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Tibial tuberosity derotation: a surgical procedure for realignment of the patellofemoral mechanism

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Abstract We retrospectively reviewed the clinical outcomes of 22 patients (9 men and 13 women) aged 17–42 years, and affected with anterior knee pain. These patients underwent surgical derotation of the tibial tuberosity in the period between September 1992 and December 1993. We describe the details of this new surgical technique to correct a torsional abnormality that has perhaps been underestimated in the past, as a possible cause of anterior knee pain. Follow-up clinical and radiographic controls (average follow-up, 78 months; range, 72–87 months) allowed us to document the efficacy of this new procedure as a treatment for anterior knee pain resistant to conservative therapy, in young patients with external hypertorsion of the proximal tibial metaphysis and without significant chondropathology.

Key words Derotation · Malalignment · Maltracking

Introduction

In accordance with Holmes and Clancy [1], we believe that it is possible to divide the pathology of patellofemoral joint into 3 broad categories:

1. Patellofemoral instability (luxation and subluxation);
2. Patellar pain without malalignment;
3. Patellar pain with malalignment, but without instability.

Falling in this last category are the patellofemoral syndromes caused by torsional defects of the extensor apparatus, the objective of our study.

The frequent association of patellofemoral pain and malalignment of the extensor mechanism is well known [2]. In 1988, Merchant maintained that the malalignment produced by femoral intratorsion and compensatory tibial extratorsion leads to an increase in the lateral patellar compression forces [3]. Subsequent experimentation [4] has demonstrated the effects of tibial rotation on the patellar tracking and on the patellofemoral contact areas. Recently, Jackson [5] asserted that the principal cause of maltracking of the patella is malalignment of the quadriceps, which produces a bowstring effect between its mean point of origin and its insertion onto the tibial tubercle. Moreover, isolated external tibial torsion is a rare cause of patellar instability [6].

In our experience, lateral hypertorsion of the tibial metaphysis (enough to cause excessive compression on the external facet of the patella) is a common finding in patients with anterior knee pain, and is even observed with computed tomography (CT).

The biomechanics of the extensor apparatus of the knee can be compared roughly to a belt on a pulley. The pulley represents the femoral trochlea while the belt represents the complex formed by the quadriceps tendon-patella-patellar tendon. Mechanically, such a system must be aligned on the same frontal plane.

When lateral hyper-torsion of the tibial metaphysis exists, the belt, while coming out of the pulley, is drawn not only outwardly (this first component corresponds to an excessive Q angle and it can be corrected with internal

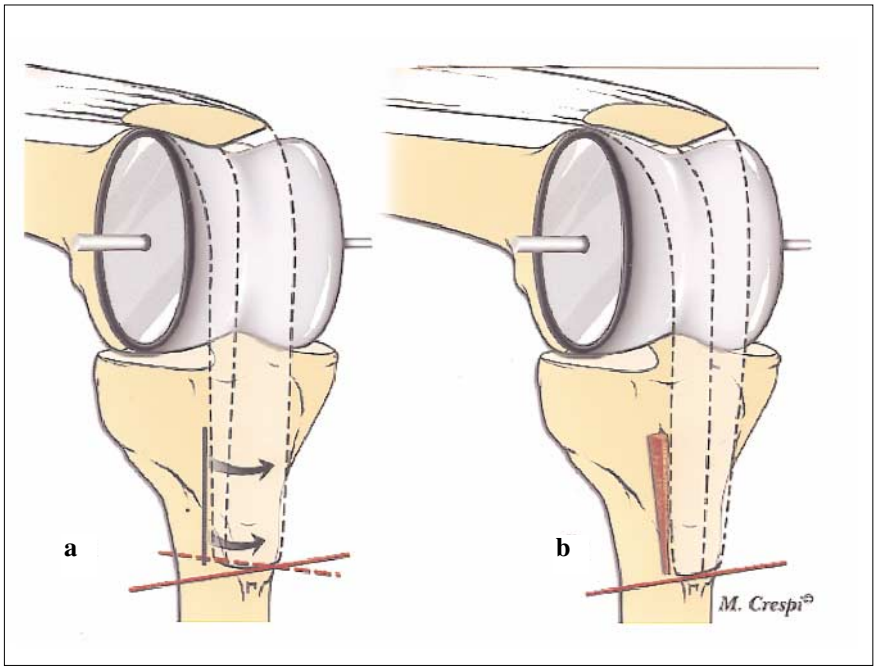

Fig. 1 a External hypertorsion: the distal portion of the belt is not aligned on the same plane of the proximal portion. **b** The goal of surgery is that of reducing the torsional anomaly

translation of the Emslie-Trillat type), but also, and most importantly, posteriorly, due to a torsion movement around its vertical axis (Fig. 1a).

A system then develops where the two elements, trochlea and patella, are aligned on almost parallel planes (especially if the trochlear angle is closed and little possibility is left for lateral movement of the patella), but where the plane of the patellar tendon forms a dihedral angle open outwards and backwards with the former. The Q angle is therefore not only amplified, but is no longer situated on a frontal plane with its sinus facing backwards and outwards. This type of torsional anomaly has the following consequences:

1. A medial recentering of the patella at the beginning of flexion due to the action of the patella itself on the trochlea (this may be the cause of some of the lesions of the inferior half of the patella so often found).
2. A dynamic lateral excessive compression when the flexion is more pronounced (this may explain the pain under stress especially downwards, and the pain while in a prolonged sitting position).

Many surgical procedures have been described, both for the realignment of the extensor apparatus and for the reduction of the excessive patellar compression. Several authors [2, 7] divide all the techniques into four principal groups:

- Surgical release of the lateral retinaculum
- Lateral release and medial retension
- Surgery for proximal realignment
- Surgery for distal realignment (e.g. anteriorization and/or medialization of the tibial tuberosity [2], derotational osteotomy of the tibia [6], Maquet tibial osteotomy [5]).

The technique of tibial tuberosity derotation, proposed and used by De Nicola et al. [8], consists of a distal realignment on the frontal plane with consequent reduction of the external patellofemoral pressure (Fig. 1b). This latter, based on studies on anatomic preparations [4] – and on a par with the more widely used techniques such as the Maquet procedure – can achieve a reduction of about 50% if the tibial extratorsion is reduced surgically.

In our study, the results obtained with this surgical procedure in the medium term have been evaluated in a group of 22 patients with patellar maltracking.

Materials and methods

From 1992 to the present, we performed 103 tibial tuberosity derotations. However, our study only concerned 22 patients: 9 men and 13 women, aged 17–42 years. These patients were affected by a painful patellar syndrome that had persisted for a period between 8 and 18 months. Nine patients had surgery of the right knee, 11 were operated on the left knee and 2 patients underwent bilateral surgery during the period between September 1992 and December 1993. Preoperatively, each patient underwent a cycle of physiokinesiotherapy [9, 10] for at least six months. Seven patients had already undergone lateral release surgery in arthroscopy with little improvement, about one year prior.

To analyse the relationship between the patella, trochlea and tibial tuberosity [11, 12], the following preoperative radiological evaluations were performed: a standard view radiogram of the knee, an axial radiogram at 30° (Merchant) and a computed tomography (CT) scan according to the Lionese protocol. The trochlear plane was determined by a straight line linking the end points of its

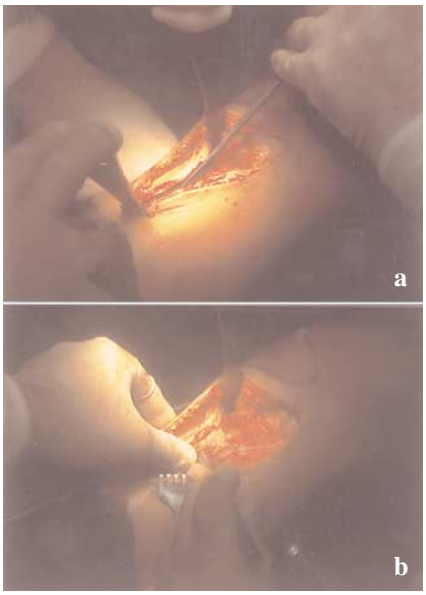

Fig. 2 a Fragment mobilization with a scalpel. **b** The graft insertion maintains the internal rotation of the osteotomy

margins. The patellar plane (P) was determined by a straight line that passes its internal and external articular limits; the plane of the patellar tendon (PT) was determined by a straight line passing by the 2 points equidistant from the top of the tibial tuberosity. The PT-P angle, opened outwards and formed by the plane of the patellar tendon and the patella, corresponds to the part of the tibial torsion concerned and the objective of the surgery is that of reducing it until it disappears (Fig. 3). Another useful assessment to perform is that of the AT-TG space (anterior tibial tuberosity-trochlear groove), using the Goutallier method [12]: it is actually possible to measure the interspace that separates the tibial tubercle from the intercondylar groove (normal value, 12 mm). The average tuberosity sulcus distance in our group of patients was 12.9 mm.

Patients who had histories of at least one episode of patellar dislocation, those in whom the knee presented a high patella, i.e. evident signs of patellofemoral dysplasia, and of course, patients with growth cartilage still fertile, were not included in our study.

The preferred type of postoperative rehabilitation was continuous passive mobilization, immediate, active, assisted mobilization (non-weight bearing) and light weight-bearing perambulation on the seventh day, with the achievement of full weight bearing by the thirtieth postoperative day.

Surgical technique

The site of access was longitudinal-lateral in a distal-proximal direction (1 cm laterally to the patellar tendon and to the lateral border of the patella), beginning in correspondence with the apex of the tibial tuberosity and ascending to the superior pole of the patella itself. The lateral alar ligament was sectioned completely. The liberation of the lateral margin of the patellar tendon and of the patella was completed from the bottom upwards until the inferior fibers of the lateral vastus were reached. The capsule was not incised, as this was an extra-articular operation. Using a periosteal elevator, the anterior tibial muscle was partially separated from the lateral facet of the metaphysis for about 6 cm distally, where osteotomy was performed.

Osteotomy of the tibial tuberosity was initially performed with an oscillating saw notching the cortex transversally, a few millimeters above the insertion of the patellar tendon for a length of about 5 cm, distally, directly parallel to the insertion of the patellar tendon itself. Next, with a scalpel (Fig. 2a), moving internally and from top to bottom, the medial cortex was reached; this should by no means be notched so the pivot can be built to allow the tuberosity to turn. This fragment was mobilized with delicate movements of the scalpel and then a specially made bony wedge was grafted (Unilab Surgibone Inc., Mississanga, Ontario, Canda), degrading in the proximodistal and lateromedial directions, which can be done at various angles. The wedge (inserted using the proper tool) has the task of maintaining the internal rotation of the osteotomy and, therefore, that of the tuberosity (Fig. 2b). A careful hemostasis and layer-by-layer suturing followed.

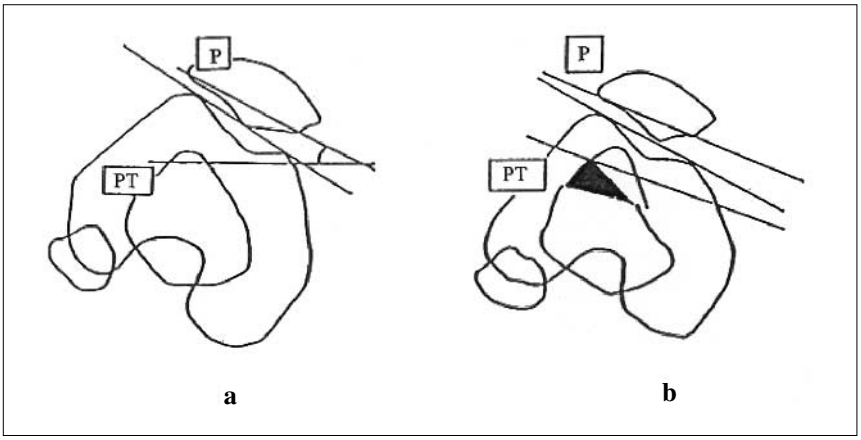

Fig. 3a,b *The graft insertion reduces the PT-P angle until it disappears.* **a** Preoperative situation. **b** Postoperative situation

Results

Clinical and radiological follow-up (average follow-up of 78 months; range, 72–87 months) was done by external colleagues, using the Crosby, Insall and Heywood evaluation form (Table 1) [9, 13], integrated with Lysholm functional knee score. Each patient also had a standard radiogram as well as one with axial view (Fig. 4 a, b). In 2 cases we performed CT (Fig. 5).

The pain disappeared in 13 patients; it developed after moderate activity in 3 patients and appeared only occasionally in 4 patients. In only 2 cases did the pain remain unchanged. In 2 cases, occasional episodes of joint rigidity were reported, while in 4 cases, partial limitation of sporting activities was reported. No patients reported problems with the scar or with the slightly increased size of the tibial tuberosity, while 5 patients reported difficulty in assuming or maintaining a kneeling position. The form designed by Crosby and Insall [13] allows the expression of a final grade (poor, fair, good, excellent) based on the score obtained by each patient. The range of scores was as follows: 9 patients, excellent; 6 patients, good; 4 patients, fair; 3 patients, poor. After surgery, the Lysholm score increased from 43 to 81.

When questioned about the degree of satisfaction with the corrective surgery, 16 patients declared themselves to be very satisfied, 3 patients were fairly satisfied, and 3 patients were not satisfied.

Table 1 Criteria for evaluation of the clinical results

Pain	4, none; 3, occasional and minimal; 2, after moderate activities; 1, persistent
Stiffness	4, none; 3, occasional and minimal; 2, after moderate activities; 1, persistent
Retropatellar crepitus	4, none; 3, only by passive movements; 2, after moderate activities; 1, persistent
Limitation of flexion	4, none; 3, 0°–5°; 2, 6°–10°; 1, more than 10°
Loss of function	4, none; 3, restriction of strenuous sports but not of other activities; 2, moderate restriction of sports and/or other activities; 1, complete restriction of sports and/or other activities
Results	Excellent, 19–20 points; Good, 17–18 points; Fair, 15–16 points; Poor, 10–15 points

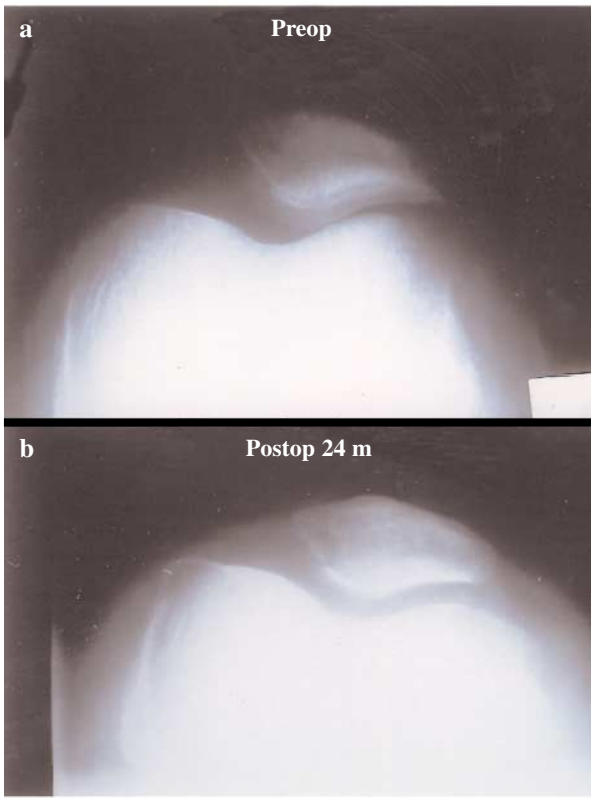

Fig. 4a,b *Axial radiograms.* **a** Preoperative situation. **b** Postoperative situation

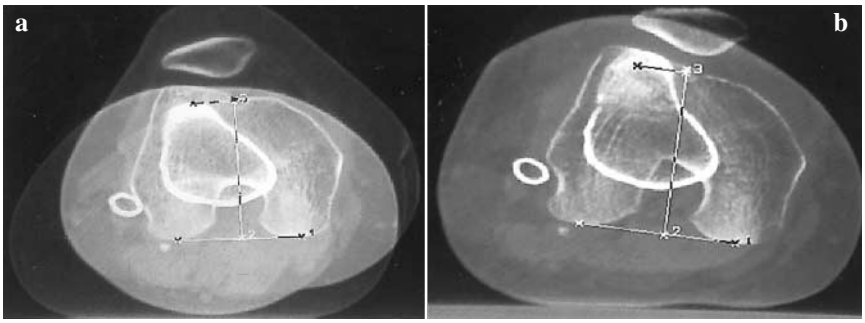

Fig. 5a,b *Computed tomograms*. **a** Preoperative situation. **b** After tibial tuberosity derotation

Discussion

Maltracking of the patella may lead to excess overload with sheer forces being applied to the articular cartilage in some areas while underloading may occur in others. Both hyperpression and hypopression may be detrimental to nutrition of the cartilage. But patellar maltracking is only one of the possible causes of obscure knee pain [5, 14]: how should one approach patients in whom the diagnosis is not obvious? Surgery should not be performed in the absence of a demonstrable abnormality: an adequate program of physical therapy (consisting of a progressive isometric strengthening program of the quadriceps, stretching of the ischiocrurals, elimination of activities that require knee flexion of more than 90° and periodic administration of anti-inflammatory medications) produces a positive outcome in about 82% of the cases [9, 10, 15].

Numerous authors [16–18], in addition to confirming the success of bloodless treatment, have reported satisfactory results for lateral release with percentages ranging from 14% to 99% of the cases. We believe, however, that the chronic retraction of the lateral alar ligament is sometimes only the consequence of a rotational abnormality and thus, in these cases, simple sectioning of the external alar ligament can be insufficient or give transitory positive results. In at least 50% of symptomatic patients, it is possible – with radiography or with CT – to actually show precise signs of malalignment of the extensor apparatus [19]. The radiological studies we used, based on determination of the planes of alignment of the femoral trochlea, of the patella and of the patellar tendon, showed the possible presence of an alteration in alignment of the extensor apparatus on the frontal plane.

The therapeutic effect of tibial tuberosity derotation (if used when maltracking has been well demonstrated) is represented by the medial rotation of the tibial tuberosity and therefore of the patellar tendon insertion, to give a parallel disposition to the planes passing through the femoral trochlea, the patella and the patellar tendon (Fig. 6). In this way the postero-external component of the Q angle is eliminated, while its value on the frontal plane is preserved. Maintaining the Q angle is important for keeping control of movements in varus-valgus, insuring automatic rotation during flexion and allowing knee stability when it assumes positions at the maximum grades of valgus and in external rotation. Moreover, elements of the principle of Maquet are incorporated into this derotational osteotomy, which invariably leaves a slightly elevated tubercle (Fig. 7).

The critical review of the results obtained – with an average follow-up of 6.5 years – showed the importance of the selection of patients to undergo surgical treatment. In fact, the worst results obtained were in 3 patients older than 35 years of age, with significant patellar chondropathies. In these cases, the damage caused by persistent patellar maltracking was too advanced to benefit from this kind of surgery.

In more than half of patients operated, we were able to achieve the complete disappearance of the anterior knee pain, and in all patients under 30 years of age – without

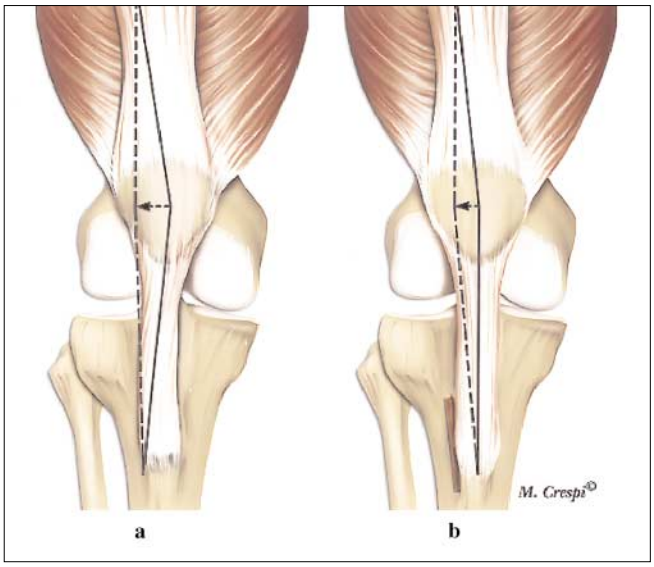

Fig. 6a,b *Therapeutic effect of derotational osteotomy*. **a** Preoperative situation. **b** Tibial tuberosity derotation reduces the external patellofemoral pressure

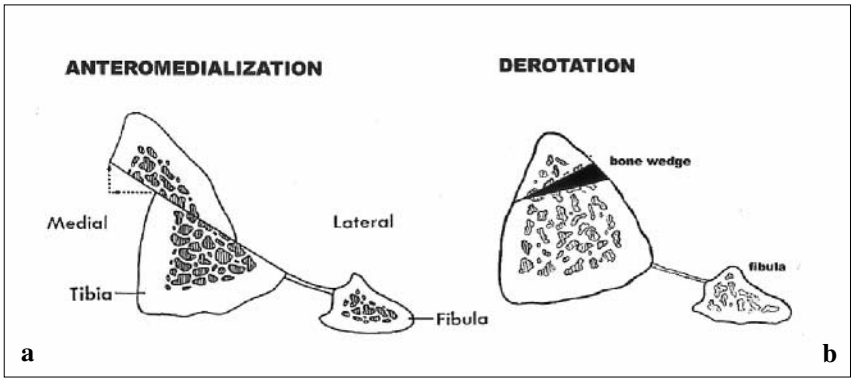

Fig. 7a,b *Tibial tuberosity derotation and its Maquet effect.* **a** Anteromedialization. **b** Derotation

associated chondropathies – we were able to obtain a considerable reduction in the pain symptomatology.

The tibial tuberosity derotation is therefore a simple and effective procedure: the lower level of invasiveness of this treatment compared to the most common surgical techniques of distal realignment (e.g. Maquet, Fulkerstone, Elsmie-Trillat, Cameron) allows for the immediate, passive and active mobilization (assisted and non-weight-bearing) of the operated knee, and light weight-bearing walking on the seventh day, reaching full weight-bearing status one month after surgery.

In light of these issues, limiting ourselves to cases with precise specifications (i.e. young patients with anterior pain resistant to conservative treatment, with documented extratorsion of the extensor apparatus, and without significant chondropathies), the technique produced good outcomes. This leads us to believe that we are on the right track.

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