A modified tibial tubercle osteotomy for patellar maltracking

RESULTS AT TWO YEARS

S. Koëter, M. J. F. Diks, P. G. Anderson, A. B. Wymenga

From St Maartenskliniek, Nijmegen, The Netherlands

Malalignment of the quadriceps mechanism can predispose to unstable lateral tracking of the patella and anterior knee pain, or to objective patellar instability.

We consider lateral tracking of the patella to be a subset of Dejour’s potentially unstable group, in which an anatomical abnormality can lead to maltracking and potentially to instability but there is no history of patella dislocation. A patient with lateral tracking of the patella characteristically complains of pain without symptoms of instability. The patella is stable in extension, but CT shows lateral displacement of the tibial tubercle. By contrast, a patient with objective patellar instability presents with episodes of acute subluxation or dislocation. Examination reveals a positive apprehension sign and increased mediolateral patellar mobility in extension. Those patients with maltracking must be distinguished from those with obscure anterior knee pain of unknown cause and those with patellofemoral arthritis. The pathological tracking which leads to malalignment can be caused either by patella alta, trochlear dysplasia, insufficiency of the medial patellofemoral ligament or distal malalignment resulting from an increased tibial tubercle-trochlear groove distance.

Patellar tracking is governed by a complex interaction between soft tissues and bony structures. The anatomical structures which stabilise the patella can be divided into three groups. First, the active stabilisers are the components of quadriceps femoris. Loss of muscle control due to weakness or dysplasia can result in patellar tilt. Secondly, passive stability is afforded by the medial retinaculum as the medial patellofemoral ligament. Laxity of the retinaculum or rupture of the ligament will compromise stability. Thirdly, the bony anatomy and morphology of the patellofemoral joint provide static stability. This is influenced by trochlea dysplasia, patella alta and an increase in the tibial tubercle-trochlear groove distance.
Although many patients with patellar malalignment benefit from conservative treatment, including physiotherapy, some do not. For these, surgery must be considered. Numerous operative procedures have been described, including lateral retinacular release, reconstruction of vastus medialis obliquus, trochleaplasty and transfer of the tibial tubercle. There is no consensus on the indications for these various procedures. The purpose of this clinical and radiological assessment is to identify the factors causing instability so that appropriate treatment may be selected.

We have been particularly interested in distal malalignment and the CT assessment of the tibial tubercle-trochlear groove distance. In a previous retrospective study we performed transfer of the tibial tubercle when the distance was greater than 15 mm strictly according to the CT measurements obtained. We reviewed the outcome in patients with lateral tracking of the patella and objective patellar instability as already defined. All patients in the unstable group became stable except one who had a valgus deformity of the knee of 6°. Relief from pain was good in both groups but better in those with lateral tracking of the patella. We have now carried out a prospective, controlled study to determine if we could confirm these findings. Our aim was to describe the indication, the operative technique and the results of transfer of the tibial tubercle as defined according to the CT scan in patients with lateral tracking of the patella and objective patellar instability.

Patients and Methods

A sample size calculation based on our previous study indicated that we required two groups of 30 patients in order to compare relief from pain in the two groups. The inclusion criteria were the presence of symptoms for more than one year and a tibial tubercle-trochlear groove distance of 15 mm or more.

Trochlear dysplasia was not an exclusion criterion. Patients with previous surgery on the lower limb and complex comorbidity such as a neurological deficit or malignancy were excluded. The institutional review board approved the design of the study.

There were 18 patients who were eligible to participate in the study who did not do so and were not included. Three patients refused to give informed consent. Consent was given by eight patients who did not proceed to surgery for a variety of reasons. For seven patients the interval between inclusion in the study and the operation was too short to collect informed consent or pre-operative scores. One patient with a pre-existing neurological deficit was excluded. A total of 60 patients (30 in each group) were included in the study.

Initial examination. Physical examination included assessment of patellar stability in flexion and extension. The patellar apprehension test and assessment of the range of movement and of the position of the tubercle relative to the trochlea were also recorded. All patients had routine radiological assessment including a standard anteroposte-
rior (AP), true lateral, and 30° skyline views and CT for assessment of the tibial tubercle-trochlear groove distance (Fig. 1). The radiographs were assessed according to Dejour’s criteria.

According to Dejour, four factors are relevant in knees with patellar instability; 1) trochlea dysplasia as identified by a crossing of the bottom of the trochlear and the anterior aspect of the femoral condyles, and a trochlear bump on a conventional lateral radiograph (crossing sign), 2) patella alta as defined by a Caton index equal to or greater than 1.2 on a conventional lateral radiograph, 3) quadriceps dysplasia is present when patellar tilt is more than 20° on a CT scan in extension, 4) an excessive tibial groove tuberosity distance is seen on a CT scan in extension.

**Operative technique.** We use an operative technique which differs slightly from that described by previous authors. A lateral osteotomy of the tibial tubercle is performed in the frontal plane using a small saw blade. This guarantees that there is no anterior or posterior displacement of the tubercle since it is displaced medially. We believe that anterior displacement of the tibial tubercle does not reduce cartilage pressure in a predictable way. The osteotomy is 5 cm in length and 0.75 cm thick. We strongly advise the avoidance of a step cut because we think that this can create a stress riser (Fig. 2). With a periosteal elevator, the medial soft tissue is released subperiosteally to facilitate medialisation. The medial soft tissue remains attached to the tubercle in order to maintain vascularity. In patients with patella alta, the patella is moved distally in keeping with a Caton value of 1.0 to 1.2 provided that the extensor mechanism is sufficient and not unduly tightened. The tubercle is then temporarily fixed bicortically at its lower end with a 2.5 mm drill. The knee is then flexed to 90° so as to ensure that the patella is centred between the femoral condyles. The tibial tubercle will automatically rotate and align to its ‘neutral’ position due to the pull of the extensor apparatus. The amount of correction calculated on the CT scan corresponds to that achieved spontaneously with the knee in 90° of flexion (Fig. 3). Three small-fragment lag screws are used to fix the tubercle in its new position. The drill and screws should be handled with caution to avoid possible injury to the posterior neurovascular bundle. We do not tap the screws.
extreme cases where the patella is initially displaced laterally by about 50% of its width, additional reefing of the medial retinaculum is performed. Continuous passive movement is allowed post-operatively until approximately 60˚ of flexion is obtained. A removable walking cast is applied for six weeks. Physiotherapy is directed primarily at restoring normal gait.

The complications were classified as minor when there was no compromise of outcome and if little or no treatment was required, and major when the final result was compromised or further surgery was required.

Post-operatively, the patellar height was reassessed.

**Statistical analysis.** The variables tested were age, diagnosis (objective patellar instability and lateral tracking of the patellar), pre-operative tibial tubercle-trochlear groove values, the size of the trochlear bump, and the presence of dysplasia (a crossing sign of 1 or 2) as well as the post-operative and post-operative Kujala, Lysholm and VAS scores. In order to include the data from the four patients who were lost to follow-up at 24 months, imputed data (the mean for the diagnosis group) were used. In this way the mean of the group and its standard deviation remained unaffected. Student’s t-test was performed on interval data (age, Kujala, Lysholm and VAS scores) and Pearson’s chi-squared test on the dichotomised variables (tibial tubercle-trochlear groove, trochlear bump and dysplasia). A p-value ≤ 0.05 was considered to be significant.

A logistic regression model was made to determine whether certain variables (i.e. diagnostic group, tibial tubercle-trochlear groove of 20 mm or more, crossing sign or the pressure of a trochlear bump of 3 mm or greater) influenced the outcome of the operation, with success being defined as a reduction of pain of at least 50% at 24 months.

**Results**

The two groups were similar in their findings (Tables I and II). The prevalence of trochlear dysplasia, as expressed by the crossing sign, was higher in the objective patellar instability group. Four patients in this group had a trochlear bump of more than 3 mm according to Dejour’s criteria. The mean medial displacement of the tibial tubercle for the whole group (n = 60) was 6.6 mm (5 to 12). For the lateral tracking patellar group it was 6.6 mm (5 to 11) and for the objective patellar instability group 6.6 mm (5 to 12).

Distal displacement was carried out in 31 patients with a mean displacement of 5.7 mm (4 to 10). In nine patients in the lateral mal-tracking group it was 5.4 mm (3 to 7), in 22 in the objective patellar instability group it was 5.9 mm (4 to 10). In five patients with objective patellar instability and marked lateral displacement of the patella of more than 50%, a medial soft-tissue procedure was required. We did not perform any lateral releases.

Both groups showed similar improvement with no statistically significant differences in the Kujala, Lysholm, or pain scores at 12 months and at the latest follow-up at 24 months (Table II). There was more variability in the outcome in the objective patellar instability group. No logistical model could be made since none of the variables (age, diagnosis, pre-operative tibial tubercle-trochlear groove...
value, trochlear bump of more than 3 mm, or presence of dysplasia) contributed significantly to the outcome (≥ 50% pain reduction).

Complications. A total of 29 patients had symptoms from the screws which were therefore removed after consolidation of the osteotomy had been confirmed radiologically. One patient, in the objective patellar instability group had a patellar dislocation three months after surgery and was successfully treated by an additional medial reefing procedure.

All complications occurred within 90 days. These included two haematomas and one infection which was treated with antibiotics. Major complications included two tibial fractures sustained six and seven weeks after surgery following injury. One fracture was treated by immobilisation in a cast and the other was fixed with a plate. One tibial tubercle fractured per-operatively and later required further fixation. Finally, one patient with a neuroma received pain management.

Discussion

Our prospective study has shown that restoration of the normal anatomical position of the tibial tubercle yields good results in patients with both lateral tracking of the patella and objective patellar instability. Medial displacement of the tibial tubercle as first described by Hauser in 1938 was later popularised by Elmsie et al. Unfortunately, the procedure has been used indiscriminantly for pain reduction. Although the operation seems simple, there are some pitfalls. Most of the major complications which we encountered could probably have been avoided by an improved surgical technique. The two tibial fractures which occurred could be related to the osteotomy. It is essential to make a straight osteotomy (Fig. 2) because a step cut at the distal end of the osteotomy will act as a local tibial stress riser which can result in fracture if the patient sustains even minimal trauma. In order to avoid fracture of the tibial tubercle, the osteotomy needs to be of an adequate length and width. We recommend a length of 5 cm and thickness of 0.75 cm. The thickness can at times be hard to judge during sawing because of movement of the saw blade. A broad chisel used as a saw guide can be helpful.

Because of difficulty in correcting the bony anatomy and morphology of the patellofemoral joint, investigators have focused on the medial soft-tissue structures, predominantly the medial patellofemoral ligament. Several studies have demonstrated promising results with reconstruction of the medial patellofemoral ligament for patellar instability in patients with and without trochlear dysplasia. However, in patients with severe trochlear dysplasia or distal malalignment caused by considerable lateral placement of the tubercle, the medial patellofemoral ligament may be structurally unable to withstand the higher stresses imposed by the lack of bony restraint. Reconstruction of the medial patellofemoral ligament is only indicated in those cases in which it is expected that a reconstruction or repair will be able to withstand these stresses. In all other cases a bony procedure is indicated.

Osteoarthritis remains a long-term risk in patients with objective patellar instability whether the patient has had an operation or not. The incidence of damage to cartilage after patellar dislocation is estimated to be as high as 8.4%. In our opinion, early stabilisation of the patella may prevent further damage and the development of patellofemoral osteoarthritis. Using our operative technique, the amount of medialisation was limited to between 5 mm and 12 mm. The patella centres in the trochlear groove and the tibial tubercle medialises at 90° of knee flexion. We believe this prevents high patellofemoral pressure with subsequent arthritic changes as is seen after the Hauser procedure, is unlikely. It is unclear whether pre-operative arthritic change is a contraindication to surgery. It would be expected that the results would be worse in the objective patellar instability group, but our findings showed that with regard to pain the outcome was the same in both groups. In contrast, in our previous retrospective study the objective patellar instability group had more pain.

Our findings indicate that a modified tibial tubercle transfer with strict attention to correcting both the tibial tubercle-trochlear groove distance and patellar height gives...
good results in patients with both lateral patellar tracking and objective patellar instability. A longer follow-up period is required to evaluate the effects on degeneration of the articular cartilage and the onset of symptomatic osteoarthritis.

We thank Dr. M. Holla for his help in preparing the illustrations. 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