Gracilis tendon transfer associated with distal alignment for patella alta with recurrent dislocations: An original surgical technique

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KEYWORDS
Medial patellofemoral ligament; Recurrent patellar dislocation; Muscle transfer; Gracilis muscle; Patella alta

Summary  Many surgical techniques for the medial patellofemoral ligament have recently been suggested, all of which included problems identifying the femoral anchorage point and determining the proper extent of knee flexion for the transplant. P. Burdin proposed a different and original approach consisting in performing a gracilis muscle transfer to the medial edge of the patella, thus obtaining progressive tension of the transfer during knee flexion by means of the myotatic reflex. We report the results herein. We retrospectively assessed 17 knees treated for patellofemoral instability using this technique. Two cases presented subjective patellofemoral instability and 15 presented objective patellofemoral instability. The patients’ mean age was 17.4 years (range, 8–47 years) during the first episode of dislocation. Two cases of instability were secondary to advanced neuromuscular disease. Two knees had already undergone two stabilization attempts. Fifteen knees presented trochlear dysplasia (four stage A, eight stage B, and three stage C). The mean age at surgery was 28.2 years (range, 16–47 years). In 15 cases, the gracilis transfer was associated with lowering the anterior tibial tuberosity (mean, 10 mm). No patellar fracture occurred. A persistent sensory deficit of the anterior branch of the internal saphenous nerve was observed in 15 cases. One knee remained painful and retained subjective instability; total knee arthroplasty was performed 3 years after the intervention. The mean follow-up at revision was 5.5 years (range, 1.5–16.5 years). No recurrence of dislocation was reported. Eight cases retained subjective instability. The SF-36 and IKDC scores were good or excellent in 12 cases and the KOOS was good or excellent in 13 cases. Radiologically, patellar tilt persisted in six cases out of 14, translation persisted in two cases out of 14, and secondary patella baja was observed in one. Medial patellofemoral osteoarthritis was observed in five cases: one case IWANO stage I and four cases IWANO stage II. These satisfactory results seem stable over time and were acquired using a simple procedure with reduced morbidity, making it possible to avoid significant displacement of the anterior tibial tuberosity and stabilize the extensor apparatus. It can also be hoped that the onset of secondary patellofemoral osteoarthritis, undoubtedly inevitable, has been delayed.

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doi:10.1016/j.otsr.2011.03.013
Introduction

Among patients with recurrent dislocation of the patella, cases with the association of patella alta, trochlear dysplasia and medial stabilizer deficiencies are challenging [1,2]. Since patella alta has been documented in association with hypoplasia of the medial patellofemoral ligament (MPFL) and as well as a dysplastic vastus medialis obliquus muscle (VMO), we hypothesized that these specific cases could be the result of compound tissue dysplasia of both muscular and ligamentous stabilizers on the medial side of the patella [3–6]. In the past 10 years, the MPFL has been documented to be and the main stabilizer of the patella [7]. At the same time, numerous surgical ligamentoplasty techniques have been proposed for medial patellar reconstruction [8]. At present there is no consensus about the isometric points or the tension to be applied to these reconstructions although this is an important aspect of these ligamentoplasties [9]. Consequently abnormal tracking of the patella due either to anisometric or over tightened medial realignment has been shown to overload the patellofemoral joint, exposing the patient to premature patellofemoral secondary arthritis [10,11]. In an attempt to avoid overcorrection of either distal alignment or MPFL reconstruction and to address the different components of this pathology, we propose a procedure that combines distal tibial tubercle alignment with a gracilis tendon transfer to the patella. The aim of transferring the gracilis tendon to the patella is to reconstruct the MPFL and increase the VMO [12]. The aim of this study was to explain this surgical technique and report the follow-up of these cases.

Patients and methods

Inclusion criteria

This retrospective study included patients who were consecutively operated on from 1992 with a minimum follow-up of 18 months. Inclusion criteria were: recurrent luxation of the patella (minimum of three), patella alta, trochlear dysplasia and medial stabilizer deficiencies in which conservative treatment had failed. The surgical procedure was proposed based on the results of a clinical and radiological evaluation. Patella alta was defined by a Caton-Deschamps Index greater than 1.2 based on a lateral view of the knee at 30° of flexion [13]. Trochlear dysplasia was defined according to the Dejour classification based on a lateral view of the knee as well as on CT-scan [14]. Associated lateral implantation of the tibial tubercle was defined by tibial tubercle-trochlear groove (TT-TG) offset greater than 20mm, which was also identified on CT-scan to plan distal realignment [15]. A medial stabilizer deficiency was defined by the association of: abnormal patellar tracking with a J sign in early flexion, transverse hypermobility of the patella and a positive Smillie apprehension test [16]. Surgery was performed by two surgeons (PB, JB) according to a predefined surgical protocol.

Figure 1 Transposition of the anterior tibial tubercle. 1: step cut osteotomy is performed first at the level of the attachment of the patellar tendon with a reciprocating saw; 2,3: double distal osteotomies separated by planned patellar lowering; 4: ostectomy of the tibial tubercle finalized by a thin oscillating saw strictly on the coronal plane. The tibial crest fragment is mobilized and translated according to preoperative planning. The tibial tubercle is then translated distally as the previously resected distal fragment is transposed under the proximal step cut and plugged in to the proximal gap to bridge it.

Surgical technique

The patient is placed in the supine position on the operating table and examined under anaesthesia to assess patellar kinematics during passive knee flexion before inflation of the tourniquet. A lateral thigh post helps stabilize the femur during the wide range of motion required for the procedure. A tourniquet is placed high on the thigh and inflated with the knee flexed to limit its effect on muscle balance. Distal realignment of the tibial tubercle is performed first with the knee in complete extension. This is limited to correction of patellar height (neutral Caton-Deschamps Index = 1) and tibial tubercle-trochlear groove offset (neutral TT-TG = 13 mm). A medial parapatellar approach is performed. Dissection is performed to expose the attachment of the patellar tendon to the tibial tubercle. A 7 cm long tibial tubercle osteotomy is marked by electrocautery taking care to leave the pes anserinus intact. Release of the musculature of the anterior compartment of the lateral tibia is performed with minimal periosteal elevation. The lateral edge of the patellar tendon is released taking care not to extend to the patella and to perform a lateral release. Step cut osteotomy is performed first at the level of the attachment of the patellar tendon with a reciprocating saw (Fig. 1). The tibial tubercle osteotomy is completed with a thin oscillating saw on a strictly coronal plane. The tibial crest fragment is mobilized and translated according to preoperative planning. Measured distal transfer of the tibial tubercle is performed by careful resection of the distal tibial crest fragment. The tibial tubercle is then translated distally as the previously resected distal fragment is transposed under the proximal step cut and plugged in to the proximal gap to bridge it. After making final adjustments, the tibercle is fixed with two 4.5 mm screws. Countersinking the screws helps minimize skin irritation and potential need for screw removal.

Gracilis tendon transfer is then performed. Incision of the intermediate layer is made along the proximal edge of the pes anserinus. This transverse incision is extended prox-
While pulling on the free ends of the suture placed earlier in the procedure, the gracilis tendon is freed from its attachments to the medial gastrocnemius either with a scissors or a blunted tendon stripper.

Initially in a reverse L shape along the anterior edge of the medial collateral ligament up to the medial epicondyle. The proximal extremity of this incision serves as a soft pulley for the gracilis tendon transfer. The gracilis tendon is picked out from under the sartorius tendon and isolated on a ribbon. An additional limited incision is performed over the end of the gracilis tendon to avoid severing the proximal edge of the sartorius tendon. The sartorius tendon is then split and the insertion of the gracilis tendon in the tibia is cut sharply with a knife. The end of the gracilis tendon is whip stitched with a number 2, non-absorbable, braided suture. While pulling on the free ends of the suture with the knee in maximum flexion, the gracilis tendon is freed from its attachments to the medial gastrocnemius either with a scissors or a blunted tendon stripper (Fig. 2). Care must be taken not to damage the muscle belly during this sequence.

A small incision is made on the medial edge of the patella elevating the medial retinaculum and periosteum. The bony surface is exposed at the level of the native insertion of the MPFL distal to the VMO. A short medial parapatellar arthrotomy is performed to inspect the cartilage and remove the ossifications, which are frequently located in the medial retinaculum. The condition of the medial patellar femoral joint is noted at the time of surgery. This arthrotomy is also helpful for checking medial facet loading when the gracilis tendon transfer has been secured to the patella. A 4.5 to 6 mm diameter (depending on the size of the gracilis tendon) bone tunnel is drilled in the patella at the level of the native insertion of the MPFL. This tunnel is blind and runs posterior to anterior through the medial third of the patella. Once this tunnel has been drilled, two smaller tunnels are drilled with a 1.8 mm K wire from the distal part of the tunnel to the anterior cortex of the patella. Wire loops are run through these tunnels to help pull the free ends of the whip suture through. The sutures are grasped, and the tendon transfer is recessed in the patellar tunnel (Fig. 3).

Although tension is evaluated as the knee is moved through the range of motion, there is no specific tensioning maneuver of the graft since fixation of the transfer and muscle activity will compensate for this. Tendon transfer should be sufficient to limit lateral translation of the patella to approximately one to two quadrants while avoiding medial patellar translation. If necessary, the tourniquet is deflated to allow free motion of the muscles during this part of the procedure. A lateral release is not indicated since it may lead to overmedialization of the patella. The whip sutures are knotted together and buried under the anterior periosteum to prevent skin irritation. The remaining free part of the gracilis tendon is stitched to the medial superficial layer with thin absorbable sutures with the knee in a flexed position. The initial reverse L-shaped incision and the medial arthrotomy are sutured once the wound has been irrigated (Fig. 4). Wound closure is performed in layers over routine suction drains. After dressing the wound, a bandage is applied and the joint is immobilized using a removable brace, near extension.

Drains are removed after a postoperative period of 24 to 48 hours. Postoperatively, the patient is authorized to apply weight as tolerated with the knee in full extension in a knee splint. Protected range of motion is started immediately and should progresses as quickly as the patient can tolerate. Weight bearing without the knee splint is authorized six weeks after surgery when the tibial tubercle osteotomy has healed (Fig. 5).

**Evaluation**

Results were evaluated by an independent observer (EM) in the first semester of 2008 with a minimum follow-up of 18 months. Clinical and radiological data were obtained from the patient’s charts. Surgical complications, recurrent dislocation as well as any additional operations were recorded. All patients were contacted by telephone and a functional evaluation was obtained during the interview...
The gracilis tendon is stitched to the medial superficial layer with thin absorbable sutures with the knee in a flexed position. The initial reverse L-shaped incision and the medial arthrotomy are sutured once the wound has been irrigated.

Figure 4

Results

The series

All patients were contacted. There were 19 cases (16 patients). Three patients (three cases) were excluded from the study because of an associated disease: one with Charcot-Marie-Tooth disease, one with severe polyneuropathy with equinus deformity and one with post-traumatic knee joint arthritis requiring total knee arthroplasty. Sixteen cases (13 patients, five males, eight females) were evaluated using the standardized questionnaire on the telephone. All patients were asked to consult for a clinical and radiological evaluation. Two patients (two cases) living abroad declined. Fourteen cases (11 patients) were reviewed.

Mean age at surgery was 23.5 years old (16—48). One case had undergone two prior operations; lateral release of the patella and distal realignment. Six cases (six female) presented documented joint hyperlaxity syndrome. Mean age at the time of the first dislocation was 14 years old (8—32). Tibial tubercle transposition to obtain distal realignment was 10 mm (5—20) distal and 10 mm (0—20) medially. In two cases, simple lowering was performed. There were no patellar fractures. The only complication was a sural phlebitis in one case that resolved without sequelae after medical treatment. Seven cases underwent a second intervention for screw removal.

Functional results

After a mean 7.5 years of follow-up (2—17), none of the patients had experienced recurrent dislocation or feelings of subluxation. Although all patients had returned to sports, apprehension was still present in four cases (four patients) when jumping. The mean SF-36 activity score at follow-up was 81 (43—88). KOOS profiles at follow-up were: mean symptoms score 93 (39—96), mean pain score 97 (47—100), mean daily living activities score 97 (60—100), mean sports and recreational activities score 70 (range 35—100) and mean quality of life score 81 (31—100).

Clinical results

None of the 14 cases examined had changes in range of motion. One case had a secondary 10° recurvatum after distal tibial tubercle transposition. Eleven cases of crepitus were noted during active range of motion compared to seven in the preoperative evaluation. There was a persistent positive Smillie apprehension test as well as transversal hypermobility of the patella in four cases. Persistent abnormal patellar tracking with a J sign in early flexion was present in four cases.

Radiological results

Preoperative and follow-up radiographic findings were compared in the 14 cases. All cases had trochlear dysplasia according to Dejour’s classification: three type A, nine type B and four type C. Mean trochlear angle was 139.1° (127—143). Tibial tubercle-trochlear groove mean offset on CT-scan was...
20 mm (range 7—28). Patella alta was present in all cases with a mean Caton-Deschamps index of 1.3 (1.2—1.5). At follow-up, the mean Caton-Deschamps index for patellar height was 1.03 (range 0.81—1.17). Two cases had limited patellofemoral arthritis with less than 50% of joint narrowing at 5 and 7 years follow-up respectively.

**Discussion**

The purpose of this study was to evaluate the results of our original procedure in recurrent dislocation of the patella associated with patella alta, trochlear dysplasia and a medial stabilizer deficiency. The results of our cases support the success of the procedure for this indication. Although numerous different procedures have been described for the treatment of patellar instability, the optimal surgical treatment has not been defined [19]. Although this series does not change this, we would like to discuss the rationale that led us to develop this original approach.

Instability of the patellofemoral joint is multifactorial. It relies on osseous architecture, soft-tissue constraints and the interplay of the surrounding muscle. When dealing with patellar instability from patella alta, trochlear dysplasia and a medial stabilizer deficiency, the different aspects of this pathology must be understood and addressed. Patella alta is due to increased length of the patellar tendon [20] which has at least two mechanical consequences: first it delays the amount of flexion needed to achieve stability with congruence of the patellofemoral joint, second it adds to the normal valgus alignment of the extensor apparatus [21]. It is also associated with a smaller or absent MPFL [4]. This association is crucial since the MPFL is known to be the major soft-tissue static restraint for resisting lateral patellar displacement [22—24]. The MPFL itself has close anatomical connections with the VMO, which is the only active medial restraint of the patella [25]. Since VMO has been shown to be dysplastic in knees with patellar instability [26] and the MPFL was absent or non-identifiable in 69% of the knees dissected by Reider et al. [4], we hypothesized that both the VMO and MPFL were part of medial soft tissue complex dysplasia in knees with patella alta and trochlear dysplasia. We concluded that any procedure to address these cases would require both increasing patellofemoral joint stability at 20° of flexion by lowering the patella with distal translation of the tibial tubercle [27] and increasing the strength of the dysplastic medial soft tissue complex. For the latter, both passive and active reconstructions were required. The idea of muscle transfer to supplement the deficient VMO muscle as well as the deficient medial retinaculum ligaments appeared to be a key aspect of the procedure.

Although trochlear dysplasia is a major aspect of this pathology it was not addressed in our procedure [13,28,29]. This was mainly due to the poor and inconsistent results obtained by trochleoplasty [30—32] associated with potentially fatal complications [33]. This point was crucial when developing the rationale of our procedure: could we consistently perform the procedure with limited iatrogenic complications for our patients? Transposition of the tibial tubercle was limited to normalizing both patellar height and tibial tubercle-trochlear groove offset to avoid overloading the patellofemoral joint [34]. Dynamic reconstruction of the MPFL was also partly for this. From a technical point of view, although MPFL reconstruction studies seemed to have the lowest redislocation rate [19], at least two obstacles remain. First, the pattern of length change during MPFL reconstruction mainly depends on the site of femoral attachment and at present there are insufficient data to provide a basis for a physiological attachment point. Second, there are insufficient data on the amount of graft tensioning and the optimal degree of flexion necessary for tensioning. We hypothesized that a dynamic muscle transfer would self adjust and provide protection against potential overload of the patella from graft reconstruction due to non-anatomic positioning or non-physiological tensioning of the graft [35]. However, we must admit that the data supporting this conclusion are limited. One limitation of this technique is that control of the transferred muscle depends on the patient’s ability to control lower leg muscles and the unique anatomy of the trochlea in each case.

Dynamic reconstruction of the MPFL by transferring the semitendinous tendon to the patella has recently been proposed [36,37]. These techniques use the medial collateral ligament as a pulley to orient the distal part of the tendon. We believe that although this may solve the problem of tensioning the graft, once it has healed it may lose the dynamic aspect of the transfer and unnecessarily damage the medial collateral ligament.

In relation to the choice of muscle to transfer, although the hamstring tendon has been shown to have a potential for regeneration and the semitendinosus muscle may recover, we were concerned with the impact of harvesting the semitendinosus muscle [38]. Harvesting a muscle as strong as the hamstring to reconstruct a 208 N structure such as the MPFL seemed unnecessary and possibly damaging [39]. Thus, we chose to transfer the gracilis muscle to reduce the potential iatrogenic risks of the procedure. This was also due to the anatomical proximity of the gracilis muscle to the dysplastic VMO which we wanted to augment.

Finally, we evaluated the choice of tendon to patella fixation. Although Mountney et al. [40] found the bone tunnel to be optimal, patellar fractures have been documented after fixation of the tendon. When reviewing the published cases, fracture occurred either because of violation of the anterior cortex of the patella or with completely transversal bone tunnels [41—43]. Thus we propose fixation in a blind tunnel limited to the medial third of the patella.

This study is limited by its retrospective design as well as the limited number of cases. It is however a homogeneous group of patients with a median 7.5 years follow-up including eight cases (50%) with more than 6 years follow-up and four cases of over 15 years. No recurrent dislocation was observed but apprehension as well abnormal patellar tracking was persistent in four cases (25%). Despite this, limited patellofemoral arthritis was observed in two cases at 5 and 7 years follow-up, suggesting that long-term follow-up is required to document the potential impact of the procedure on patellofemoral arthritis.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.
References


