with a missed osteochondral fracture of the patella.

In Dejour’s series, 32 patients underwent 40 trochleoplasties. Twenty-seven knees were subjectively satisfied or very satisfied, with 36 achieving patellar stability postoperatively. Verdonk et al have also reported on 7 patients with patellar instability out of 12 patients (13 knees) using Dejour’s technique. The other patients had retropatellar pain. Their results were poor, but this was significantly influenced by the latter patients.

The results of the Bereiter trochleoplasty have also been recently reported. This is also a deepening trochleoplasty, but the osteochondral flap is thin and flexible. It is suitable in patients in whom the articular surface is normal, without chondral defects.

### COMPLICATIONS

The most important complication to avoid is stiffness. Complete pain control and early movement help this. After discharge, supervised sessions with a physiotherapist are important in patients who need encouragement.

Many patients have had multiple previous procedures and incisions. Poor blood supply and early full movement can lead to wound breakdown. Advice from a plastic surgeon preoperatively can be helpful. Otherwise, if there is concern for the wound, reducing knee flexion may be needed. If this results in stiffness, arthroscopic arthrolysis may be needed at 6 weeks.

Patellar pain and crepitus arises postoperatively if the patellar articular surface is damaged. In fact, if the fascia is closed with continuous 2-0 Vicryl, and the skin with subcuticular 3-0 Vicryl and SteriStrap. No drain is used.

The wound is then covered with a clear waterproof dressing, wool, and crepe bandage.
patella is normal, the subjective and functional results are very good. If not, the patient will notice crepitus and may have mild anterior knee pain. However, patients feel that the knee is stronger and are pleased with the result.

Some patients experience recurrent instability. A few patients have patellar maltracking after the procedure. Instability usually results from poor quadriceps control. Often this is compounded by pre-existing quadriceps dysplasia, with absence of the vastus medialis obliquus. Overweight patients are particularly prone to poor quadriceps function. In the occasional patient who has maltracking, this has been because only a medial reefing was performed to control patellar tracking in addition to the trochleoplasty. In full extension, the patella falls laterally and in flexion does not engage the new groove properly. This is easily corrected with a medial patellofemoral ligament reconstruction using a free hamstring graft.

POSTOPERATIVE MANAGEMENT
A continuous passive motion (CPM) machine is applied in the recovery room. The knee should be moved as fully as possible, although it will initially be restricted by the bandages. Continuous passive motion is continued until adequate pain control is achieved with oral analgesics. Over the next 2 to 5 postoperative days, the epidural dose is titrated against the oral analgesics. When the pain is controlled orally, the epidural is discontinued.

The knee bandage is removed on the first postoperative day, and the knee redressed. Ice is applied intermittently to help reduce any swelling. The CPM need not be on continuously. Once oral pain control is achieved, the patient is mobilize full weight bearing, and full knee motion encouraged. Crutch support is required until quadriceps control is achieved.

By 6 weeks, most patients are walking free of support, and by 3 months, most have fully recovered.

CONCERNS AND THE FUTURE
Both patients and clinicians have a number of concerns and questions.

Chondrolysis
Chondrolysis has never occurred. Articular cartilage is avascular, and keeping thick flaps preserves the subchondral bone and theoretically allows early blood supply through the cancellous bone.

Osteoarthritis
Subsequent OA is recognized as a late sequela of patellar stabilization surgery. In the early patients in this series, the osteochondral flaps were secured with metallic screws. These were removed arthroscopically at 1 year. The groove and drill holes had all filled in. At this stage, it is often not possible to distinguish between fibrocartilage and original hyaline cartilage macroscopically. No evidence of articular cartilage damage was found. It is hoped that the rate of OA after patellar stabilization will decrease as a result of adding in a trochleoplasty, because this reduces the joint reaction force.

Anterior Knee Pain and Trochlear Dysplasia
Trochleoplasty for anterior knee pain has been tried with limited success. In established patellofemoral OA, it has a place, being akin to an upper tibial osteotomy in tibiofemoral OA. Subsequent conversion to a patellofemoral joint arthroplasty can then be performed as a fallback procedure.

Return to Sports
About 20% of patients return to playing significant level sports, including soccer. One patient, a sports teacher, underwent autologous chondrocyte implantation (ACI) on the lateral femoral condyle, but, on the tibial, not the trochlear surface. This was as a result of a new injury while playing basketball following trochleoplasty.

Operative Time
The operative time is between 90 and 120 minutes, depending on whether a medial patellofemoral ligament reconstruction is needed.

The technique and indications are still evolving. Ideally, the 3-dimensional shape of each groove should be analyzed and then programmed through a computer to define the new shape. An arthroscopic procedure using navigation could then be used to produce the new groove with a precise geometry. Development of this is unlikely, as the commercial benefits would be outweighed by the setup costs. However, the key area for improvement is managing the damaged articular surface of the patella when present. Current techniques of ACI would require another major operation in a recovering knee. An off-the-shelf resurfacing matrix would change this. There is no doubt that many patients labeled “chondromalacia patellae” in fact had an unrecognized trochlear dysplasia with a traumatic injury to the cartilage. Furthermore, some of the poor results from ACI on the patella may be for the same reason. This area is ripe for research and development.

REFERENCES


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