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Original article

ACL reconstruction with lateral extra-articular tenodesis using a continuous graft: 10-year outcomes of 50 cases

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ABSTRACT

Background: Persistence of pivot shift is the main problem after isolated intra-articular anterior cruciate ligament (ACL) reconstruction. Adding lateral extra-articular tenodesis (LET) to the ACL procedure increases the knee's stability by controlling rotational laxity. The aim of this study was to evaluate the long-term clinical and radiological outcomes of combined ACL reconstruction with LET using a continuous hamstring graft as a first-line procedure.
Material and methods: Fifty patients were reviewed at 10 years postoperative. Subjective outcome scores –IKDC, Lysholm, KOOS and Tegner– were collected. A clinical and radiological assessment was done. The knees' anteroposterior laxity was measured with a rollimeter.
Results: The mean IKDC subjective score was 85.5, the mean Lysholm score was 90.2 and 80% of patients had a score graded as good or very good. No pivot shift was present in 94% of patients and there was a firm endpoint in the Lachman test in 86% of patients. There was a flexion deficit > 5° in 5 patients and an extension deficit of 10° in one patient. Most patients (56%) had resumed their physical activities at the same level as before the surgery. Signs of osteoarthritis were found in 26% of patients (16% were Ahlback stage 1 and 10% were stage 2). There was only one graft failure. These good outcomes are consistent with other published studies on combined ACL-LET. There was neither significant stiffness, nor a higher rate of secondary osteoarthritis relative to ACL reconstruction only, particularly in the lateral tibiofemoral compartment.
Conclusion: Adding primary LET to ACL reconstruction improves control of rotational laxity over time without increasing the complication rate.
Level of evidence: IV, retrospective study without control group.

1. Introduction

Persistence of pivot shift is the main problem after intra-articular anterior cruciate ligament (ACL) reconstruction. In fact, 25% to 38% of patients have a residual pivot shift after isolated ACL reconstruction [1,2]. This can be explained by the fact that the anterolateral ligament (ALL) may be torn in as many as 93% of those who suffer an ACL rupture [3]. One of the solutions proposed to this problem is double-bundle ACL reconstruction; while this procedure is effective at reducing the residual pivot sift [4], the drawback is its adverse effects (cyclops syndrome, tunnel fracture) [5,6]. Another solution is adding lateral extra-articular tenodesis (LET) to the intra-articular ACL reconstruction. LET has made a comeback in recent years because of the rediscovery of the ALL by Claes et al. in 2013 [7]. Some studies have shown that doing LET to address the ALL rupture helps to reduce the residual pivot shift after ACL reconstruction [8,9]. In fact, it increases the knee's stability by controlling rotational laxity [10–12], given its peripheral positioning relative to the joint by increasing the moment arm. The stresses are shared between the LET and ACL graft, up to 43% [13]. Lastly, if there is necrosis or stretching, the LET can counter dysfunction of the ACL graft. However, several adverse effects have been reported with LET. The first is knee stiffness in flexion/extension [14,15] and limited internal rotation [13,16]. Another drawback is the increased stresses on the lateral side of the knee with the development of lateral tibiofemoral osteoarthritis (OA) over the long term [17,18].

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However, these findings have been questioned by several other studies reporting that combining LET with ACL reconstruction helps to reduce the risk of secondary meniscal lesions [3] and OA, mainly because of the better control over rotational laxity [19,20].

In the literature, only a few studies have described the long-term outcomes of combined LET and ACL reconstruction. These studies either used the extensor mechanism or fascia lata during the reconstruction [21–23], but the techniques required harvesting a long graft from anatomical structures that may contribute to complications [24,25]. Since 2004, we have been using a reconstruction technique with a continuous graft taken from the hamstring tendons (gracilis, semitendinosus).

The aim of this study was to evaluate the long-term clinical and radiological outcomes of combined ACL reconstruction with LET using a continuous graft as a first-line procedure. We hypothesised that adding primary LET will lead to good clinical and functional outcomes over time without increasing the complications such as joint stiffness or OA.

2. Methods

2.1. Patients

This was a retrospective single-centre standard of care study in which patients operated between January 2006 and December 2011 were re-evaluated to determine the clinical and radiographic outcomes. Over this period, 129 patients underwent ACL reconstruction and LET with a continuous graft. All patients were operated by the same surgeon (S.C.) using the technique described below. Patients had to be less than 40 years of age at the time of surgery to reduce the chance that signs of OA on radiographs were due to age. ACL rupture had to be unilateral. The preoperative workup consisted of AP and lateral weight bearing radiographs of the knee and MRI. When osteochondral lesions > 3 cm^2 were discovered intraoperatively, these patients were excluded from the study cohort. Altogether, 50 patients were reviewed between January and December 2018 after a minimum follow-up of 7 years. Seven patients were excluded and 72 were lost to follow-up – 52 because they did not respond to our invitations and 20 because they no longer lived in the area, thus could not come to the clinic for an in-person review. Thirteen patients had meniscal lesions: 3 occurred before the ligament reconstruction and 10 at the same time. All the data related to the patients and injury mechanisms are shown in Table 1.

2.2. Clinical evaluation

During the final assessment, all the patients completed the following questionnaires: IKDC subjective, KOOS, Lysholm and Tegner. An objective evaluation was done by a single surgeon (P.M.) using the IKDC objective score at the final assessment. During this visit, the anteroposterior knee laxity in millimetres was measured using the digital Rollimeter® [26] and AP and lateral weightbearing views of the knee were taken to determine the Ahlback grade. Meniscal lesions and other clinical events that occurred on the operated knee during the follow-up period were documented. Lastly, the patients were asked three questions to provide a subjective evaluation of the surgery's functional outcomes:

1) Is your knee stable?
2) Are you apprehensive about your knee?
3) Are you satisfied with the surgery?

Table 1
Details about the patients and mechanism of injury.

	Mean ± standard deviation
Mean age at the time of surgery (years)	28.5 ± 8.1
Mean age at the time of review (years)	37.6 ± 8.1
Sex, Men/Women	33/17
Side, Right/Left	27/23
Mean follow-up (years)	9.9 ± 2
Time from injury to surgery (months)	7.7 ± 7.3
Height (m)	1.72 ± 0.1
Mass (kg)	75.6 ± 15
BMI (kg/m^2)	25.4 ± 4.4
Mechanism of injury	***n*** **(%)**
Sports	42 (84%)
Football	12 (28.5%)
Ski	8 (19%)
Rugby	5 (11.9%)
Motorcycle	4 (9.5%)
Combat sport (judo, karate)	4 (9.5%)
Basketball	3 (7.2%)
Handball	3 (7.2%)
Badminton	1 (2.4%)
Dance	1 (2.4%)
Tennis	1 (2.4%)
Injury at home	6 (12%)
Work-related injury	2 (4%)

n = Number of patients.

2.3. Surgical technique

We used a hamstring (gracilis and semitendinosus) graft that was left attached to the tibia to carry out a continuous intra-articular reconstruction with LET (Fig. 1). This technique was developed by one of the authors (S.C.) and has been used routinely in our practice since 2004. Passing the graft under the lateral collateral ligament (LCL) and the popliteal tendon results in a vertical orientation of the first portion of the external return. The highly posterior exit at the level of the posterior joint capsule provides an anterior (lateral femoral condyle) to posterior (joint capsule) orientation of this vertical portion and thus partially contributes to controlling external rotation. The horizontal portion acts as an anterolateral tenodesis to limit internal rotation.

The patients were positioned supine with a tourniquet at the base of the thigh. The various steps of the LET surgery are shown in Fig. 2. The lateral approach started slightly above Gerdy's tubercle and extended proximally in the axis of the fascia lata towards the lateral femoral condyle over 4–5 cm (Fig. 2B). The external return path was done first to make it easier to dissect various structures before the tissues become filled with arthroscopy fluid. The following anatomical structures were identified: Fascia lata, LCL, popliteal ligament, Gerdy's tubercle and posterior joint capsule. This step was done with the knee flexed 90° to relax the tissues. An arthrotomy was done with a scalpel about 2 cm above Gerdy's tubercle on the lateral side of the lateral condyle. Next, Metzenbaum scissors were used to trace the graft's future path, under the LCL and popliteal ligament, and coming back out posteriorly and through the posterior joint capsule (Fig. 2C). A shuttle suture was set in place (Fig. 2D). The gracilis and semitendinosus tendons were harvested with a stripper. Their distal insertion was preserved to improve the graft's vascularisation [27,28] and fixation [29]. We then prepared the graft to make a three-bundle continuous pedicled reconstruction (gracilis × 2 + semitendinosus) corresponding to the intra-articular ACL reconstruction, with a diameter of 7 to 9 mm. The second portion of the graft was a single bundle (semitendinosus) and used for the LET (Fig. 2E). The tibial and femoral tunnels were made during arthroscopy. The tibial tunnel was made using a 55° outside-in drill guide. The fibres from the original ACL were preserved as much as

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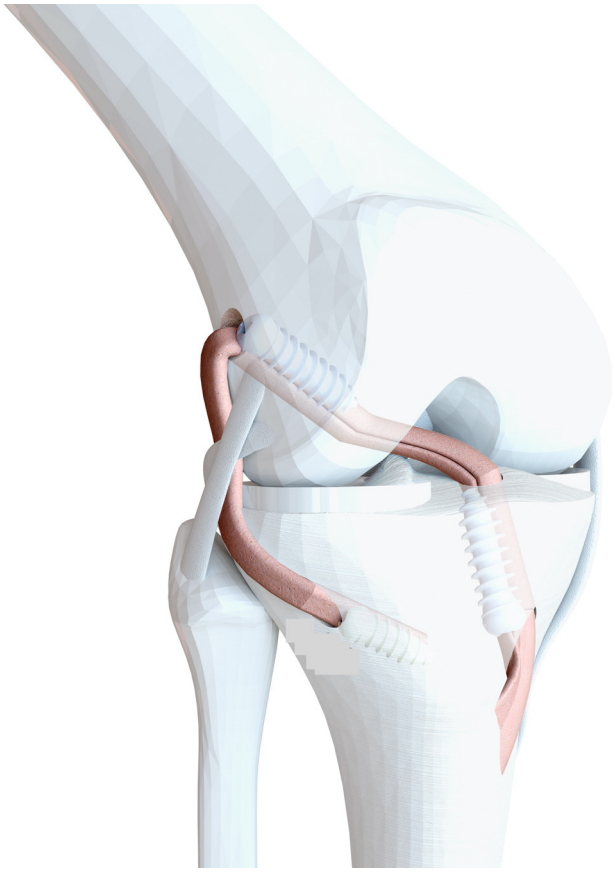

Fig. 1. Drawing showing the path taken by the graft for combined ACL reconstruction and lateral extra-articular tenodesis.

possible as they contribute to vascularisation and proprioception in the graft [30]. The femoral tunnel was made using an outside-in drill guide. The entry point was located on the proximal and posterior portion of the lateral femoral condyle. This is the femoral fixation point for anterolateral reconstruction described by Krackow [31]. The graft was passed through the knee using a traction suture then externalised on the lateral side of the femoral condyle. After cyclic loading, the intra-articular portion was fixed with interference screws (LIGAFIX®, SBM, Lourdes, France or ARTHROTEK®, Biomet, USA) in the tibial and femoral tunnels. The LET was moved along its path using the previously positioned shuttle suture (Fig. 2F). It was fixed at the tibia slightly behind Gerdy's tubercle using an interference screw in a tibial socket. Fixation was done with the knee flexed 90° and in neutral rotation.

2.4. Statistical analysis

The statistical analysis was done using Statis software (https://www.statis.fr; Toulouse, France). Quantitative data were summarised by their mean ± standard deviation. Qualitative parameters were compared using Fischer's exact test, while mean values were compared using Student's *t*-test. A p value ≤ 0.05 was considered significant.

3. Results

3.1. Subjective outcomes

The subjective outcome scores at the last follow-up are given in Table 2. The IKDC subjective score was above 70 in 80% of patients, while 80% had a good or very good Lysholm score. The KOOS score was also good with a mean value of 86.3 ± 16.3. The subscales "symptoms", "pain" and "daily living activities" had scores of 90. At 10 years' follow-up, the Tegner score had decreased by 1 point (not significant). Fig. 3 shows the preoperative and final Tegner scores.

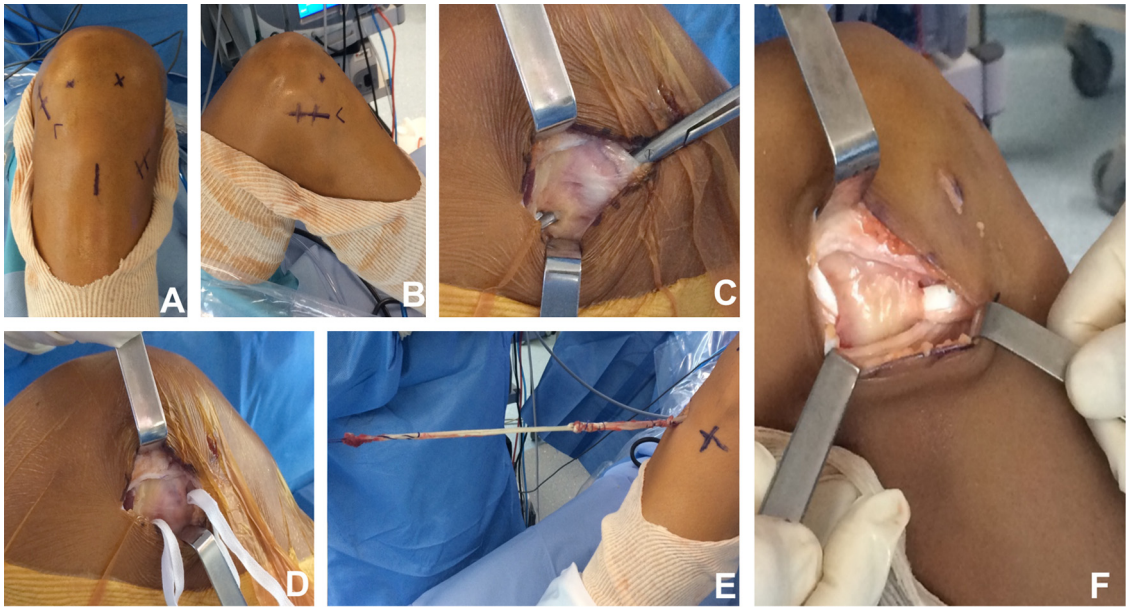

Fig. 2. A. Incisions: Two arthroscopic anteromedial and anterolateral portals and one surgical approach used to harvest hamstring tendons. B. Lateral surgical approach: The lateral incision starts slightly above Gerdy's tubercle and extends proximally in the axis of the fascia lata towards the lateral femoral condyle over 4–5 cm. C. Arthrotomy is done with a scalpel about 2 cm above Gerdy's tubercle on the lateral side of the lateral condyle. Next, Metzenbaum scissors are used to trace the graft's future path, under the LCL and popliteal ligament, and coming back out posteriorly and through the posterior joint capsule. D. Surgical tape is run over the course and used to pass the traction suture in the correct path. E. Three-bundle continuous pedicled reconstruction (gracilis × 2 + semitendinosus) corresponding to the intra-articular ACL reconstruction. The second portion of the graft is a single bundle (semitendinosus) and used for LET. F. View of the entire LET with its vertical trajectory that becomes horizontal after passing the posterior joint capsule.

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Table 2
Subjective outcomes.

Subjective outcome scores	Mean ± standard deviation (min, max)
IKDC subjective	85.5 ± 12.3 (52.9–100)
Lysholm	90.2 ± 9.1 (70–100)
100–84	40
65–83	10
< 64	0
Tegner before ACL injury	7.4 ± 1.7 (4–9)
Tegner at 10 years' postoperative	6.2 ± 1.7 (3–9)
KOOS	
Mean	86.3 ± 16.3
Symptoms and stiffness	89.6 ± 10.4 (60.7–100)
Pain	91.0 ± 11.3 (58.4–100)
Function daily living	94.2 ± 9.4 (66.7–100)
Sports and recreation	79.9 ± 23.6 (25–100)
Quality of life	76.6 ± 26.6 (12.5–100)

Table 3
Objective outcomes.

Objective assessment	*n* (% of patients)
IKDC objective	
None	43 (86%)
Glide	6 (12%)
Clunk	1 (2%)
Gross	–
Pivot shift	
None	47 (94%)
Slip	3 (6%)
Clunk	–
Locking	–
Lachman	
Firm endpoint	43 (86%)
Delayed firm endpoint	6 (12%)
Soft endpoint	1 (2%)
Radiographs (Ahlback classification)	
Stage 0	37 (74%)
Stage I	8 (16%)
Stage II	5 (10%)
Stage III	–
Stage IV	–
Knee laxity using Rollimeter	
Mean operated side	2.9 mm
Mean healthy side	3.9 mm
Difference between sides	0.9 mm

n = Number of patients.

3.2. Objective clinical outcomes

The results are summarised in Table 3. During the clinical examination for the final assessment, 47 patients (94%) had no pivot shift, while 43 patients (86%) had a firm endpoint on the Lachman test. In 49 of the 50 included patients, the operated knee was considered as "normal" or "nearly normal" (grade A or B) on the IKDC objective. The difference in anterior laxity measured with the Rollimeter between the healthy and operated knee was 0.9 mm on average. One patient had 6–10 mm difference while six patients (12%) had 3–5 mm difference. Range of motion measurements identified a 6° to 15° flexion deficit in five patients (10%) and a 10° extension deficit in one patient (2%). The other 44 patients had no reduction in range of motion.

3.3. Return to physical activity

More than half the patients (56%) had resumed their physical activities at the same level as before the injury. Twenty-two patients (44%) had resumed at a lower level. Among these 22 patients, 15 (68%) attributed their reduced activity level to their family or professional life, while 4 (18%) attributed it to their age. Only three patients attributed it directly to their knee.

3.4. Satisfaction and apprehension

Answers to questions:

- Is your knee stable? 4 patients (8%) said their knee was not stable. Among these 4 patients, three had knees considered as normal based on the objective IKDC score;
- Are you apprehensive about your knee? 35 patients (70%) said they had no apprehension about using their knee;
- Are you satisfied with the surgery? 36 patients (72%) said they were very satisfied, 13 patients (26%) were satisfied and 1 was not satisfied.

3.5. Radiographs

There were no radiographic signs of OA in 37 patients (74%). In the other 13 patients, the signs of OA were limited to the medial compartment and classified as Ahlback stage 2 in 5 patients (10%) and stage 1 in 8 patients (16%). There were no signs of OA in the lateral compartment. The mean age of patients was significantly higher ($p = 0.05$) in those with a higher Ahlback stage: 36 years for stage 0, 40 years for stage 1 and 44 years for stage 2.

3.6. Meniscal lesions

Altogether, 8 patients (16%) had medial meniscal lesions months or years after the ligament reconstruction; 4 of them (8%) had to undergo another surgical procedure. Two patients had both a concurrent lesion and a later one. Lastly, two patients had a meniscal lesion before the ligament reconstruction and one afterwards. These meniscal lesions were treated by partial meniscectomy. Eight patients (62%) had a meniscal lesion among those who had signs of tibiofemoral OA versus nine patients (24%) without OA ($p < 0.05$).

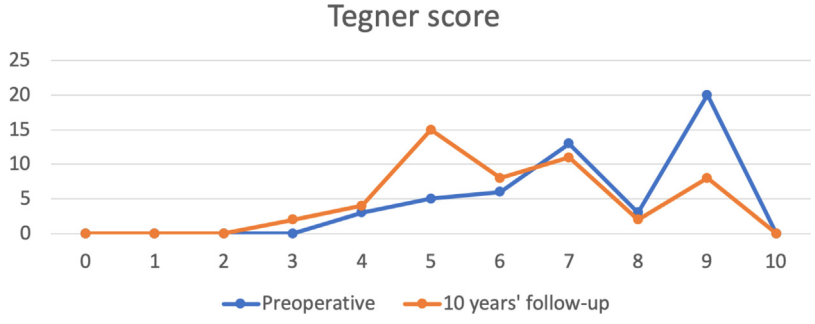

Fig. 3. Preoperative and final Tegner score.

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3.7. Events and complications

Among the patients who developed tibiofemoral OA, two were treated by viscosupplementation and one received a platelet-rich plasma injection. The graft failed in one patient at 4 years postoperative. This was a consequence of a running injury; the patient did not want to be reoperated. This failure can be explained by incorrect graft placement, as the femoral tunnel exit was too distal relative to the lateral femoral condyle.

Seven patients (14%) had surgical site complications:

- at 8 years postoperative, one patient stated having continued pain behind her thigh due to the hamstring tendon harvesting. She also had hypoesthesia on the anterior side of the tibia (saphenous nerve);
- one other patient had hypoesthesia on the anterior side of the tibia;
- three patients had discomfort related to the interference screw near Gerdy's tubercle; one of these three patients asked for the screw to be removed;
- one patient had a granuloma on the lateral scar;
- one patient had a neuroma near the incision used to harvest the hamstring tendons.

Overall, five patients (10%) required a surgical revision.

4. Discussion

Our working hypothesis was confirmed. Satisfactory outcomes were achieved after combined ACL reconstruction with LET using a continuous graft with 98% of knees considered normal or nearly normal at 10 years. Also, 56% of patients were able to return to sport at the same level. The LET is distinctive because its course is not anatomical; it is extra-articular upon exiting the femur, then becomes intra-articular at the posterior joint capsule. Standard anterolateral reconstruction procedures use a more direct course that mimics the ALL's anatomical configuration [32–35].

4.1. Subjective outcomes

Given the rapid expansion of ALL reconstruction, the Francophone Society of Arthroscopy (SFA) did a symposium on this topic in 2016. The resulting multi-centre study reported the 7-year outcomes of 478 patients. A continuous graft was used in 386/478 cases, with the hamstring tendons being used as the graft in 55%. The subjective IKDC and Lysholm scores [19] were comparable to ours although the follow-up was shorter. Other published studies report similar functional scores to ours [3,32,33]; however, the follow-up was shorter [33] or the patients younger [3]. While recent articles with similar follow-up report a Tegner score around 4 [32,36], the mean score (6.2) was better in the current study.

4.2. Objective clinical evaluation

The only two studies of continuous hamstring grafts found residual pivot shift of 6% at 10 years, according to Marcacci et al. [32] and 14% at 20 years for Zaffagnini et al. [36]. In a review of literature by Sonnery-Cottet et al. of seven comparative studies [37], residual pivot shift was found in 27% of patients who underwent ACL reconstruction only and 13% in those who underwent ACL reconstruction with LET. In the current study, residual pivot shift was found in 6% of patients. This is lower than in studies describing the outcomes after ACL reconstruction only [38–40]. Thus, combining LET with ACL reconstruction is thought to reduce the occurrence of pivot shift in the long term.

The knee ROM after isolated ACL reconstruction in various published studies identified a flexion deficit (> 5°) in 11% to 13% of patients and an extension deficit (> 5°) in 0% to 7% of patients [39,41,42]. In the current study, none of the patients had significant knee stiffness after 10 years. Nevertheless, one patient had a minor extension deficit and five patients had a flexion deficit that did not impact their activities of daily living. These findings and those in the current literature [19] support the idea that adding extra-articular LET is not a risk factor for joint stiffness.

4.3. Return to sport/physical activities

The secondary objective of ACL reconstruction in a younger population is return to sport at the pre-injury level. Other published studies found that at least 80% of patients returned to their sports activities, but only in a recreational setting [36] or without specifying the level [35,43]. In the current study, the patient population was fairly young at the time of surgery (28.5 years on average) and 92% were athletes. At 10 years' follow-up, 82% of patients still regularly participated in sports. Of the 9 patients who had reduced or stopped their sports, only 3 attributed it to their operated knee. Also, 56% of patients returned to sport at the same level as before their injury, which is a higher share than in other published studies [22,44].

4.4. Osteoarthritis

One concern about adding LET is the risk of OA in the lateral knee compartment over time. In fact, some authors found a higher rate of degenerative changes in the lateral compartment when LET was done [18,45,46]. The incidence of OA in the literature varies greatly from 16% to 71% at 10 years' follow-up. However, most of these studies found a significantly relationship between the occurrence of OA and the presence of a meniscal lesion [2,3,14,19,34,47]. Lastly, recent studies found a lower incidence of knee OA when LET was added relative to studies where only ACL reconstruction was done [3,19].

In this long-term study, a 26% incidence of OA (Ahlback stage 1 or 2) was found, solely in the medial compartment. Two factors can explain this finding. The first is a history of meniscectomy (before, during or after ligament reconstruction). In fact, the meniscectomy rate was higher in the patients who developed OA (62%) than those who did not (24%). The second is the patients' age at the final assessment, which was significantly higher in those with OA (42.8 years vs. 35.9 years). This is consistent with other published studies [34,44,47], while other studies report a higher OA incidence at 10 years' follow-up [14,23,36].

4.5. Complications

Performing a combined ACL reconstruction with LET using a continuous distally pedicled graft has the advantage of reducing the morbidity associated with harvesting multiple grafts. The fact that it is pedicled provides duplicate tibial fixation (pedicled graft + tibial interference screw) and also preserves the graft's vascularisation as reported by Sonnery-Cottet et al. [30].

As for graft failures, the rate varies between 4% and 8% in studies of ACL reconstruction only and similar follow-up period [38,39,41,48]. In the SFA study (ACL reconstruction + LET) [19], the failure rate was 5.4%. In the current study, there was only one failure, as in the Zaffagnini study [36].

4.6. Limitations

This study has a few major limitations. Even though patients underwent an independent clinical and radiological review, the

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lack of a control group undergoing ACL reconstruction only means that we cannot draw any firm conclusions about one technique being better than the other. Furthermore, the number of patients lost to follow-up is also a limiting factor. Only a comparative prospective study would allow us to achieve this certainty. Conversely, our study reports the long-term outcomes of a relatively large number of patients. There are only two other studies describing long-term outcomes (>10 years) of combined ACL reconstruction with LET using continuous hamstring graft that had a similar sample size as ours [32,36].

5. Conclusion

This study shows that adding LET to an ACL reconstruction procedure provides good clinical and functional outcomes over time, without increasing the complications related to joint stiffness or osteoarthritis.

Disclosure of interest

The authors declare that they have no competing interest.

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Author contributions

PM evaluated patients, collected data and wrote the article; HP collected data; AA contributed to the writing of the article; YL and PL revised the article; RdB and TF designed the study; and SC sponsored the study, developed surgical techniques and operated on all the patients.

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