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Outcomes of tibial tuberosity transposition and patellofemoral ligament reconstruction in the treatment of objective patellar instabilites: Evaluation using the swiss müller score

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Abstract
Background: Patellar instability results from bony, capsulo-ligamentary and/or muscular deformities. The most performed surgical techniques are anterior tibial tuberosity translocation and medial patellofemoral muscle reconstruction.
Objective: The aim of this study was to evaluate the clinical and functional results of these two surgical techniques.
Method: This retrospective study included 54 unstable patellas managed between January 1999 and November 2019 in several hospitals in Abidjan (Côte d'Ivoire). According to the Dejour classification, 13 lesions (24%) were classified as Type A, 30 (55%) as Type B, 9 (17%) as Type C, and 2 (4%) as Type D. Treatment consisted of ATT transfer and anatomical MPFL reconstruction guided by Dejour's classification. Clinical and functional results were assessed using the Müller score.
Results: Forty-three (79%) knees classified as Type A (n=13, 24%) and Type B (n=30, 55%) were operated on by ATT translocation (Group A). Eleven (20%) knees classified as Type C (n=9, 17%) and D (n=2, 4%) were operated on by anatomical MPFL reconstruction (Group B). In Group A, 11 (25%) had a very good result, 29 (67%) had a good result, 1 (2%) had an average result, and 2 (4%) had a poor result. In Group B, 2 (18%) had a very good result, 7 (63%) had a good result, 1 (9%) had an average result, and 1 (9%) had a poor result. Six (13%) complications were found in the 43 patients in Group A. In Group B patients, 4 (36%) complications were identified.
Conclusion: Our results were satisfactory overall in both surgical techniques, as demonstrated by significant statistical tests.

Keywords: Clinical and functional assessment, müller score, patellar instability, surgical techniques.

Introduction

Patellar instability differs from recurrent dislocation of the patella [1]. The difference lies in the anatomy of the patellofemoral joint [2].
Recurrent dislocation of the patella may be congenital, due to injury, or simply habitual, with a basic anatomical defect in the knee region [3].
Patellar instability is the result of bony, capsulo-ligamentary and/or muscular deformities [4]. A distinction is made between subjective patellar instability (or patellar subluxation) and objective patellar instability, which is a true dislocation [5].
Objective instability is usually found in young, active subjects [6]. Its incidence was estimated in 2014 at 1 in 1000 cases by Koh *et al* [7]. Clinical signs are not very specific. The diagnosis is confirmed by signs found on radiography and magnetic resonance imaging (MRI) [8].
The criteria for instability are trochlear dysplasia, a distance between the anterior tibial tuberosity and the trochlear groove (TT-TG) greater than 20 mm on a CT scan of the knee in extension, a patella alta with a Caton-Deschamps index greater than 1.2, and patellar tilt [1, 3].
Several surgical techniques have been developed [9]. Depending on the indication, the most frequently performed are translocation of the anterior tibial tuberosity (ATT) [10-12] and anatomical reconstruction of the medial patellofemoral ligament (MPFL) [13-15].
The aim of this study was to evaluate long-term clinical and functional outcomes using the Swiss Orthopaedic Society of Knee Working Group (SOSKWG) score [16].

Method

Patients (Table I)

Fifty-four patients with 54 unstable patellas were managed between January 1999 and November 2019 in several health facilities in Abidjan, Côte d'Ivoire (Yopougon University Hospital and some private sanitary establishments) (Figure 1). This retrospective study included 19 men (35%) and 35 women (64%) with an average age of 31.8 years (extremes: 19 and 59). Three of them were professional sportsmen. The circumstances of discovery were dominated by walking accidents (n=39, 72%), followed by sports accidents (n=8, 15%) and finally public road accidents (n=7, 13%).

Table 1: Characteristics of the Dejour classification.

Dejour type	Lateral radiographies	Axial image
Type A	Crossing sign	Shallow trochlea or symmetric concave trochlea
Type B	Crossing sign and supratrochlear spur	Flat or convex trochlea
Type C	Crossing sign and double contour	Asymmetry of the trochlear facets; lateral facet convex with hypoplastic medial facet
Type D	Crossing sign, supratrochlear spur, and double contour	Asymmetry of the trochlear facets; vertical slope demonstrating a “cliff”pattern

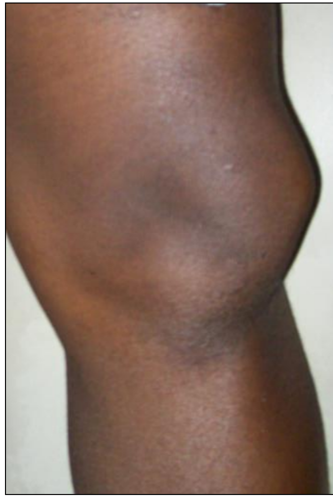

Fig 1: Clinical aspect of a dislocated patella.

Dejour classification system was divided into Types A, B, C and D dysplasia using specific radiographic parameters (Table 1). In Type A dysplasia, there was a crossover sign on profile radiographs, and the trochlear groove was symmetrical but shallower than normal, with a Sulcus angle greater than 145° on axial views. In Type B, there was a crossover sign and a supratrochlear spur on lateral radiographs, with a flat trochlea on axial radiographs. In Type C, there was a crossover sign and a double contour on lateral radiographs, with convexity of the lateral facets and hypoplasia of the medial facets on axial images. In Type D, there was a crossover sign, supratrochlear spur and double contour on lateral radiographs, and a "cliff" on axial images due to asymmetry of the lateral and medial femoral trochlear facets.

According to Dejour classification, 13 lesions (24%) were classified as Type A, 30 (55%) as Type B, 9 (17%) as Type C and 2 (4%) as Type D.

Inclusion criteria and indications

This study included consenting patients aged 15 years or older who had presented with at least two episodes of patellar dislocation during knee flexion, and in whom the analysis of imaging studies had revealed dysplasia of the femoral trochlea according to the Dejour classification [8] and a patella alta with a Caton-Deschamps index greater than 1.2. Patients lost to follow-up or who died before the minimum time for clinical evaluation were excluded from the study.

ATT transfer was indicated for patellofemoral instability without patella alta. This technique involved transferring the tibial tuberosity with its insertion to realign the knee extension mechanism and/or correct the vertical height of the patella.

Anatomical reconstruction of the MPFL was indicated for patellar instability with trochlear dysplasia and/or without patella alta.

Diagnosis

The patients included in this study were diagnosed based on a full radiological work-up, including a front and side X-ray of the knee, and a patellofemoral angle at 30° flexion (Figures 2 and 3). A CT scan was also performed to classify the lesions according to the Dejour classification. The patients were operated on by different surgical teams. The aim of the surgical treatment was to correct the instability factors. This treatment was based on surgical procedures inspired by the general principles of patellar instability surgery as described in the literature [17]. Depending on the surgical indications, the usual techniques used in this study were translocation of the ATT and anatomical reconstruction of the MPFL.

Forty-three patients (79%) designated as Group A underwent ATT translocation. Eleven (20%) patients designated Group B underwent anatomical reconstruction of the MPFL.

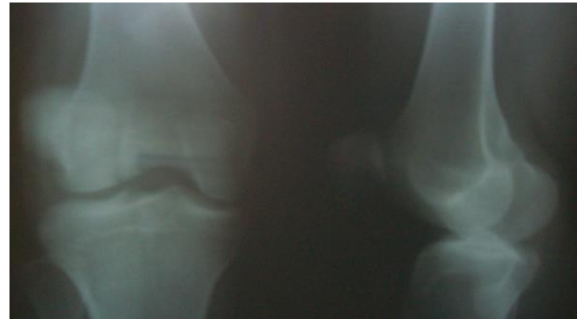

Fig 2: X-ray of the knee showing an alta patella.

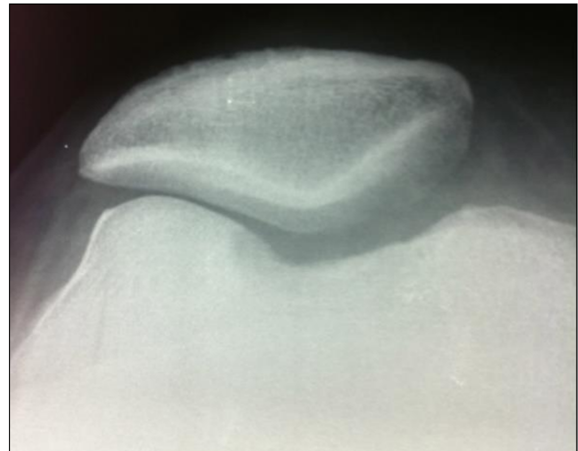

Fig 3: X-ray of the knee showing a malformed trochlea.

Table 2: Characteristics of the series.

Characteristics	n	%
Gender		
Male	19	35%
Female	35	64%
Age		
Mean	31.8	
Extremes	19 - 59	
Professional sportive statue		
Yes	3	5%
No	51	94%
Etiology		
Sportive accident	8	15%
Road accident	7	13%
Occasional accident	39	72%
Dejour Classification		
Type A	13	24%
Type B	30	55%
Type C	9	17%
Type D	2	4%
Treatment		
ATT translocation (Groupe A)	43	79%
Reconstruction MPFL (Groupe B)	11	20%

ATT transfer [2] (Figure 4)

Transfer osteotomy of the medial tibial tubercle

The approach was anteromedial. The lateral retinaculum was released, followed by an arthrotomy to check the joint space. The medial soft tissue was sectioned to obtain complete exposure of the ATT. Once the patellar tendon insertion had been identified, the osteotomy could be performed using a bone chisel. The tibial tubercle was completely detached with the chisel on three sides, leaving only a distal bony hinge before elevating the medial periosteum. Before fixation of the tuberosity, medialization was checked with a ruler to correct the misalignment and bring it back to a normal value for the TT-TG. For example, if the preoperative TT-TG was 2cm, the medialization would be 1cm maximum. After checking the normal position of the tibial tuberosity using a punch inserted temporarily along its lateral edge, a hole was drilled through the tibial tuberosity to the opposite tibial cortex using a 3.2mm drill bit. The tuberosity was then fixed with a 4.5mm cortical screw. The procedure was completed by plasty of the medial retinaculum and suture of the lateral periosteum to the tibial tuberosity.

Distal or proximal transfer of the tibial tubercle

Using an anteromedial approach, the patellar tendon was dissected, and the lateral retinaculum released, followed by sectioning of the medial retinacular tissue (Figure 4). The ATT was completely detached on three sides, using a chisel and an oscillating saw for the distal part. In the case of the patella alta, a piece of bone was removed from the distal edge of the tibial tuberosity to correct the Caton-Deschamps index to 1. The proximal part of the tibial tuberosity was then removed, grasped with bone forceps, and fixed distally with a 4.5mm screw after drilling a 3.2mm hole. Prior to complete fixation of the distal screw, a medial transfer of the tibial tuberosity was required to correct the TT-TG distance, after which the screw could be tightened. A second 4.5mm screw was inserted 1.5cm proximally after 3.2mm drilling. The medial retinacular tissue and the periosteum lateral to the tubercle were closed. Finally, knee flexion was tested to ensure that the distal part of the bone block adapted to the tibial anatomy and that the amount of the medial transfer was correct. The proximal transfer for correction of the inferior patella followed the same procedure after joint release if the patellar tendon was equal to or greater than that of the patella. The patellar tendon was equal to or greater than 2.5cm to avoid transferring the tibial tuberosity too proximally.

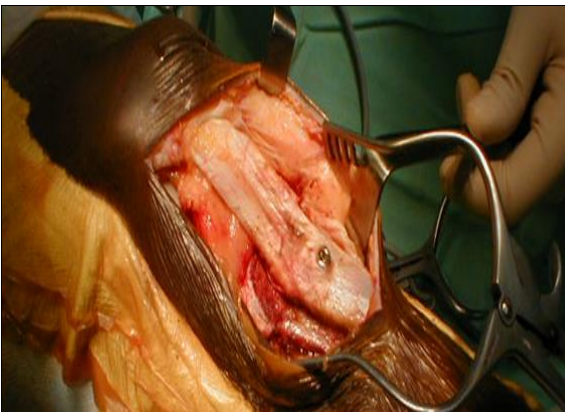

Fig 4: Peroperative picture of a ATT translocation.

Plasty of the medial patellofemoral ligament [18].

Harvesting the gracilis tendon

Through a two-centimetre medial tibial incision, the gracilis tendon was harvested with a stripper. The fleshy fibres were removed, and the end of the tendon was laced.

Section of the medial patellar fin

This was performed via a small anterior approach measuring 3 to 4 centimetres in length, opposite the medial edge of the patella. Using retractors, it was possible to make a section of this fin and extend it upwards into the quadricipital tendon a few millimetres from the muscle fibres of the vastus medialis, and downwards along the patellar tendon.

Positioning the gracilis tendon

Sectioning the medial patellar fin gave access to the underlying space between it and the synovium at depth. This extra-articular plane was cut with scissors along the medial side of the knee, as far as the insertion of the medial collateral ligament on the femur. At this point, identified by palpation of the medial femoral epicondyle, a punctiform opening of the skin was made with a scalpel. The gracilis tendon was inserted in this plane using small, curved forceps with a traction wire. Posteriorly, opposite the medial condyle and the previous skin puncture, the forceps pierced the medial patellar aileron, to emerge through this skin puncture, allowing the tendon, pulled by its thread, to pass through for the first time. The forceps were then repositioned in the same plane, and passed backwards through the fin a second time, 1 cm from the first perforation. It loaded the traction wire, which allowed the tendon to pass a second time from the back to the front. In this way, a "U"-shaped attachment was obtained at the back of the medial fin opposite the medial femoral epicondyle. Anteriorly, the fixation at the level of the patella was placed in the middle of its medial edge. Fixation was achieved by a subperiosteal pass over the anterior aspect of the patella using fine rugin: the laced end of the gracilis tendon was passed under the periosteum. The tendon was turned towards the medial femoral epicondyle and sutured to itself, under tension, on a knee bent at 45°, to avoid medial hypercorrection of the patella. In this way, a medial patellofemoral ligament was reconstituted, stretched from the fibrous plane opposite the medial condyle to the medial edge of the patella, reproducing its anatomical course and reinforcing the suture of the medial wing. The procedure was completed with a paleta suture of the medial patellar fin, using separate stitches. Closure was performed without drainage unless transposition of the ATT had been associated.

Evolution

Following the operation, there was no immobilisation. Immediate weight-bearing was allowed on an extended knee with a crutch for 15 days. Rehabilitation began after two weeks and was planned to last 1.5 to 2 months. Recovery of joint range of motion began on the first postoperative day. Range of motion should not exceed 90° to avoid excessive tension on the ATT fixation. Resumption of sporting activities was authorised at six months post-operatively.

Outcome evaluation

At a minimum follow-up of 36 months, the clinical and functional outcomes of the two surgical techniques were

assessed using the score of the SOSKWG [16, 19]. Also known as the Müller score, the aim of the SOSKWG score was to evaluate anamnestic and clinical examination data, knee stability, and functional tests according to criteria specific to knee ligament injuries. The anamnestic data evaluated were pain, oedema or effusion, possible loosening, work, and sports activities. During the clinical examination, the following were assessed: knee pain on pressure, search for effusion, difference in thigh circumference at 15cm proximal, passive extension deficit and passive flexion. The SOSKWG score assessed knee stability by examining anterior and posterior drawers, lateral flexion, and the pivot sign. Finally, the clinical assessment using the SOSKWG score ended with the categorisation of the sum of the different values obtained during the previous tests. This was categorised as Very Good (if total >90 points), Good (if total between 81 - 90 points), Fair (if total between 71 - 80 points) and Poor (if total <70 points). Patients were assessed during a clinical examination by independent surgeons, using the SOSKWG Score table. The SOSKWG score table is clearly described in the book by Favreul *et al* [16].

Data analysis
The data were processed and analysed using Epi Info software. The Pearson Chi-squared test was applied, and the significance threshold was set at $p<0.05$.

Results
The average hospital stay was 5.7 days (extremes: 4 and 14). This study enrolled 54 patients with 54 unstable patellas divided into 2 groups: one (Group A, n=43, 79%) was treated by translocation of the ATT and the other (Group B, n=11, 20%) was treated by anatomical reconstruction of the MPFL. Crossing the numbers in the 2 groups by the numbers distributed according to Dejour's classification, we obtain: Unstable patellas classified as Types A and B were those treated by transfer of the ATT; and unstable patellas classified as Types C and D were those treated by anatomical reconstruction of the MPFL.
The 54 operated unstable patellas were evaluated clinically and functionally at a minimum follow-up of 36 months. The outcomes are shown in Table IV. Of the 43 unstable patellas operated on by translocation of the ATT, 11 (25%) had a very good outcome, 29 (67%) had a good outcome, 1 (2%) had an average outcome and 2 (4%) had a poor outcome. Of the 11 unstable patellas operated on by anatomical reconstruction of the MPFL, 2 (18%) had a Very Good outcome, 7 (63%) had a Good outcome, 1 (9%) had an Average outcome and 1 (9%) had a Poor outcome.
In the long-term post-operative period, we found a few complications which are shown in Table V. Six (13%) complications were found among the 43 patients operated on by translocation of the ATT (Group A), including: one case of post-operative haematoma, 2 cases of surgical site infection, 2 cases of knee stiffness, 1 case of pseudarthrosis of the translocated ATT, and no cases of phlebitis. Among the 11 patients operated on by anatomical reconstruction of the MPFL, we found a total of 4 (36%) complications, including: 1 case of post-operative haematoma, 1 case of phlebitis, 1 case of surgical site infection and 1 case of knee stiffness.

Table 3: Breakdown of types of treatment according to the Dejour classification.

Classification	Groupe A	Groupe B	n	%
Type A	13	-	13	24%
Type B	30	-	30	55%
Type C	-	9	9	17%
Type D	-	2	2	4%
Total	43	11	54	100%

Table 4: Overall outcomes according to SOSKWG score.

Score	Groupe A	Groupe B	p
Very good	11 (25%)	2 (18%)	*0.0048*
Good	29 (67%)	7 (63%)	*0.0210*
Average	1 (2%)	1 (9%)	*0.0035*
Bad	2 (4%)	1 (9%)	*0.0000*
Total	43	11	

Table 5: Postoperative complications.

	Groupe A	Groupe B
Postoperative haematoma	1	1
Phlebitis	0	1
Local infection	2	1
Knee stiffness	2	1
ATT Nonunion	1	-
Total	6 (13%)	4 (36%)

Discussion
This study included 54 patients with 54 unstable patellas treated surgically using two standard techniques depending on the indications. We designated Group A patients treated by translocation of the ATT, and Group B patients treated by anatomical reconstruction of the MPFL. This was not a direct comparative study between the two surgical techniques, but rather a simple allocation of patients to better assess their respective efficacy.
The mean age of our patients in both groups was 31.8 years (extremes: 19 and 59), of whom 19 (35%) were men and 35 (64%) were women. Most patients in our study were young and predominantly female, as has been observed in several other studies in the literature [4, 9, 20-24]. The profile of the patient with patellar instability is therefore that of a young woman with an anatomical anomaly of the femoral trochlea and patellar height.
The morphological criteria for instability predispose the patella to the slightest dislocation during flexion movements or minor trauma. This explains the predominance of occasional aetiologies in our study (72%) (Table II). This observation was made by other authors who also found a low rate of public road accidents as an aetiology [25, 26]. In our study, however, the aetiology was presented as the triggering factor that led to consultation.
The criteria for instability were ranked according to the Dejour classification. We were able to classify 13 (24%) as Type A, 30 (55%) as Type B, 9 (17%) as Type C and 2 (4%) as Type D of the Dejour classification (Table III). Few studies had adopted our approach, with most authors preferring to describe the measurements relating to these criteria [2, 4, 13]. In our study, the data from Dejour's classification were presented simply as epidemiological information to satisfy scientific curiosity. Table III has enabled us to reaffirm the theory that knees classified as Dejour Type A or B can be treated by translocation of ATT with satisfactory outcomes [19]. Types C and D are treated by

anatomical reconstruction of the MPFL because of increasing trochlear deformities.

Professional athletes were poorly represented in our study (5%), in contrast to other studies in the literature [10]. Special attention has always been paid to the surgical treatment of legions of the knee in sportsmen and women. Their professional future depends on it. The professional athletes treated in our study had satisfactory outcomes at follow-up. There were no cases of recurrence or major complications. They had all resumed sporting activities by the sixth month post-operatively.

At a minimum follow-up of 36 months, all 54 unstable patellas operated on were assessed using the SOSKWG score. Table IV shows the overall values of the clinical and functional evaluation of the operated knees. This evaluation was carried out using the SOSKWG score, with a minimum follow-up of three years, following the example of Servien *et al*, who also used a minimum follow-up of two years [22]. The items in the SOSKWG score also need to be studied to better understand our outcomes. As developed by Müller *et al*, the SOSKWG score is exclusively dedicated to the clinical and functional evaluation of knee ligament injuries [19]. However, most authors prefer to use the IKDC score [11, 15, 24]. Nevertheless, the items in the SOSKWG and IKDC scores are almost identical. Our overall assessment outcomes were satisfactory and in agreement with those of some previous studies [18, 21, 22]. In all cases, the decision to choose the surgical technique generally depends on the indications expressed by the Dejour classification. The effectiveness of the chosen technique and the quality of its outcome may be influenced by the experience of the practitioner, the technical resources available and the clinical parameters of the patient.

Table V shows some complications in the Groups, but in negligible proportions (13% in Group A, 36% in Group B). These were the same types of complications found in other studies that used the same surgical techniques as ours [11, 27]. However, all the complications found in our study were related to the working environment and conditions, and not to the surgical procedures. We cannot therefore judge the effectiveness of the two techniques studied in our study based on these complications. Complications were managed on a case-by-case basis without the need for revision surgery, except for one case of pseudarthrosis of the ATT. Revision with cure of the pseudarthrosis was performed at eight months post-operatively, and the outcome was assessed as satisfactory, although the patient was not satisfied with being multioperated on.

Weaknesses and strengths of the study

The limitations of our study were its retrospective and non-randomised nature, which could introduce a selection bias due to recruitment over a period of 20 years in different health establishments. This led to heterogeneity in patient characteristics and surgical practices. In addition, the division of patients into two groups may lead to confusion, although the two surgical techniques studied were not comparable due to their different indications.

Nevertheless, our study provides important information on the long-term clinical and functional outcomes of surgical treatment of patellar instability in our patients. The overall outcomes were satisfactory, suggesting the effectiveness of both surgical techniques in correcting the factors contributing to instability. It is also important to note that outcomes may vary according to the experience of the practitioner, the technical platform, and the clinical characteristics of each patient. Prospective and randomised studies could be envisaged in the future to better assess the effectiveness of the different surgical techniques in the treatment of patellar instability.

Conclusion

ATT transfer has been shown to be the most suitable surgical technique for treating patella instabilities classified as Type A and B according to Dejour's classification. On the other hand, patella instabilities classified as Type C and D are treated by anatomical reconstruction of the MPFL. These two surgical techniques have different therapeutic indications and have shown satisfactory outcomes overall, as demonstrated by significant statistical tests.

However, to confirm the outcomes of our study, a prospective randomised trial with a larger sample size is required. This will enable us to gain a better understanding of the effects of the two surgical techniques in the treatment of patellar instability and ensure the reliability of our outcomes.

Conflict of interest

The authors declare that they have no conflict of interest.

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