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Original article

Compared outcomes 16 and 25 years after lateral wedge augmentation trochleoplasty: Rate of recurrent dislocation and progression to osteoarthritis

Eloïse Bauduin[a,b,c,*], Sophie Putman[a,b], Henri Migaud[a,b], Franck Remy[d], Emmanuel Debuyzer[a,b], Gilles Pasquier[a,b]

[a] Département universitaire de chirurgie orthopédique et de traumatologie, hôpital Roger-Salengro, rue Emile-Laine, 59037 Lille cedex, France
[b] Université Lille-Nord de France, 59000 Lille, France
[c] Service de chirurgie orthopédique et de traumatologie, hôpital Maison-Blanche, rue Cognacq-Jay, 51100 Reims, France
[d] Clinique de Saint-Omer, 71, rue Ambroise-Paré, 62575 Blendecques, France

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ABSTRACT

Background: Lateral wedge augmentation trochleoplasty (LWAT) was the earliest described trochleoplasty technique but was gradually replaced by other methods for the treatment of patello-femoral instability with trochlear dysplasia. Data on the outcomes of this procedure in adults are limited. We therefore performed a retrospective study in patients managed by LWAT to assess (1) clinical (recurrent instability and functional scores), (2) and radiological (patello-femoral osteoarthritis) outcomes.
Hypothesis: LWAT is associated with a low long-term rate of recurrent patello-femoral dislocation and with no risk of progression to severe patello-femoral osteoarthritis.
Material and methods: Between 1988 and 1995, LWAT was performed on 66 knees in 58 patients to treat patello-femoral instability with trochlear dysplasia. Among them, 17 knees in 13 patients were re-evaluated 16 then 25 years after surgery and were included in the study. At both time points, the following were recorded: stability, pain, the Lille patello-femoral function score, and changes in radiographic and computed tomography findings. In addition to LWAT, Insall's realignment vastus medialis advancement was performed in 4 cases, sartorius muscle transposition in 9 cases, and anterior tibial tubercle osteotomy in 10 cases.
Results: No episodes of patello-femoral dislocation were recorded during the 25-year follow-up. The mean Lille patello-femoral function score (0 worst to 100 highest) was 90 ± 15 (range, 48–99) after 16 years and 86 ± 23 (range, 33–94) after 25 years. After 16 years, 8/17 knees had evidence of patello-femoral osteoarthritis, which was Iwano stage 1 in 7 cases and Iwano stage 2 in 1 case. Patello-femoral osteoarthritis was noted in 12 of 13 knees after 25 years but was mild (Iwano stage 1 or 2) in 8 cases. After 25 years, arthroplasty had been performed for 4 of the 17 knees, with 2 cases each of patello-femoral arthroplasty and total knee arthroplasty.
Conclusion: LWAT is a reliable procedure that provides sustained protection against patello-femoral dislocation and good functional scores when used to treat patello-femoral instability due to trochlear dysplasia. Our results do not support claims that LWAT may be associated with high rates of severe osteoarthritis even after more than 20 years.
Level of evidence: IV, retrospective observational study with no control group.

1. Introduction

The main bone factor responsible for patello-femoral instability is dysplasia of the trochlea. The trochlea may be abnormally flat or convex [1], or the lateral trochlear facet may be abnormally short [2]. The goal of surgery is to stabilise the patella [3]. One option is trochleoplasty, which is the most effective procedure in severe patello-femoral instability [4–6]. Deepening trochleoplasty techniques were described by Masse et al. [7] in 1978 and Dejour et al. [3] in 1980. Subsequently, Bereiter et al. [8] developed a U-shaped deepening trochleoplasty procedure. Recession trochleoplasty was developed by Beaufils et al. [5] based on an initial description by Goutallier et al. [9].

* Corresponding author at: Traumatologie B, service de chirurgie orthopédique et de traumatologie, hôpital Maison-Blanche, rue Cognacq-Jay, 51100 Reims, France.
E-mail address: elobau@hotmail.fr (E. Bauduin).

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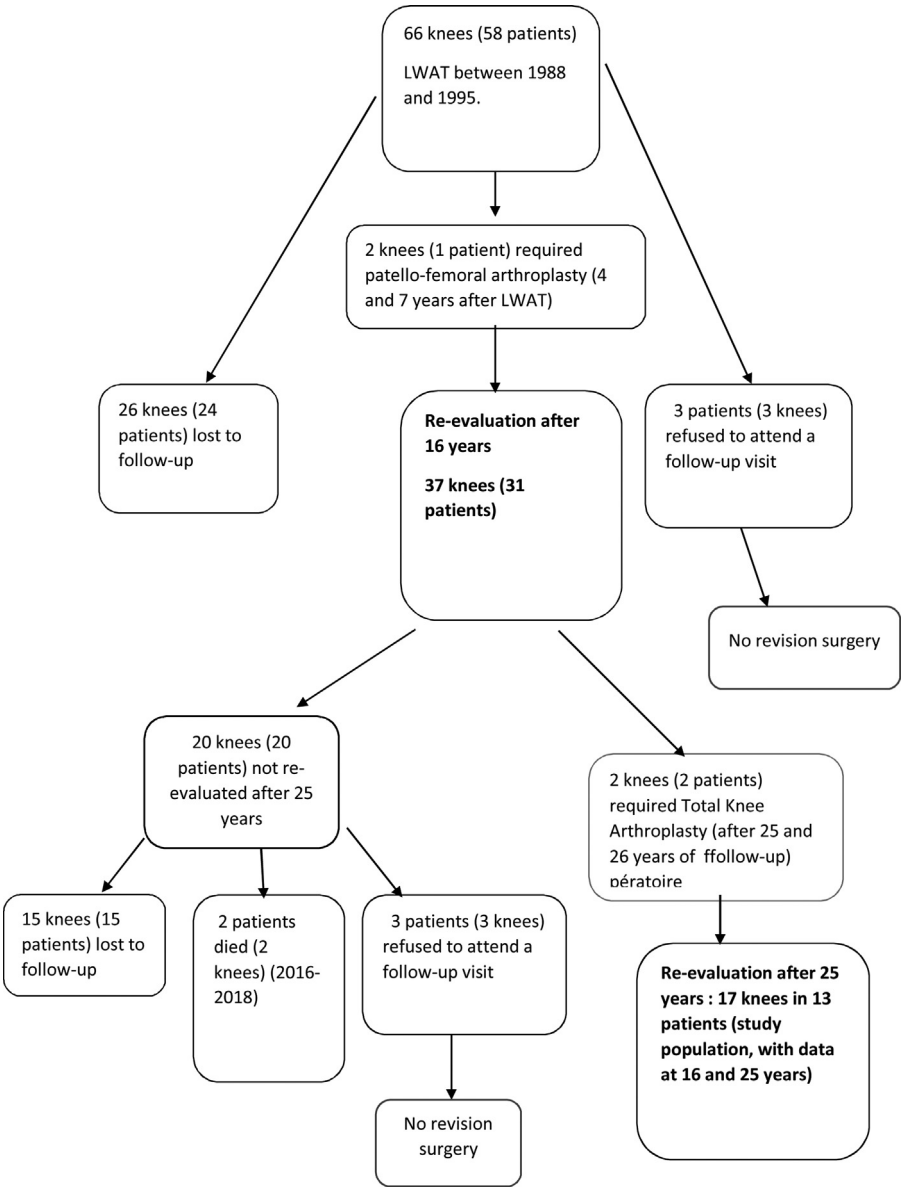


Fig. 1. Study flow chart.

Albee et al. [10] developed a lateral wedge augmentation trochleoplasty (LWAT) technique involving an osteotomy followed by the interposition of an autologous bone graft and by bone suturing. Published data on the outcomes of LWAT are scarce. LWAT restores a retentive trochlear groove and seems to produce satisfactory outcomes. This technique was eventually discarded, however, due to concern about a risk of patello-femoral osteoarthritis associated with the increased constraints on the lateral patello-femoral joint created by the augmentation of the lateral trochlear facet [3,11]. Few studies have assessed the outcomes of LWAT [11–13], and all of them have less than 20 years of follow-up.

We therefore performed a retrospective study in patients managed by LWAT to assess:

- clinical (recurrent instability and functional scores);
- and radiological (patello-femoral osteoarthritis) outcomes.

Our working hypothesis was that LWAT is associated with a low long-term rate of recurrent patello-femoral dislocation and with no risk of progression to severe patello-femoral osteoarthritis.

2. Material and Methods

2.1. Population

This retrospective study included 58 patients (66 knees) with trochlear dysplasia managed between 1988 and 1995 by LWAT at a mean age of 24 ± 8 years (range, 16–57 years). Among them, 31 (37 knees) were re-evaluated 16 years later and 13 (17 knees) 25 years later (Fig. 1). The study focussed on the 13 patients (17 knees) who were seen at both the 16-year and the 25-year time points.

Before surgery, the symptoms were objective patellar instability (one or more dislocation episodes) for 12 knees and subjective patellar instability (frequent giving way during daily activities) for the remaining 5 knees. Due to restricted availability, computed tomography (CT) was not performed routinely before surgery, and trochlear dysplasia was therefore classified according to Dejour et al. [3] initial classification launched in 1990. Dysplasia was present in all 17 knees, with the following distribution: stage 1, $n = 3$; stage 2, $n = 13$; and stage 3, $n = 1$.

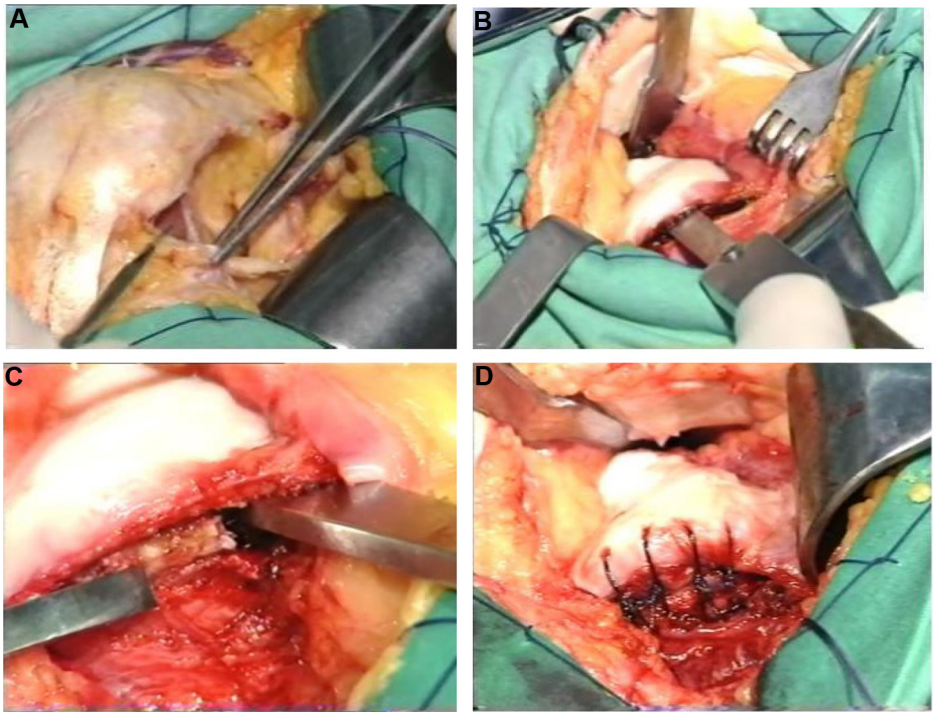


Fig. 2. Surgical steps in lateral wedge augmentation trochleoplasty. A. Lateral approach. B. Osteotomy and elevation of the lateral facet. C. Insertion of a bone graft from the lateral tibial epiphysis to maintain the correction. D. Bone suturing using 0.20–0.29 mm suture.

2.2. Operative technique

The lateral trochlear facet was elevated by about 5 mm to the edge of the trochlear groove (Fig. 2). A bone graft taken from the lateral tibial epiphysis was inserted under the elevated facet to create a retentive lateral trochlea [3,11,14]. Fixation of the osteotomy was with two or three resorbable-suture stitches through the lateral edge of the trochlear cartilage. Before wound closure, the result was checked to ensure that the trochlear groove thus obtained was retentive.

Additional procedures were performed on all 17 knees. Insall's vastus medialis advancement was performed in 4 cases [15]. In 9 cases, the sartorius muscle was transposed to the medial patellar edge by suturing to the fibrous prepatellar tissue and fixation to the medial epicondyle. Anterior tibial tubercle osteotomy was performed on 10 knees, with medialisation only in 8 cases and both medialisation and distal displacement in 2 cases. The criterion for medialisation was a tibial-tubercle-trochlear groove (TT-TG) distance greater than 20 mm and the criterion for distal displacement was a Caton-Deschamps index greater than 1.2.

2.3. Assessment methods

The patients attended follow-up visits 16.0 ± 2.4 years (range, 11–21 years) and 25.0 ± 8.0 years (range, 16–31 years) after surgery. The examiner was not involved in performing the surgical procedures. The data collected at the two time points were compared.

2.4. Clinical assessment

Patient satisfaction was self-evaluated on a 10-point scale where 10 indicated the highest possible level of satisfaction. During each follow-up visit, the patient completed the Lille questionnaire for patello-femoral function, whose results were categorised as follows: > 90, very good outcome; 80–89, good outcome; 70–79, fairly good outcome; 50–69, fair outcome; and < 50, poor outcome [16].

2.5. Imaging studies

A lateral radiograph of the knee at 30° of flexion was used to assess patellar height by determining the Caton-Deschamps index,

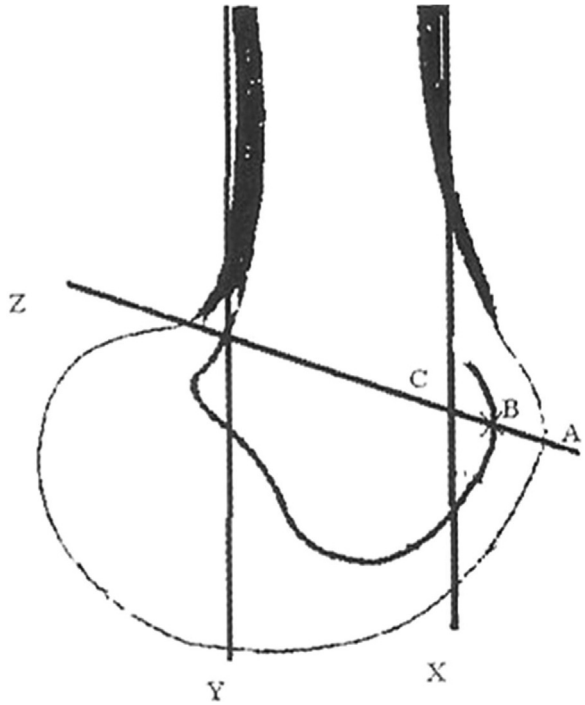


Fig. 3. Measurement of depth [AB] and protrusion [BC] as described by Dejour et al. [3].

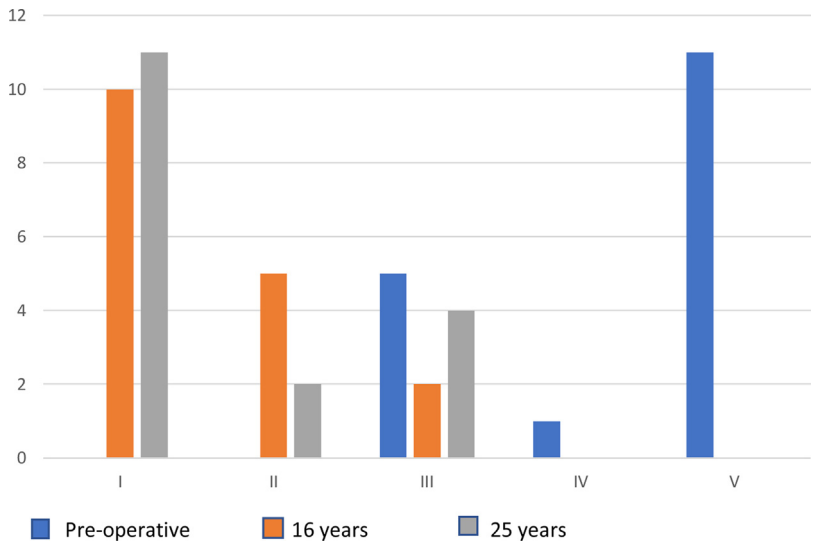


Fig. 4. Manifestations of instability before surgery and 16 and 25 years after surgery. Stade 0: stable, never gives way. Stade I: subjective instability with occasional giving way during sports. Stade II: subjective instability with occasional giving way during daily activities. Stade III: subjective instability with frequent giving way during daily activities. Stade IV: mechanical instability with at least one episode of patello-femoral dislocation. Stade V: mechanical instability with more than two episodes of patello-femoral dislocation.

to measure the trochlear bump and depth of the trochlear groove [2] (Fig. 3), and to look for signs of patello-femoral osteoarthritis. When present, the stage of patello-femoral osteoarthritis was evaluated on a skyline view at 30° of flexion according to the Iwano classification [17]. The trochlear angle was measured and considered to indicate trochlear dysplasia when greater than 143° [14]. An antero-posterior radiograph was examined for evidence of osteoarthritis, which was classified according to Ahlbäck [18]. CT was performed to measure the TT-TG distance, patellar tilt, the trochlear angle, and the lateral trochlear slope.

2.6. Statistical analysis

SAS software version 9.4 (SAS Institute, Cary, NC, USA) was used for the statistical analysis, which was performed at the biostatistics methodology department of the Lille university hospital (Lille, France). All tests were two-tailed, and *p*-values smaller than 0.05 were considered significant. Qualitative variables were described as *n* (%) and qualitative variables as mean (range). Groups were compared by applying Wilcoxon's test for paired samples.

3. Results

The study included 17 knees in 13 patients, 8 females and 5 males, who were re-evaluated 16.0 ± 2.4 years (range, 11–21 years) and 25.0 ± 8.0 years (range, 16–57 years) after surgery (Fig. 1).

Table 1
Clinical outcomes 16 and 25 years after lateral wedge augmentation trochleoplasty.

Mean (range)	Lille score [12] (/100)	Satisfaction (10-point visual analogue scale)
After 16 years	90 ± 15 (48–99)	7.6 ± 2 (4–10)
After 25 years	86 ± 23 (33–94)	8 ± 2 (4–10)

3.1. Clinical outcomes

At the 16-year time point, 2 of the 17 knees had had revision surgery with patello-femoral arthroplasty, 4 and 7 years, respectively, after the trochleoplasty procedure. At the 25-year time point, 2 additional knees had required total arthroplasty for incapacitating osteoarthritis involving all three compartments, 25 and 26 years after the trochleoplasty procedure, respectively. No cases of patello-femoral dislocation were recorded at the 25-year time point. Table 1 and Fig. 4 report the clinical findings at the two time points.

Knee pain at the first re-evaluation was absent for 7 knees and occasional for 10 knees, and the mean patient satisfaction score

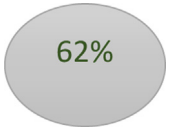
Table 2
Radiographic and computed tomography outcomes of 13 knees 16 and 25 years after lateral wedge augmentation trochleoplasty.

	Before surgery	After 16 years	After 25 years	*p*-value Preoperative vs. 16 y	*p*-value Preoperative vs. 25 y	*p*-value 16 y vs. 25 y
Trochlear bump (mm)	4 (3–4)	3 (1–4)	2.8 (0–3.5)	0.007	0.011	0.60
Trochlear depth (mm)	0 (0–3)	5 (2–9)	5 (4–9)	0.0001	0.0002	0.5313
Caton-Deschamps index	1.1 (1–1.4)	1.1 (0.9–1.3)	1 (0.6–1.4)	0.0625	0.0781	0.1563
Trochlear angle (°)	165 (142–200)	147 (130–162)	141 (120–150)	0.0010	0.0002	0.0313
TT-TG distance (mm)	15 (9–20)	14.6 (0–20)	12.6 (2.6–27)	0.0901	0.0879	0.051
Trochlear slope (°)	10 (20–17)	6.6 (−20 to +17)	23 (15–35)	0.056	0.0002	0.003
Patellar tilt (°)						
Quadriceps relaxed	16 (10–38)	17.8 (5–24)	9 (2–24)	0.064	0.0378	0.025
Quadriceps contracted	16 (8–36)	17 (6–20)	16 (4–22)	0.152	0.2991	0.140

TT: Tibial Tubercle; TG: Trochlear Groove.

Table 3
Radiological outcomes of lateral wedge augmentation and deepening trochleoplasty procedures according to the Iwano classification (knees with arthroplasty excluded from both groups).

PF OA, Iwano et al. [17]	LWAT after 16 years in our study	LWAT after 25 years in our study	Deepening trochleoplasty after 15 years (Rouanet et al. [19])
Number of knees	15 (2 PFA excluded)	13 (2TKA + 2 PFA excluded)	29 (3 PFA + 3 TKA excluded)
Stage 0	8 (53%)	1 (7.7%)	1 (3.5%)
Stage 1	6 (40%)	2 (15.4%)	8 (27.6%)
Stade 2	1 (7%)	5 (38.4%)	2 (6.9%)
Stage 3	0	2 (15.4%)	3 (10.3%)
Stage 4	0	3 (23.1%)	15 (51.7%)



PF OA: patello-femoral osteoarthritis; PFA: patello-femoral arthroplasty; TKA: total knee arthroplasty.

on the 10-point scale was 7.6 ± 2 (range, 4–10). After 25 years, the number of knees with no or only occasional pain was 10 compared to 6 preoperatively, and the number with severe pain was 1 compared to 6 preoperatively. The mean patient satisfaction score after 25 years was 8 ± 2 (range, 4–10) overall, 4 points in the 2 patients with patello-femoral arthroplasty, and 7 points in the two patients with total knee arthroplasty.

3.2. Radiological outcomes

Follow-up imaging studies were available for all 17 knees. The measurements were performed for the 13 knees that did not require arthroplasty procedures (Table 2).

Compared to the preoperative status, the trochlear bump was less prominent and the trochlear groove significantly deeper at both the 16-year and the 25-year time points. Patellar height was unchanged, with a mean Caton-Deschamps index of 1 ($p = 0.0781$). The radiographic trochlear angle was significantly diminished ($p = 0.0002$). Thus, the trochleoplasty procedure was effective in providing stable correction over time of the anatomical abnormalities (Table 2).

3.3. Patello-femoral and tibio-femoral osteoarthritis

None of the 17 knees had evidence of patello-femoral osteoarthritis before the trochleoplasty procedure. There was no evidence of patello-femoral osteoarthritis for 8/15 (53%) knees at the 16-year time point and 1/13 knees (7.7%) at the 25-year time point; thus, after 25 years, 5.9% of the 17 knees had no evidence of patello-femoral osteoarthritis (Table 3). However, after 25 years, of the 12 knees with patello-femoral osteoarthritis, 8 had only mild disease (Iwano stages 1 or 2) (8/13 knees without arthroplasty, 61.5%; and 8/17 knees in all, 47.1%).

After 16 years, none of the 15 native knees had signs of tibio-femoral osteoarthritis; 2 knees had required arthroplasty for patello-femoral osteoarthritis 4 and 7 years, respectively, after the trochleoplasty procedure. After 25 years, 2 knees had required total arthroplasty, leaving 13 knees for the assessment of osteoarthritis. Of these 13 knees, 4 had no evidence of tibio-femoral osteoarthritis. Of the remaining 9 knees, 5 were Ahlbäck stages 1 and 4 were Ahlbäck stage 2.

The 2 knees managed by patello-femoral arthroplasty had Iwano stage 3 patello-femoral osteoarthritis before the procedure. The 2 knees managed by total knee arthroplasty had predominant tibio-femoral osteoarthritis (Alhbäck stages 3 and 4, respectively) with Iwano stage 2 patello-femoral osteoarthritis.

3.4. Computed tomography (CT) findings

After 25 years, the TT-TG distance was not significantly changed ($p = 0.0879$), the trochlear angle was significantly decreased ($p = 0.0002$), and the trochlear slopes were significantly increased ($p = 0.0002$), compared to the preoperative values (Table 2).

4. Discussion

The main findings from this study indicate that LWAT provides long-term correction of trochlear dysplasia responsible for patello-femoral instability, with good functional outcomes and, most importantly, no recurrent patello-femoral dislocation. The Lille patello-femoral functional score was very satisfactory after 16 years and remained good after 25 years. Patello-femoral osteoarthritis was common after 25 years, with 2 knees requiring patello-femoral arthroplasty for stage 3 patello-femoral osteoarthritis but 8 (61.5%) of 13 knees having only mild lesions (Iwano stages 0, 1, or 2). These findings confirm our working hypothesis.

Published data on LWAT are scarce. No cases of recurrent dislocation were recorded in a paediatric study (mean age, 12.5 years) of 23 LWAT procedures combined with a soft-tissue procedure [11]. Badhe et al. [12] and Koeter et al. [13] reported significant pain relief with no change in the patello-femoral joint line after 12 and 51 months, respectively. Follow-ups were short in both studies but our findings confirm their encouraging results after 16 and 25 years.

Numerous studies have assessed the outcomes of other trochleoplasty techniques [20–22]. Goutallier et al. [9] reported a 67% satisfaction rate 4 years after deepening trochleoplasty performed on 12 knees. In studies by Longo et al. [22] and Van Sambeeck et al. [23], no meaningful differences in clinical outcomes or complications were found between the deepening trochleoplasty techniques described by Bereiter, Beaufils, and Dejour. Good long-term clinical outcomes with acceptable complication rates were demonstrated in a meta-analysis by Hiemstra et al. [24]. Severe patello-femoral osteoarthritis (Iwano stages 3 or 4) was less common 25 years after LWAT than 15 years after deepening trochleoplasty [19] (Table 3). Rouanet et al. [19] showed that deepening, although effective in permanently stabilising the patello-femoral joint, was associated with a high long-term risk of patello-femoral osteoarthritis, with Iwano stages 3 or 4 disease in 62% of cases.

The main limitation of our study is the small number of knees evaluated at the 25-year time point. In addition, a complicating factor for interpreting the results, particularly given the absence of a control group, is the use in many cases of additional procedures such as anterior tibial tubercle transposition and muscle transpositions. Medial patello-femoral ligament (MPFL) reconstruction is a fairly recent technique [6,25] that was not available 25 years ago and was therefore not used in our patients. MPFL reconstruction is now deemed necessary in many cases to manage the various components of patello-femoral instability. Despite these limitations, our study confirms that LWAT was discarded based on unconfirmed concerns. LWAT is a simple technique associated with only limited induced osteoarthritis in the very long-term and consequently remains a valid option for the treatment of patello-femoral instability.

5. Conclusion

LWAT is an effective treatment for patello-femoral instability. The limited aggressiveness of this technique is associated with a simple post-operative course. Although the natural history of the disease inevitably leads to osteoarthritis, LWAT provides good long-term outcomes in terms of patello-femoral stability, pain, and radiographic anatomical parameters. Correction of the various factors involved in patello-femoral instability requires an individually tailored surgical strategy combining appropriate bone and/or soft-tissue procedures.

Disclosure of interest

The authors declare that they have no competing interest.

S. Putman is a consultant for Corin.

H. Migaud is associated editor of *Orthopaedics & Traumatology: Surgery & Research* and is a consultant for Zimmer-Biomet, Corin, MSD, and SERF.

G. Pasquier is a consultant for Zimmer-Biomet.

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Contributions of each author

E. Bauduin contributed to collect and analyse the data and to draft the manuscript.

S. Putman contributed to collect the data and to draft the manuscript.

H. Migaud contributed to perform the surgical procedures and to prepare the final version of the manuscript.

E. Debuyzer and F. Remy contributed to collect the data.

G. Pasquier contributed to perform the surgical procedures, collect the data, and draft the manuscript.

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