Long-term outcome of surgically-treated habitual patellar dislocation in children with coexistent patella alta
MINIMUM FOLLOW-UP OF 11 YEARS

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We retrospectively reviewed the operative treatment carried out between 1988 and 1994 of eight patients with habitual patellar dislocation. In four the condition was bilateral. All patients had recurrent dislocation with severe functional disability. The surgical technique involved distal advancement of the patella by complete mobilisation of the patellar tendon, lateral release and advancement of vastus medialis obliquus. The long-term results were assessed radiologically, clinically and functionally using the Lysholm knee score, by an independent observer.

The mean age at operation was 10.3 years (7 to 14) with a mean follow-up of 13.5 years (11 to 16). One patient required revision. At the latest follow-up, all patellae were stable and knees functional with a mean Lysholm knee score of 98 points (95 to 100). In those aged younger than ten years at operation there was a statistically significant improvement in the sulcus angle at the latest follow-up (Student’s t-test, p = 0.001). Two patients developed asymptomatic patella infera as a late complication.

This technique offers a satisfactory treatment for the immature patient presenting with habitual patellar dislocation associated with patella alta. If performed early, we believe that remodelling of the shallow trochlea may occur, adding intrinsic patellofemoral stability.

Patients and Methods
Between 1988 and 1994, eight patients (12 knees) underwent operation for habitual patellar dislocation associated with patella alta (Table I). They were reviewed retrospectively. There were four females and four males with a mean age at operation of 10.3 years (7 to 14) and all had open physes. The mean follow-up was 13.5 years (11 to 16). None had trauma which had precipitated the patellar instability nor was there a positive family history.

The critiera for inclusion in the study were habitual patellar dislocation leading to functional limitation in activities of daily living with pain, requiring modification or cessation of sports, symptoms for more than one year and failure of conservative treatment which included physiotherapy and patellar bracing for at least six months. In habitual dislocation of the patella, unlike recurrent dislocation, the patella dislocates each time the knee is flexed.

The pre-operative physical examination was conducted by the senior author (BM) and all patients were reviewed by an independent observer (BB). Pre-operatively all the patients
had a prominent high-riding patella, dysplasia of vastus medialis obliquus (VMO), maltracking of the patella in the final 30˚ of extension with excessive terminal lateral displacement, a positive apprehension test, complete lateral dislocation of the patella under general anaesthesia, a normal range of movement and a normal stability at the tibiofemoral joint. Alignment of the lower limb showed genu recurvatum of more than 10˚ in four knees, genu valgum in five and normal alignment in three. No patient had a Q-angle measurement of more than 15˚. Excessive tibial torsion was not found clinically.

The functional outcome was evaluated by the knee score of Lysholm and Gillquist.11

Operative technique. The surgical approach combines proximal re-alignment which includes a lateral release and a medial advancement of the VMO as previously described5 with a technique of distal re-alignment which differs from those described for recurrent dislocation in skeletally immature patients in that it addresses the patella alta. The patellar height is restored to normal as defined by the index of Caton et al12 and that of Koshino and Sugimoto13 (Fig. 1). A long medial parapatellar incision is used extending from the superomedial pole of the patella, crossing below the tibial tuberosity and ending laterally at the metaphyseal tibial crest. A skin flap is elevated laterally exposing the superficial fascia and the lateral border of the patella. An extensive lateral release is performed leaving the superficial fascia and the lateral border of the patella. An extensive lateral release is performed leaving the superficial fascia and the lateral border of the patella. An extensive lateral release is performed leaving the superficial fascia and the lateral border of the patella. An extensive lateral release is performed leaving the superficial fascia and the lateral border of the patella.

Using the proximal insertion of the patellar tendon at the tibial tuberosity as a reference, the tendon is divided transversely as it blends with the periosteum of the proximal tibia (Fig. 1). A strip of periosteum is then removed distally from the proximal tibial crest, corresponding to the location of the eventual distal reattachment of the patellar tendon. The site is decorticated to promote future ingrowth between the advanced tendon and the bone. An anchoring hole is drilled transversely through the tibial crest at the distal end of the site of the periosteal stripping.

Two criss-cross sutures using absorbable 1-0 suture material, as a variation of a Bunnel suture are placed longitudinally on each side of the patellar tendon, each is passed through the previously drilled anchoring hole (Fig. 3). These are used to pull the tendon distally and to approximate its distal end to the periosteum on the tibial crest (Fig. 4). One or two sutures are added through the cartilaginous tibial tuberosity to anchor the tendon firmly. The newly advanced patellar tendon is secured to the periosteum at the medial, lateral and distal borders by multiple interrupted sutures (Fig. 5).

Table I. Details of the 12 knees (8 patients) in the series

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<th>Case</th>
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Finally, the proximal re-alignment of the extensor mechanism is completed according to the recommendations of Hughston et al.5 At the end of the procedure, the stability of the patella is tested by evaluating its lateral displacement at 30˚ of flexion and by passively flexing and extending the knee to confirm that it is located satisfactorily in the intercondylar groove. After ensuring haemostasis, the wound is closed in layers over a drain.

Post-operative management.

The leg is immobilised in a cylinder cast with 10˚ to 15˚ of flexion for three weeks. Toe-touch weight-bearing with crutches is allowed, but exercises are limited to static quadriceps contractions without straight-leg raising to avoid stretching the reconstruction. After removal of the cast a knee splint is applied for a further three weeks and then removed for active range-of-movement exercises. Straight-leg raising and muscle-strengthening exercises are begun with progressive weight-bearing at six weeks post-operatively. Once a full range of movement has been regained and the quadriiceps power is adequate, a progressive return to normal activities is encouraged including participation in sports with the protection of a patellar brace.

Radiological evaluation.

The basic radiological evaluation included four knee radiographs obtained pre- and post-operatively and at the latest follow-up examination. These included an anteroposterior (AP) view, two lateral views with the knee flexed at 45˚ and 90˚, respectively and a patellar tangential view with the knee flexed at 30˚. The radiographs were examined for evidence of degenerative changes. None showed pre-operative signs of osteoarthritis, but in one knee an old avulsion fracture of the medial patellar facet was observed.
On the tangential view, the sulcus angle was measured and the patellar morphology was analysed according to the Wiberg classification\(^{14}\). The mean pre-operative sulcus angle was 160˚ (153˚ to 169˚). The normal sulcus angle is considered to be less than 137˚.\(^{14}\) Patellofemoral dysplasia was present in each affected knee with seven knees having a Wiberg type-III and five a Wiberg type-II patella. The patellar height was determined from a true lateral radiograph using two different methods, the ratio of Caton et al\(^{12}\) and that of Koshino and Sugimoto.\(^{13}\) Both suggested that a ratio greater than 1.2 should be considered to be positive for patella alta. These methods were chosen because they can be used to evaluate patellar height in the presence of an open physis.

**Statistical analysis.** All the data were recorded and analysed by SPSS version 14 software (SPSS Inc., Chicago, Illinois). Student’s paired \(t\)-test was used to compare measurements in each patient before and after surgery. An unpaired \(t\)-test was used to assess differences between patients less than ten years old and those ten years old and above at the time of surgery. Comparison of the rate of complications between the older, and younger group was performed by Fisher’s exact test (two-tailed).\(^{15}\) A \(p\)-value \(\leq 0.05\) was considered to be significant.

**Results**

At the latest follow-up, 11 to 16 years after operation, no patient complained of patellar instability or recurrent dislocation. All had returned to normal daily activities and could participate in sport without limitation. The mean Lysholm knee score at the last visit was 98 points (95 to 100). With the exception of one patient (case 3) all were free from pain. The remaining patient had minor pain when walking downhill. All had a full range of knee movement and leg length had not been affected. One patient (case 3) had quadriceps atrophy of 1 cm and a positive apprehension test, and the patellae could be laterally displaced by three quarters of its width. The remainder had no atrophi of the quadriceps, an absent apprehension sign and the patella could not be laterally displaced in excess of one quarter to half its width when the knee was held in full extension.

Radiologically, the patellar height was adequately corrected in 11 knees. The mean pre-operative patellar height indices of Caton-Deschamp\(^{12}\) and Koshino-Sugimoto\(^{13}\) were 1.54 (1.48 to 1.62) and 1.31 (1.22 to 1.41), respectively. Post-operatively these were normalised to a mean of 1.04 (0.93 to 1.14). One patient was undercorrected (knee 5, Table I). This led to early patellar dislocation and revision surgery at three months. The mean patellar height for the whole series at final follow-up was 0.86˚ (0.58˚ to 1.10˚). In patients older than ten years the mean Caton-Deschamp,\(^{12}\) and the Koshino-Sugimoto\(^{13}\) indices were 0.99˚ (0.90˚ to 1.10˚) immediately post-operatively and did not show any change at long-term follow-up.

Pre-operatively, all knees had a shallow femoral trochlea with a mean sulcus angle of 160˚ (153˚ to 169˚). However, the latter was worse for patients under the age of ten years at the time of surgery at a mean of 164.6˚ (158˚ to 169˚) compared with a mean of 156.9˚ (153˚ to 159˚) in the older patients (Student’s \(t\)-test, \(p = 0.005\)). At the last follow-up, the sulcus angle was statistically significantly better in the children younger than ten years old at operation with a mean of 141˚ (137˚ to 142˚) compared with children aged ten years and over who had a mean sulcus angle of 150.4˚ (149˚ to 143˚) (Student’s \(t\)-test, \(p = 0.001\)). This represents an improvement in the mean sulcus angle of 23.6˚ (\(p = 0.001\)) compared with 6.5˚ for patients aged 10 years and older. Epi- physeal growth was not affected in any patient and none had radiological evidence of osteoarthritis at the last visit.

Early complications occurred in three patients. One (case 11) developed an abscess which was successfully debrided at one week post-operatively and another (case 10) developed a drop foot related to the application of the plaster cast which fully recovered within two months. One patient (case 5) required a revision procedure due to redislocation of the patella three months post-operatively. Two patients (cases 7 and 10) had developed patella infera at the last follow-up. At the time of operation these children were the youngest to be operated on being then aged seven years. Neither complained of pain and their knee scores were 96 and 99 points, respectively.

**Discussion**

We have evaluated the long-term results of a surgical procedure performed on growing children with patellar dislocation and followed into adulthood with a follow-up
period of almost 14 years. No patient was lost to follow-up. The major weaknesses of this study were the lack of a control group and the small number of patients. Surgical treatment was the exception at our institute for children with patellar instability with only eight patients having an operation during a period of seven years. Unlike the favourable natural history of patellofemoral syndrome in the adult, that of habitual dislocation of the patella in young children is not benign.16,17 Our experience has been that older children with habitual dislocation of the patella typically have progressively worsening symptoms of pain, quadriceps weakness and functional limitations. For this reason we believe that surgical intervention should be undertaken in a selective subgroup of patients. These children were severely incapacitated by their condition which prevented them from living a normal life.

Patellar instability in the young child is always caused by a combination of abnormalities of the extensor mechanism.1,3,4,7 Like Insall et al8 and Scuderi,7 we think that patella alta is a major factor which should be addressed during surgical re-alignment of the patellofemoral joint. At approximately 14 years later, all patients were enjoying unrestricted physical activities. The Lysholm knee score was 95 or greater in all patients. At approximately 14 years later, all patients were enjoying unrestricted physical activities. The Lysholm knee score was 95 or greater in all patients.

Macnab18 and Harrison19 have emphasised the danger of transplantation of the tibial tubercle in children with an open physes. Genu recurvatum may be caused by epiphysiodesis which is liable to occur if the block of bone removed with the tubercle damages the upper tibial epiphysis. In Heywood’s series9 of 13 knees in immature children, four developed recurvatum with valgus deformity requiring a corrective tibial osteotomy. With our soft-tissue procedure addressing patella alta, anterolateral epiphyseal arrest causing genu recurvatum was not seen. Only one other study has been published on the surgical treatment of congenital patellar dislocation with total transfer of the patellar tendon. Gordon and Schoenecker17 reported medial transfer of the entire tendon in 15 skeletally immature patients without epiphyseal arrest or complications.

Studies of patellar instability in the skeletally immature population are rare. Numerous surgical procedures have, however, been described to address this instability with a variable outcome leading to considerable confusion in the literature as to the best method of treatment of patellar instability in children. Hall, Micheli and Mcmanama20 suggested using a semitendinous tenodesis graft and reported a good to excellent result in 63% of a series of patients with a mean age of 14.5 years. In 1985, Fondren, Goldner and Basset21 examined the results of the Roux-Goldthwaite procedure obtaining good to excellent results in 91% of their patients without any cases of recurrent dislocation. A recent study22 retrospectively reviewed 20 patients of a mean age of 14.2 years with chronic recurrent patellar instability who had been treated by a modified Roux-Goldthwaite technique and had a mean follow-up of 6.2 years. No functional outcome was reported, but their reported sulcus angle was not modified.

One major concern with our procedure was the progressive lowering of the patellar height seen in the two youngest patients, aged seven years at the time of operation, who developed a true patella infera with a Caton index12 of less than 0.8. This occurred despite a correct patellar height being achieved post-operatively. Although neither patient complained of pain or showed evidence of degenerative changes, it is recognised that patella infera can predispose to osteoarthritis.13,14 In the surgical technique, by detaching the patellar tendon from the tibial tubercle and repositioning it on the opposite side of the physis, the remaining growth can displace the patella distally.9 We think that it is unlikely that patella infera occurred as the result of scarring of the fat pad. In order to prevent this complication we now include an anchoring suture through the proximal tibial epiphysis securing the patellar tendon back to the tibial tubercle.

We acknowledge that we had no control group available to monitor the natural development of the trochlea, but we believe that our findings show that it can remodel. Before surgery, all patients had a shallow trochlea which was likely to be contributing to patellar instability. The four patients aged less than ten years at the time of surgery showed statistically significant deepening and normalisation of the sulcus angle at the last follow-up (Fig. 6) which was not observed in the older population.

The capacity for articular remodelling is well known in children as exemplified in the dysplastic hip.23,24 Similarly, remodelling of articular cartilage has been documented at the shoulder.25,26 For these reasons we feel that it is reasonable to propose that by restoration of more normal biomechanics at the patellofemoral joint the development of the trochlea can be influenced. As with the hip and the shoulder, our results suggest that remodelling can occur at the knee and this potential is most apparent in the younger patients.

Bias might be considered to have occurred in the measurement of the sulcus angle. However, the positioning technique for patellofemoral views has been standardised for more than 25 years at our institution. Computerised tomography would have provided the most reliable measurements, but this was not available when our study began.

In conclusion, we believe that this long-term follow-up study linking the paediatric to the adult population demonstrates the effectiveness of our surgical technique in treating immature patients with habitual patellar dislocation associated with patella alta. If performed early, remodelling of the shallow trochlea may occur adding intrinsic patellofemoral stability.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.
References