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Surgical treatment results of chronic patellar instabilities through anterior tibial tuberosity transfer: A descriptive retrospective study involving 13 patients at the hospital Centre of the order of Malta (CHOM) in Dakar, Senegal

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Abstract
Introduction: The therapeutic management of chronic patellar instabilities involves surgical procedures aimed at alleviating symptoms and addressing etiological factors. The Roux-Elmslie-Trillat technique, enhanced by the concept of proximal or distal transfer of the anterior tibial tuberosity (TTA) by J. Caton, provides a promising therapeutic alternative that is effective in addressing both patellar tracking and etiological factors. The aim of this study, focusing on the surgical treatment of chronic patellar instabilities through TTA transfer, is to assess the anatomical, clinical, and functional outcomes of knees after TTA transfer.
Patients and Methods: This is a descriptive retrospective study spanning 72 months (6 years) with an average follow-up of 33.32 months. A series of 13 knees from 13 patients, all operated using this technique, were included. There were 3 males and 10 females, with an average age of 28.31 years. Eleven knees (84.62%) had recurrent dislocations, and 2 knees (15.38%) had permanent patellar dislocation. Smillie's apprehension was found in all 11 knees in the recurrent dislocation group. Nine trochleae were dysplastic according to Dejour, with one classified as type D. Clinical evaluation of the knees was conducted using the Lille score and the Kujala score, and femoro-patellar arthritic lesions were classified according to Iwano. Data were analyzed using SPSS 20.0 software.
Results: Surgery was performed on 10 left knees (76.92%) and 3 right knees (23.08%). Procedures associated with the Roux-Elmslie-Trillat osteotomy included lateral release (13 cases), lowering of the TTA (5 cases), medial patellar retinaculum plication (3 cases), and trochleoplasty for deepening according to Masse (1 case). We noted 1 case of surgical site infection and 1 case of TTA pseudarthrosis. At follow-up, no recurrences were reported, and subjective results were rated as 'excellent' in 69.27% of cases and 'good' in 30.77% of cases. The Lille Score improved from 34.53 points preoperatively to 92.61 points at follow-up, and the Kujala score increased from 41.61 points to 93.79 points. The Caton-Deschamps index was 1.02 vs. 1.17; patellar tilt and TT-TG measurements in the 9 patients with follow-up CT scans were 15° vs. 30.4° and 12.32 mm vs. 22.75 mm, respectively. Additionally, at follow-up, there were 3 cases of stage II osteoarthritis and 1 case of stage I osteoarthritis.

Keywords: Knee, TTA, patellar instability, TT-TG distance, Roux-Elmslie-Trillat technique

Introduction
Patellofemoral pathology is one of the many knee pathologies, ranging from simple and common pains in children and adolescents to patellofemoral arthritis, including patellar instability. The term "patellar instability" primarily represents a symptom. Patients experience a sensation of the knee giving way, known as reflex instability. It becomes mechanical when there is abnormal movement of the patella within the femoral trochlea during knee flexion, potentially leading to true dislocation. Patellar instability as a pathology encompasses both these instability concepts and typically begins with a traumatic patellar dislocation episode or acute patellar instability, progressing to chronic patellar instability with recurrent dislocation as the ultimate goal or objective instability, also known as episodic dislocation in the

Lyonnaise school [28].

In its management, various techniques have been described, some aiming to correct all etiological factors, and others focusing on correcting the abnormal patellar tracking. Anterior tibial tuberosity transposition, initiated by C. Roux in 1888 and later improved by R.C. Elmslie and A.G. Trillat [8, 37] in 1964, is one of these surgical techniques. In 1982, J. Caton [4] introduced the concept of distal or proximal transfers of the anterior tibial tuberosity. Since then, the transfer of the anterior tibial tuberosity has become the most widely used technique in the management of this pathology.

In Senegal, the history of patellar instability management began with Seye *et al*. at Aristide LeDantec University Hospital, and the first tibial tuberosity osteotomies were performed in the 1990s by S. DIOUF and MH. SY at the Center for Traumatology and Orthopedics (currently Idrissa POUYE General Hospital). The first documented work on this pathology was by R. SAAD [13] in 2017 through a multicentric study in Dakar, focusing on etiological factors and therapeutic indications for patellar instability.

The scarcity of literature data from Senegal contrasts with the enriched experience in the management of patellar instabilities within orthopedic services. Hence, the importance of this study, with the goal of analyzing the anatomical and functional results of patients operated on for chronic patellar instability at the Order of Malta Hospital in Dakar, Senegal.

Patients and Methods

Patients

This is a retrospective descriptive study, conducted at a single center with multiple operators, spanning a period of 6 years (October 31, 2012, to October 31, 2018). It was a longitudinal study with a minimum postoperative follow-up of six months. All patients who underwent knee surgery and were followed at CHOM for chronic patellar instability with a minimum follow-up of six months were included in the study. Patients with patellar instability associated with central pivot instability of the knee, cases of subjective patellar instability, patellar pain syndromes, and patients lost to follow-up after surgery were excluded. Therefore, our series consisted of 13 knees from 13 patients treated and reevaluated for chronic patellar instability: 11 cases of recurrent dislocations (RD Group) and 2 cases of permanent dislocation (PD Group).

The series included 3 males and 10 females, resulting in a sex ratio of 0.3. The average age of patients at the time of surgery was 28.31 years, with a range from 15 to 53 years. Patients aged 20 to 29 years were the majority, accounting for 69.23%. Among the 13 operated knees, 10 were left knees (76.92%), and 3 were right knees (23.08%).

Clinically, 10 patients (76.92%) had a history of trauma. This included one case of medial collateral ligament sprain of the knee and nine cases of traumatic true knee dislocations, one of which remained unreduced and neglected for 5 years. The traumatic events leading to these injuries were domestic accidents in 3 cases, everyday life accidents in 4 cases, and sports-related accidents in 3 cases. In 2 patients (15.38%), symptoms appeared without a clear history of documented trauma, and in one patient (7.69%), it was a recurrence, occurring 6 years after an initial surgery on the soft tissues at the age of 17 in another center. Familial predisposition was identified in 2 cases, with the condition occurring in both the father and son of one patient and in the brother of another patient. None of the patients reported engaging in professional sports. Knee pain and swelling were consistently present, varying in severity. The average duration of symptoms was 6.1 years, ranging from 1 to 17 years. The RD Group had an average of 10.25 dislocations (ranging from 2 to 30). Smillie's apprehension sign was present in all 11 patients (84.61%) in the LR Group; it could not be evaluated in the PD Group (since the patella was already dislocated).

In terms of diagnostic imaging, only standard X-rays and CT scans were performed. Nine trochleas were deemed dysplastic according to Dejour's classification (Type A: 5 cases; Type C: 3 cases; Type D: 1 case). Patellar morphology varied according to the Wiberg-Baumgartl classification: 4 patellas were Type I, 6 were Type II, and 3 were Type III. Patellofemoral arthritis was found in 2 cases, classified as stage II according to Iwano's criteria [15]. Eleven of our patients (84.62%) had a tibial tubercle to trochlear groove (TT-GT) distance of 20 mm or more. The results of the evaluated quantitative radiological parameters are listed in Table 1.

Table 1: Quantitative radiological parameters of patients

	Mean (± standard déviation)	Range
TT-GT Distance (in mm)	23,16 (±4,89)	17,3 - 32,10
Patellar height (ICD) (n =11) *	1,17 (±0,22)	0,86 - 1,48
Trochlear angle (in °)	136,31(±15,16)	115 - 175
Patellar tilt (in °) (n =11) *	29,36 (±18,09)	15 - 80

* Patellar height and the degree of patellar tilt could not be assessed within Group LP due to the loss of anatomical landmarks caused by permanent dislocation.

The reference surgical technique used was the Roux-Elmslie-Trillat procedure *47-82*, which was indicated for all our patients. In its application (Figure 1), we made some modifications in the osteotomy and in the fixation of the anterior tibial tuberosity (TTA):

- The bone wedge created after the osteotomy was almost parallelepiped in shape, and no hinge was preserved.
- Cortical screws with washers were used for securing the bone wedge.

The only absolute contraindication would be the presence of a fertile physial plate, which was not the case for our patients under 18 years old. The treatment aimed not only to correct the excessive tibial tubercle to trochlear groove (TT-GT) distance and Caton-Deschamps index but also to realign the extensor apparatus of the knee to achieve normal patellar tracking in the femoral trochlea for a functionally normal knee.

Preoperative planning was performed for all patients by the operating surgeon. All patients underwent surgery under spinal anesthesia. The average time from diagnosis to surgical intervention was 4.95 months, with a range from one week to 30 months.

The surgical approach used was the anterior approach of the knee, with a median or anterolateral skin incision. Medialization of the TTA coupled with lateral wing release was performed in all patients. The knee was temporarily immobilized with a removable knee brace.

No intraoperative incidents or accidents were reported.

Fig 2: The different stages of the surgical transfer of TTA (photos from the orthopedic department of CHOM) (A-B: Setup. C: Exposure of TTA and pre-drilling. D: Total osteotomy of TTA. E: Fixation of the bone rod with a temporary pin in place, followed by TTA fixation with 2 screws and washers, then a post-op X-ray showing the placement of the pins. F: End of the procedure with compressive dressing, Redon drain, and removable knee brace in place.)

Additional procedures (Table 2) were performed as needed, based on the significance of other primary etiological factors. These additional procedures included lowering of the TTA, medial patellar retinaculum plication (suture in a jacket) or trochleoplasty according to Masse's technique (Figure 2).

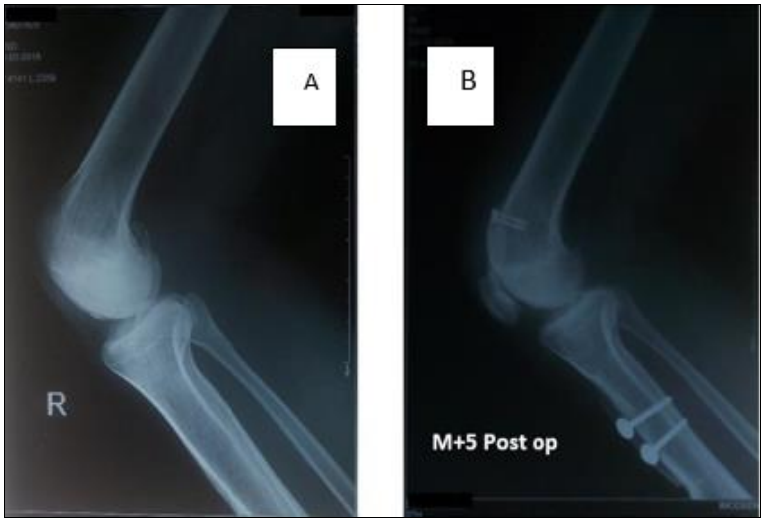

Fig 2: Case of a permanent dislocation evolving for 5 years: (A) Preoperative X-ray (B) Postoperative X-ray with luxation reduction + TTA transfer + trochleoplasty.

Postoperative recovery was uneventful in 10 patients and complicated in 3 patients. There were no reported cases of recurrence. The postoperative complications included 1 case of surgical site infection, 1 case of early knee stiffness that was successfully resolved through mobilization under general anesthesia and physical therapy, and 1 case of screw loosening with aseptic pseudarthrosis of the anterior tibial tuberosity (TTA), necessitating a revision surgery (osteosynthesis with autologous bone graft) 16 months after the initial surgery (Figure 3).

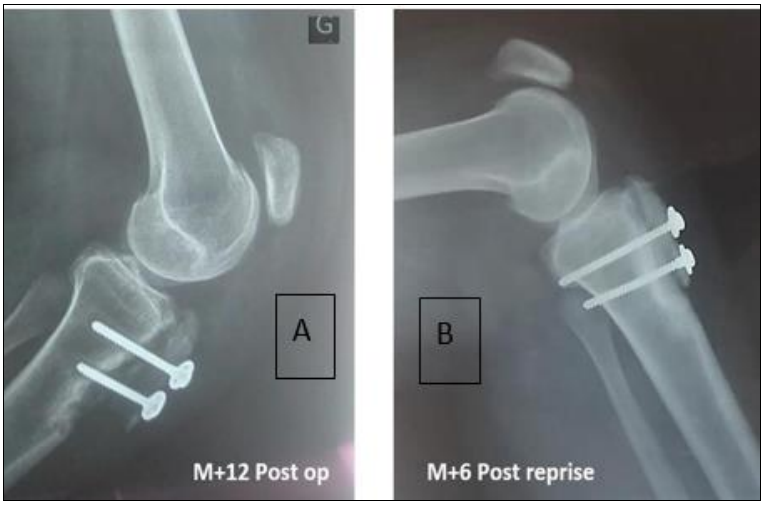

Fig 3: Case of aseptic pseudarthrosis: (A) Removal of the two screws; (B) Consolidation of the bone rod after surgical revision.

In the postoperative period, standard X-rays of the operated knee in both anterior-posterior and lateral views were used to assess the positioning of the screws and their compressive effect on the bone wedge. Physical therapy was administered systematically, involving non-weight-bearing for 6 weeks, along with passive range of motion exercises and isometric contractions starting the day after surgery. Partial weight-bearing with a toe-touch was allowed, supported by a pair of crutches and a removable knee brace. Full weight-bearing was permitted on the 45th day, and a return to sports activities was allowed as early as the 6th month after the surgery.

The average follow-up period in our study is 33.32 months, with a minimum of 6.3 months and a maximum of 6.5 years. All patients were assessed at follow-up by the same observer, various operators, and using both subjective and objective criteria.

The subjective evaluation included assessing the presence of knee pain, the sensation of instability or patellar dislocation, and the subjective Smillie apprehension sign (Table III). Additionally, the patient's level of satisfaction regarding the current clinical state of the operated knee was assessed using the Customer Satisfaction (CSAT) score [5] at the follow-up.

Objective evaluation was conducted using clinical criteria, including preoperative Lillois scores [32] and Kujala scores [20], with joint mobility also assessed at follow-up. Paraclinical assessments included standard X-rays to examine the consolidation of the bone wedge, patellar height using the Caton-Deschamps Index, trochlear angle, and patellofemoral arthritis based on the classification by Iwano *et al.* [15]. Additionally, CT scans were performed at follow-up to evaluate postoperative tibial tubercle to trochlear groove (TT-GT) distance in extension, patellar tilt, and potential patellofemoral arthritis. Table 3 summarizes the medical observations for the 13 patients in the study.

Table 2: Distribution of patients according to the additional procedure (N = 13)

Additional Procedures	N	%
TTA (Tibial Tuberosity Advancement) lowering	5	38, 46
Medial patellar retinaculum plasty	3	23, 08
Further trochleoplasty	1	7, 69
Total	9	63, 23

Table 3: Characteristics of the study population

Patient Nº	1	2	3	4	5	6
Age/Gender	24/F	21/F	17/M	45/M	30/M	15/F
Profession	Soudent	Styliste	Soudent	Administration	Administration	Soudent
Origin	Dakar	Dakar	Dakar	Kaolack	St-Louis	Dakar
Traumaticpast	Dislocation Left patella	Dislocation Left patella	Dislocation Left patella	NO	Dislocation Right patella	NO
number of dislocations	10	>30	3	2	1	1
symptoms onset (years)	11	7	2	6	5	4
Side	Bilateral: Left operated	Left	Left	Left	Bilateral: Right operated	Right
Smillie's apprehension	+	+	+	+	?	?
Dysplasia (Dejour)	Type C	Type C	No	No	Type D	Type C
ICD Pre-op	0,93	1,03	0,96	1,48	?	?
TA-GT pre-op (mm)	20,7	20	17,3	20,1	32,1	32
Trochl pre-op angle	141º	140º	115º	138º	175º	150º
BP Pre-op	25º	80º	20º	28º	?	20º
FP osteoarthritis Pre-op	Iwano II	NO	NO	NO	Iwano II	NO
Lillois pre-op /100	13	13	40	13	55	25
Kujala pre-op/100	11	12	70	11	60	50
Type of instability	Récurrent dislocations	Recurrent dislocations	Recurrent dislocations	Recurrent dislocations	Permanent dislocation	Permanent dislocation

Time to treatment	30 months	12 months	5 months	21 days	3 months	4 months
Surgical indication	Med TTA + section of lateral fin	Med TTA+ SLF+ medial fin plasty	Med TTA+ SLF	Med TTA+ SLF+ lowering of the TTA	Med TTA+ SLF+MFP+ Trochleoplasty	Med TTA+ SLF+MFP
Hospital stay duration (days)	3	4	3	3	4	3
Physiotherapy	15	15	15	28	45	25
Weight-bearing	45 days	45 days	45 days	10 days	45 days	30 days
Complication	0	Non union of TTA / surgical revision	0	0	Stiffness followed by mobilization under general anesthesia	0
Setback	M6D15	M6D9	M9D18	Y3M6	M11	M7D21
Post-op dislocation	0	0	0	0	0	0
Post-op Smillie	-	-	-	-	-	-
Knee mobility	Complet	Complet	Complet	Complet	Passive flexion to 120 degrees	Complet
Hardware removal (screw)	Yes	No	No	No	No	No
Patient satisfaction	Very satisfied	Very satisfied	Very satisfied	Very satisfied	Satisfied	Very satisfied
Lillois post-op /100	96	98	90	96	97	85
Kujala post-op/100	94	95	98	94	91	90
Condition of the TTA	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++
FP osteoarthritis post-op	Iwano II	No	No	NO	Iwano II	No
ICD post-op	1	1,23	0,83	0,81	1,2	1,1
TA-GT post-op (mm)	15,7	11,1	13,8	16,3	20	17,6
Trochl post-op angle	143º	140º	118º	140º	147º	150º
Post-operative patellar tilt	12º	20º	15º	17º	13º	22º

Patient Nº	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Age/ Gender	15/F	41/F	22/F	23/F	28/F	53/M	34/F
Profession	Student	Retailler	Student	Un-employed	Student	Retailler	Cashier
Origin	Dakar	Mali	Congo	Dakar	Cameroun	Dakar	Dakar
Traumatic past	Dislocation Left patella	LLI sprain Left Knee	Dislocation Left patella	Operated on the left knee in 2006	Dislocation Left patella	Dislocation Left patella	Dislocation Right patella
Number of dislocations	10	15	10	11	2	6	14
Symptoms onset (years)	1	2	6	6	7	5	17
Side	Left	Left	Left	Left	Left	Left	Right
Smillie's apprehension	+	+	+	+	+	+	+
Dysplasia	Type A	Type A	No	Type A	No	Type A	Type A
ICD Pre-op	1,28	1,35	1,03	1,4	1,411	1,14	0,86
TA-GT post-op	20,7	21,5	17,7	26,3	24,2	27,2	21,3
Trochl pre-op angle	138	135	125	130	140	125	120
BP Pre-op	25	35	15	15	20	35	25
FP osteoarthritis Pre-op	No	No	No	No	No	No	No
Lillois pre-op /100	57	13	62	40	18	40	60
Kujala pre-op/100	84	22	79	34	19	54	35
Type of instability	recurrent dislocations	recurrent dislocations	recurrent dislocations	recurrent dislocations	recurrent dislocations	recurrent dislocations	recurrent dislocations
Time to treatment	20 Days	7 Days	5 Months	1 Months	6 Days	6 Days	3 Days
Surgical indication	Med TTA+ SLF+ lowering of the TTA	Med TTA+ SLF+ lowering of the TTA	Med TTA+ SLF	Med TTA+ SLF+ lowering of the TTA + MFP	Med TTA+ SLF+ lowering of the TTA	Med TTA+ SLF	Med TTA+ SLF
Hospital stay duration	4 Days	5 Days	2 Days	8 Days	6 Days	6 Days	3 Days
Physiotherapy	40	30	15	35	29	25	15
Weight-bearing	15 Days	45 Days	45 Days	45 Days	30 Days	45 Days	45 Days
Complication	Surgical wound infection	0	0	0	0	0	0
Setback	Y2M4D21	Y5M1	Y1M8	Y6M7	Y6M7	Y4D12	Y2M10
Post-op dislocation	Patellar subluxation	0	0	0	0	0	Catching sensation
Post-op Smillie	+	-	-	-	-	-	-
Knee mobility	Complet	Complet	Complet	Complet	Complet	Complet	Complet
Hardware remova (screw)	No	Yes	No	No	No	No	No
Patient satisfaction	Satisfied	Very satisfied	Very satisfied	Satisfied	Very satisfied	Satisfied	Satisfied
Lillois post-op /100	82	100	99	94	99	81	85
Kujala post-op/100	92	94	98	90	100	85	90
Condition of the TTA	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++	Bone callus +++
FP osteoarthritis post-op	No	Iwano I	No	No	No	Iwano II	No
ICD post-op	1,1	0,71	1,15	1,12	1,07	1,12	0,8
TA-GT post-op (mm)	14,7	?	14,6	?	14,1	?	?
Trochl post-op angle	138º	136º	125º	130º	140º	130º	120º
Post-operative patellar tilt	18º	?	9º	?	9º	?	?

Methodology

Data collection was done using patients' medical records, surgical protocol registries, and hospitalization records. All patients included in the series who were living in Senegal were called in for evaluation. Functional assessment of patients residing outside Senegal was conducted through telephone (video call).

Data entry and analysis were performed using SPSS

(Statistical Package for the Social Sciences) version 20.0 software. Figures were generated using Microsoft Office Excel 2016. Results for quantitative variables are presented as means (± standard deviation), minimum, and maximum values, while results for qualitative variables are expressed in absolute values and percentages. The Student's t-test was used to compare means of quantitative variables, and ANOVA conformity tests were occasionally used to confirm p-values. The significance level was set at $p < 0.05$, with a confidence interval CI > 95%.

Results: The subjective clinical evaluation of patients at follow-up is reported in Table 4.

Objective evaluation revealed complete extension in all patients (100%) and complete flexion with a positive heel-to-buttock test in 12 patients. In the patient who experienced early postoperative stiffness, the heel-to-buttock test was negative at the last follow-up, but passive maximal flexion was estimated at 120° (Figure 4). According to the Lillois score, 10 knees were rated as "very good," and 3 knees were rated as "good." In terms of the Kujala score, 9 knees were classified as "excellent," and 4 knees were rated as "good" (Table 5). At the follow-up, all patients were able to engage in sports activities, and some even at a higher level than before the surgery.

Table 4: Distribution of patients according to subjective clinical signs

Subjective Clinical Signs	n	%
Knee pain*	5	38,46
Sensation of instability**	1	7,69
Patellar dislocation	0	0
Subjective apprehension of Smillie**	1	7,69

* Mechanical pain, significant during exertion or on very uneven terrain

** One patient in Group RD experienced both a sensation of instability, resembling patellar subluxation without a true blockage, and a positive Smillie apprehension.

Fig 4: Incomplete flexion of the right knee, viewed from the front (a) and from the side (b) in a patient who underwent TTA transfer + Trochleoplasty surgery

Table 5: Functional results based on scores at follow-up

Score	Mean (± standard deviation)	Range
Post-operative Lillois score	92,62 (±6,49)	81-100
Post-operative Kujala score	93,79 (±4,75)	85-100

At the follow-up, standard X-rays were conducted for all patients, while CT scans were performed for only 9 patients (69.23%). Postoperative and follow-up MRI scans were not indicated. Bone consolidation of the anterior tibial tuberosity (TTA) was achieved and normal in all 13 patients (100%). The osteosynthesis material (2 cortical screws) was present in 10 patients (76.92%) and removed (screw removal) in 3 patients (23.08%). The degree of femoro-patellar degeneration observed in 4 patients and the quantitative radiological parameters are provided in Tables 6 and 7, respectively.

Table 6: Distribution of patients according to the Iwano arthritic stage

IWANO stage	n	%
I *	1	7,69
II	3	23,08
III	0	0
IV	0	0
Total	4	30,77

*Only one case was observed at follow-up, and the other two cases existed before the surgery.

Table 7: Quantitative radiological parameters of patients at follow-up

Radiological Parameters	Mean (± standard deviation)	Range
TT-GT Distance (in mm) $^{(n = 9)}$	15,32 (±2, 52)	11, 1 – 20
Patellar height (ICD)	1,02 (±0, 17)	0, 71 - 1, 23
Trochlear angle (in °)	135,15 (±9,92)	118 - 150
Patellar tilt (in °) (n = 9) $^{(n =9)}$ *	15 (±4, 63)	9 - 22

* Parameters assessed in the 9 patients who had a follow-up CT scan.

The average preoperative Lillois score was 34.53 points, ranging from 13 to 62 points. The average preoperative Kujala score was 41.61 points, with a range from 11 to 84 points. A comparison of the clinical functional outcomes of patients before and after surgery is provided in Table 8.

Table 8: Comparison of preoperative and postoperative functional scores.

	$\Delta\bar{x}$	p-value
Lillois score - differential	+ 58,09	< 0,001 (S)
Kujala score - differential	+ 52,18	< 0,001 (S)

$\Delta\bar{x}$ = differential of preoperative and postoperative means. The "+" sign indicates a gain.

For the 9 patients in our series who had both preoperative and postoperative CT scans, including those at follow-up, the differences between preoperative and postoperative measurements of the parameters "Distance TT-GT" and "patellar tilt" (Figure 5) were statistically significant (p = 0.001 < 0.05 and p = 0.027 < 0.05). The average calculated medialization from the CT scans was 7.43 mm, with a range from 3.1 to 14.4 mm. For the parameter "patellar height" evaluated in all 13 patients in the series, this difference was statistically non-significant (p = 0.070 > 0.05). In an exceptional case where trochleoplasty was performed, the trochlear angle changed from 175° preoperatively to 147° postoperatively and at follow-up, but with persistence of the crossing sign.

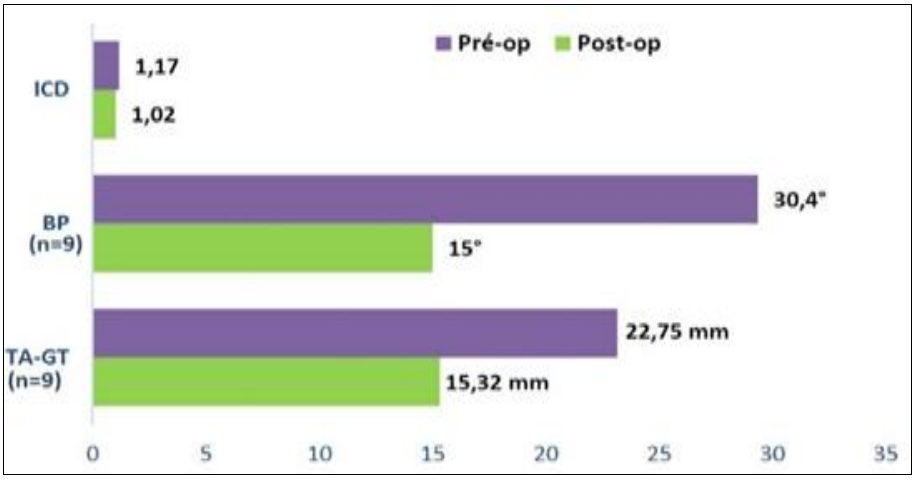

Fig 5: Comparative results of preoperative and postoperative radiological parameters.

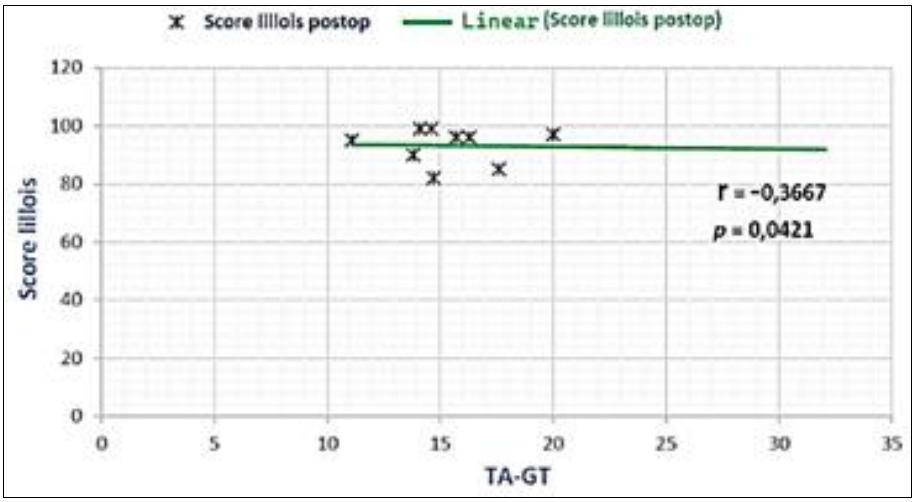

Fig 6: Correlation between TT-GT Distance and Lillois Score

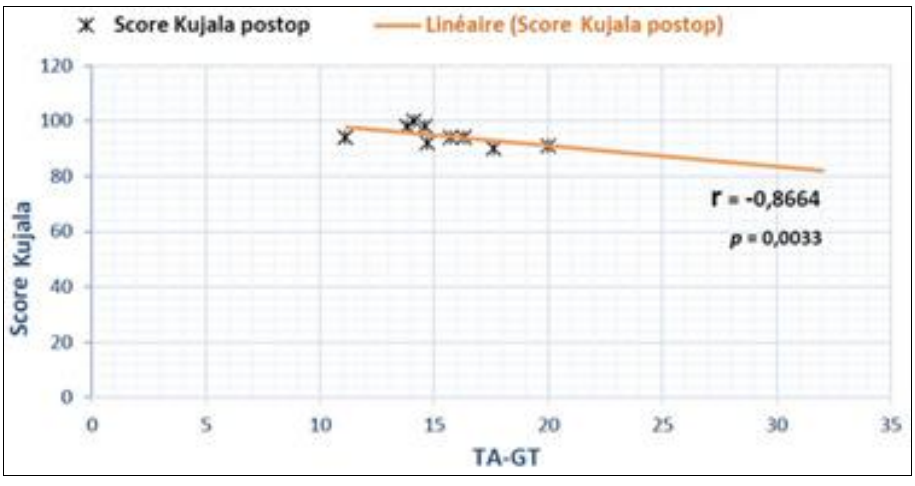

Fig 7: Correlation between TT-GT Distance and Kujala Score

Figures 6 and 7 illustrate the correlation between TT-GT and postoperative functional outcomes, enabling the following analyses:

- **First analysis:** The predictive linear correlation curves between functional scores (Lillois score and Kujala score) and the TT-GT distance of the 9 patients who had a postoperative CT scan showed negative correlation coefficients of -0.3667 and -0.8664, respectively. This indicates a decreasing correlation trend, meaning that if there is a correlation, a lower postoperative TT-GT distance is associated with a better functional score.
- **Second analysis:** The scatterplot points (TT-GT; Functional score) are concentrated around the predictive lines, indicating a correlation between these two postoperative parameters, with a strong correlation expressed with the Kujala score.

Discussion

The therapeutic options for chronic patellar instability consist of numerous surgical procedures, with some aimed at realigning the knee extensor mechanism and others addressing etiological anatomical factors. According to many authors, anterior tibial tuberosity transfer remains a primary choice in the treatment of chronic patellar instability with excessive TT-GT distance [6, 9, 13, 25, 29].

Our indications considered the existing literature. While 84.62% of our patients had an excessive TT-GT distance (≥ 20 mm), the remaining 15.38% of patients had a TT-GT distance between 17 and 20 mm and were highly symptomatic. Expanding the indication for anterior tibial tuberosity transfer to these patients with TT-GT distances < 20 mm was a judicious approach due to the symptomatic nature of their condition, even though their trochleae were less dysplastic (Dejour type A). This approach is consistent with studies by Koeter *et al.* [18] and Zhao *et al.* [38], who indicated medialization of the TTA for TA-GT distances > 15 mm in cases with mildly dysplastic trochleae in their studies on the treatment of patellar instability using TTA transfer. Additionally, to achieve the goal set by Goutallier *et al.* [14] of 10 mm < TT-GT < 15 mm, it is advisable to medially transfer any TT-GT distance > 15 mm.

To enhance patellar stability, in addition to the systematic section of the lateral patellar retinaculum, we employed medial patellar retinaculum plication in 3 patients (both knees in the PD Group and one case of severe tilt in the RD Group). This approach can be justified by referring to the study by Ma *et al.* [23], which preferred medial plication as a simpler method with results very close to those of MPFL reconstruction. Trillat *et al.* in 1964 [37], when discussing this technique as a therapeutic advance, stated that it involved medialization of the TTA with periosteal hinge, sectioning of the lateral patellar wing, and medial capsulorrhaphy.

A literature review conducted by Payne *et al.* [31] highlights potential cases of perioperative and postoperative complications related to anterior tibial tuberosity transfers. These complications include hematomas (during the sectioning of the lateral patellar wing), TTA fractures, infections, TTA pseudarthrosis, and overcorrection of the TT-GT distance.

Our series is notable for the absence of perioperative incidents or accidents. The systematic use of washers allowed us to achieve sufficient compression without fracturing the bone rod.

Table 9 presents a comparison of the complication results in our series with those of other authors.

Table 9: Comparison of complication results with those of other authors

Authors	n	Complications			
		Fracture of TTA	Hematoma	Infection	Pseudarthrosis
Servien *et al*., 2007 [35]	174	2	- 2	4	- 1
Koeter *et al*., 2011 [18]	60	2	-	1	
Neveed *et al*., 2013 [27]	34	2	-	**- 2**	**1**
Our series	13	-			1

The recurrence rate reported in the literature after TTA transfer varies between 0% and 13% [2]. In our series, no recurrences were noted over 3 years of follow-up. This result is consistent with the findings of Lim *et al.* [22], who reported no cases of recurrence in 14 patients over 16 months of follow-up, as well as Kumar *et al.* [21], who had a series of 27 knees without recurrences. However, other authors [2, 30, 39] have reported varying recurrence rates in their series, up to 17%. Nevertheless, it's important to note that we cannot draw definitive conclusions from this result due to the relatively short follow-up duration for our patients thus far.

From a clinical perspective, the subjective evaluation at follow-up, focused solely on the satisfaction level of our patients, provides very encouraging results. All our patients reported being very satisfied (62%) or satisfied (38%) with the treatment received in relation to the clinical condition of their knee, resulting in a dissatisfaction rate of 0%.

Overall, patellar tracking was considered normal both during flexion and extension, except for one patient (7.69%) who reported occasional patellar subluxation during fast walking with a positive Smillie apprehension. In our view, this case is not a failure but rather a less favorable outcome with subjective patellar instability.

The small size of our series prevents us from directly comparing these patellar stability results to those of larger series. However, when reviewing the literature, there are some series similar to ours that suggest our results are not unprecedented. For example, Marteau *et al.* [24] analyzed 14 knees treated with TTA transfer combined with MPFL reconstruction and reported 4 cases of subluxation with a positive Smillie test in 5 years of follow-up. Dantas *et al.* [7], with 24 cases, reported a 100% satisfaction rate in 52 months.

In slightly larger series than ours, cases of dissatisfaction can be found, as shown by Berruto *et al.* [2] with 38 knees, Kumar *et al.* [21] with 22 knees at follow-up, and Karataglis *et al.* [17] with 44 knees. These authors reported dissatisfaction rates of 6% at 16 months of follow-up, 18.18% at 36 months, and 27% at 40 months of follow-up, respectively.

However, by examining the reasons for dissatisfaction as reported in the study by Jacquot *et al.* [16], we understand that none of our patients were dissatisfied at follow-up simply because we were able to resolve the few post-operative problems encountered in a timely manner, such as infection, knee stiffness, and potential pseudarthrosis. This would have justified any dissatisfaction in the case of failure.

When looking at the clinical results in relation to functional

scores, 9 to 10 out of 13 knees were rated as "very good" or "excellent," with the remaining knees rated as "good." These functional results are consistent with the level of patient satisfaction, as discussed earlier. Patients experienced a significant improvement in the function of their knees. The mean Lillois score increased from 34.53 points out of 100 preoperatively to 92.61 points at follow-up, and the mean Kujala score increased from 41.61 points out of 100 to 93.79 points. It is challenging to determine which of the surgical procedures performed contributed to these very encouraging results (Highlighting the need for a cohort study). In reality, the choice of associated surgical procedures, both bony and soft tissue, was not made blindly. It aimed, through preoperative planning, to achieve better results considering the etiological factors identified and the intensity of the symptoms. The results of our functional scores at follow-up, taken as a whole, only add to the list of "Very good" and "good" results found in the literature, as illustrated by the table 10.

Table 10: Comparison of functional scores with those of other authors at follow-up

Authors	n	Follow-up (months)	Functional scores
Otsuki *et al.* [30] 2013	12	38,4	Kujala 94, 1; Lysholm 94, 7
Dantas *et al.* [7] 2005	24	52	Lysholm 98
Kumar *et al.* [21] 2001	22	36	Kujala 91
Tecklenburg *et al.* [36] 2010	33	36	IKDC 80,4; Kujala 88
Marteau *et al.* [24] 2011	14	84	SF-36: 81; KOOS 93
Our serie	13	33,32	Lillois 92,61; Kujala 93, 79

On the other hand, other authors have reported less favorable functional outcomes. This is the case of Lim *et al.* [22] with 14 cases, who reported Lysholm scores of 60.5 points and IKDC scores of 67 points at 16.5 months of follow-up. This result contrasts with the quality of their postoperative outcomes, but it could be explained by the fact that several of their patients complained of pain at the scar site at follow-up, probably related to saphenous nerve neuroma, and discomfort in the kneeling position, often due to screw-related issues. This was not a common issue in our series.

Similarly, Berruto *et al.* [2] and Zhao *et al.* [39] reported low Kujala and IKDC scores, with scores of 73.4 and 64.8 points at 16.5 months of follow-up for one group and scores of 73.8 and 61 points at 5 years of follow-up for the other. Evaluating the results obtained by Trillat *et al.* [37], J.S. Cox [6] points out that functional outcomes that appear better in the short term may not always remain so in the long term. This observation, confirmed through the studies of many authors [2, 3, 12, 26], suggests that it would be desirable to continue long-term functional evaluation of our patients.

Radiologically, at follow-up, all bone grafts had consolidated, even in the case of the patient who underwent a revision surgery for pseudarthrosis. Removal of the osteosynthesis material was performed in 3 out of 13 patients. There was no clear cause for reintervention in these patients, except for unfounded concerns expressed by two patients, such as fear of having metal in their bodies. The screws were well tolerated, and kneeling was comfortable, even in patients from whom the screws had been removed.

Concerning the removal of screws in TTA transfer, it is generally considered an unnecessary and potentially harmful surgical procedure because it can weaken the tibial bone, leading to iatrogenic fractures. However, it is occasionally indicated in cases of discomfort due to screw heads during kneeling positions. When indicated, screw removal can be performed as an outpatient procedure under local anesthesia, without the need for complete limb unloading or taking sick leave. Karataglis *et al.* [17] performed screw removal between 9 and 12 months postoperatively for 44 knees operated due to screw head sensitivity.

Endres and Wilke [10] reported 11 cases of reintervention for screw removal at 1 year due to poorly tolerated screw head prominence. In a somewhat different approach, Otsuki *et al.* [30] systematically performed screw removal for all their patients without providing a specific explanation for this particular approach. According to them, surgery results in a stabilization of pressure progression at the lateral femoropatellar joint and normalization of the medial femoropatellar joint space. None of their patients developed femoropatellar arthritis over 3.5 years of follow-up. In our case, while two patients kept their stable femoropatellar degeneration, two others developed external femoropatellar arthritis at stage I and II of Iwano at 11 and 48.4 months, respectively. Once again, only further evaluation will tell us more about the condition of the femoropatellar joint in our patients. Will it go against the flow and corroborate Otsuki *et al.*'s [30] results, or will it align with many of our predecessors [2, 6, 11, 12, 19] who have stated that? "While the Roux-Elmslie-Trillat procedure significantly improves patellar tracking, it does not have the same effect on the femoropatellar joint, which has a degenerative evolution in the long term."? Everything suggests that the challenge lies in finding the right balance in modifying patellar tracking. Insufficient medialization can favor the persistence of hyperpressure on the lateral side, while overcorrection can lead to medial femoropatellar conflict.

Patients with patella alta underwent simultaneous distal TTA transfer. This etiological factor alone can cause instability by late and inappropriate engagement of the patella in the femoral trochlea during knee flexion, known as the mal-tracking phenomenon. In the group with recurrent dislocations, more than half (54.54%) of the patients had patella alta preoperatively, and at follow-up, only one case of patella alta (9.1%) was observed. This case was a revision surgery for pseudarthrosis. As for the two patients in the PD group, the Caton-Deschamps index postoperatively and at follow-up was normal. After the reduction of their dislocation and TTA osteotomy, there was an automatic proximal transfer of TTA by a few millimeters due to relative quadriceps retraction.

In one of the two patients, trochleoplasty was performed for a flat trochlea (Type D dysplasia), recreating a retentive trochlea with a trochlear angle of 147° compared to 175° preoperatively. To combat the frequent patellar ascent and improve joint mobility after reducing a permanent dislocation, Anoumou *et al.* [1], in a clinical case of neglected traumatic dislocation in Ivory Coast, performed an excessive lengthening of the retracted quadriceps tendon with a Z-plasty, according to them. This resulted in a low-lying patella with a Caton-Deschamps index of 0.6 at follow-up. For the

group of patients with pre- and postoperative CT scans, the mean TA-GT in extension at follow-up was 15.32 mm compared to 22.27 mm before surgery. More than 70% of the patients had a TA-GT distance in extension within therapeutic limits (between 10 and 15 mm). Only 30% of them had a TT-GT distance at follow-up ranging between 15 and 20 mm and exhibited relatively lower functional scores compared to the others.

We sought to determine a correlation between postoperative TT-GT and functional scores to address the question we had in mind when initiating this research project, namely, whether knee function improved after medialization of TTA at CHOM.

Virtually all authors concur on the effectiveness of the Roux-Elmslie-Trillat technique (modification of the TT-TG, and thus, the Q-angle) on the function of the operated knee. However, we were unable to obtain meta-analysis data explaining this. A few rare studies available to us have established anatomic-clinical correlations but not a direct correlation between postoperative TT-GT and postoperative functional scores.

In a study on interobserver reproducibility of measurements for the calculation of an index indicative of objective femoro-patellar instability in MRI, Sébilo [34] established a linear correlation between TT-GT and the transverse engagement index of the patella in the femoral trochlea. He concluded that the smaller the TT-GT, the closer the patellar engagement index was to 1, indicating better patellar engagement in the femoral trochlea with a normal course.

Through an analysis of 27 knees that underwent TTA transfer according to Elmslie-Trillat, Kumar *et al*. [21] determined the strong connection that exists between the Q-angle and subjective outcomes after a 3-year follow-up. According to these authors, optimal results were observed when the Q-angle values were less than or equal to 10°, while the results were less satisfactory when this angle was equal to or greater than 15°. In our study, we found a correlation between postoperative TT-GT (Tibial Apophysis to Greater Trochanter) and the functional scores used. The smaller the postoperative TT-GT, the better the knee function at follow-up. However, due to the small size of our sample and the combination of surgical procedures for optimal results (requiring analytical cause-and-effect studies), it seems prudent not to generalize this result.

Conclusion

Through a postoperative anatomic-clinical correlation established between TA-GT and functional scores, we conclude that TTA transfer significantly improves the clinical and functional status of knees suffering from chronic patellar instability. The low morbidity observed in our series should be reevaluated through long-term follow-up.

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