

# Posterolateral Bundle Reconstruction With Anteromedial Bundle Remnant Preservation in ACL Tears

## Clinical and MRI Evaluation of 39 Patients With 24-Month Follow-up

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**Background:** Augmentation consisting of a selective reconstruction of the ruptured bundle while preserving the remnant bundle has been proposed as a treatment option for partial anterior cruciate ligament (ACL) tears. Good clinical outcomes after selective anteromedial (AM) bundle augmentation have been reported, whereas little is known about selective reconstruction of the posterolateral (PL) bundle with preservation of the AM bundle remnant.

**Purpose:** The purpose of this study was to evaluate the clinical outcomes and the magnetic resonance imaging (MRI) characteristics of selective PL bundle reconstruction with a median follow-up of 24 months.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** In a consecutive series of 741 ACL reconstructions, 44 patients underwent a selective PL bundle reconstruction with preservation of the AM remnant. Four patients with contralateral knee ligament surgery and 1 patient who sustained a traumatic rupture of his graft were excluded, leaving 39 patients for final evaluation. Clinical evaluation of knee function and laxity were recorded preoperatively and at a mean 24.2-month follow-up. Magnetic resonance imaging was performed on 35 patients at a mean 25.9-month follow-up for evaluation of graft and remnant bundle continuity, tunnel enlargement, and graft remodeling status by measuring the signal intensity of the graft (contrast/noise quotient [CNQ]).

**Results:** Tegner and Lysholm knee scores were significantly improved after surgery. The subjective International Knee Documentation Committee (IKDC) score was  $43.5 \pm 16.6$  preoperatively and  $89.9 \pm 6.6$  at the final follow-up ( $P < .01$ ). The objective IKDC score was “B” for 17 patients, “C” for 21 patients, and “D” for 1 patient preoperatively, while it was “A” for 34 patients and “B” for 5 patients postoperatively ( $P < .01$ ). The mean side-to-side anteroposterior laxity was 5 mm (range, 4-10 mm) preoperatively and 1.5 mm (range, -1 to 4 mm) at final follow-up ( $P < .01$ ). On MRI, the graft was visible and continuous in all cases. No cyclops lesions were noted. The average CNQ for the PL graft and the AM remnant bundle was  $3.2 \pm 1$  and  $2.9 \pm 1.2$ , respectively. Minimum bone tunnel enlargement was found.

**Conclusion:** Selective PL bundle reconstruction restores knee stability and function. At final follow-up, MRI showed continuity of the PL graft without signs of dramatic tunnel enlargement or cyclops syndrome.

**Keywords:** ACL partial tear; anterior cruciate ligament; posterolateral (PL) bundle

Improved knowledge of the anatomy and biomechanics of the anterior cruciate ligament (ACL) has increased considerably

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The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.

in the past 10 years. This knowledge has led to a modification of techniques for ACL reconstruction with the emergence of double-bundle reconstruction.<sup>43,44</sup> More recently, reconstruction of a selective bundle with preservation of the ACL remnant in cases of partial tears has been described. These partial ACL tears can be identified in 10% to 20% of all ACL injuries,<sup>26,47</sup> and the clinical results from published series of selective ACL augmentation have generally been excellent.<sup>2,5,26,27,36,39,40</sup> However, a standard definition of a partial ACL tear does not exist, and its diagnosis remains clinically challenging. The American Medical Association<sup>4</sup> defines a partial tear on the clinical assessment, whereas Noyes et al<sup>24</sup> base it on the percentage of ACL remnant and Crain

et al<sup>7</sup> and Sonnery-Cottet et al<sup>39</sup> on the arthroscopic evaluation; DeFranco and Bach<sup>8</sup> use a multifactorial definition. Preservation of the ACL remnant with reconstruction of the torn bundle seems theoretically beneficial in terms of vascularity,<sup>11,23</sup> proprioception,<sup>1,9,18,28</sup> and kinematics.<sup>7</sup> Moreover, accelerated graft integration has been recently demonstrated in animal models.<sup>21,22</sup>

Although a number of articles have shown good outcomes following anteromedial (AM) bundle augmentation with preservation of the posterolateral (PL) remnant,<sup>2,5,26,27,36,39,40</sup> there is a paucity of studies on PL bundle augmentation with preservation of the AM remnant.<sup>27,29,36,45</sup>

Selective reconstruction of the PL bundle with preservation of the AM remnant has been used in our department since January 2008. Our hypothesis was that selective PL augmentation could restore normal knee stability and function. The purpose of this study was to evaluate the clinical outcomes of this technique and to correlate these results with magnetic resonance imaging (MRI) assessment of tunnel widening and graft healing achievement in a series of 39 patients with a mean follow-up of 24.2 months.

## MATERIALS AND METHODS

### Patients and Inclusion Criteria

Between January 2008 and December 2009, in a consecutive series of 741 ACL reconstructions, 44 patients (6%) underwent an isolated PL bundle reconstruction with preservation of the AM remnant. Diagnosis of the ACL injury was made on physical examination (Lachman and pivot-shift tests) and confirmed by MRI of the involved knee. The indication for surgery was symptoms of instability that prevented the patient from resuming their previous level of activity.

The decision to perform a PL augmentation was made during arthroscopy after thorough analysis of the ACL tear. At surgery, patients were included in this study when examination under anesthesia revealed a positive Lachman test with a firm endpoint, a meticulous arthroscopic assessment of the ACL confirmed an AM remnant bridged the femur to the tibia in an anatomic fashion, probing of the AM remnant confirmed continuous fiber preservation irrespective of the preoperative laxity and its diameter attenuation, and a positive pivot shift was observed.

Patients with a complete ACL rupture, multiple ligament injuries, previous or contralateral knee ligament surgery, or grade 4 osteochondral lesions were excluded from the study. In total, 4 patients were excluded because of contralateral ACL reconstruction and 1 because of a traumatic graft failure that occurred 18 months after reconstruction, leaving 39 patients available for clinical evaluation at  $24.2 \pm 4.2$  months postsurgery. All procedures were performed by the senior author (B.S.-C.). The mean interval between injury and surgery was  $5.7 \pm 6.8$  months. The mean patient age was  $30 \pm 10.2$  years. In 17 cases, the mechanism of ACL injury was due to contact while playing soccer, rugby, or basketball. A noncontact pivoting injury was the cause in the other 18 cases (Table 1).

TABLE 1  
Patient Demographic Data<sup>a</sup>

Ratio, M:F	22:17
Age at surgery, y, mean $\pm$ SD	$30 \pm 10.2$
Cause of injury, n	
Noncontact sport	20
Contact sport	19
Preoperative period, mo, mean $\pm$ SD	$5.7 \pm 6.8$
Follow-up, mo, mean $\pm$ SD	$24.2 \pm 4.2$
Lachman test	Positive in all cases with a firm endpoint
Pivot-shift test	Grade 1: 34 Grade 2: 3 Grade 3: 2
Concomitant surgery, n	
Partial meniscectomy	1 MM, 3 LM
Meniscal suture	7 MM, 1 LM

<sup>a</sup>M, male; F, female; SD, standard deviation; LM, lateral meniscus; MM, medial meniscus.

### Surgical Technique

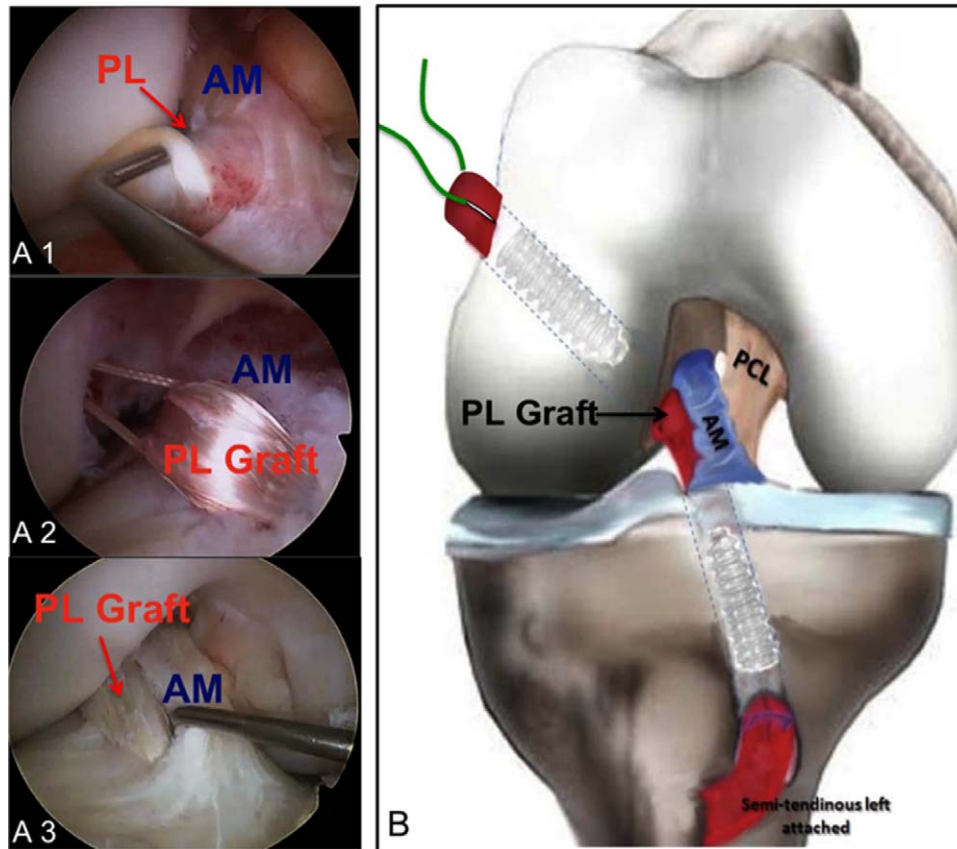
Before surgery, examination under anesthesia was performed to confirm the diagnosis of ACL tear. The Lachman test was positive with a firm endpoint for all the patients included in this study. A meticulous arthroscopic assessment of the ACL tear was performed via standard AM and anterolateral portals. To distinguish the complete or incomplete nature of an ACL tear, the knee was placed in the figure-of-4 position.<sup>38</sup> This allows the 2 bundles of the ACL to be observed from the femoral to tibial insertions. Confirmation of a bundle's continuity was made using a probe. When continuous fibers were found to bridge the femoral and tibial insertions of the AM bundle in anatomic position, they were preserved irrespective of preoperative laxity. Following this, any associated meniscal injury or articular cartilage lesions were evaluated, and if necessary, meniscectomy or meniscal repair and treatment for cartilage lesions was performed. No notchplasties were performed in this series.

### Graft Harvesting

Our chosen graft for the PL bundle reconstruction was the hamstring tendon, the goal being to obtain a graft with a diameter of 7 to 9 mm. In all cases, this was achieved with a doubled or tripled semitendinosus graft. To harvest the graft, a 3-cm longitudinal skin incision was made on the medial aspect of the anterior tibial tuberosity. The graft was harvested using an open-ended tendon stripper, allowing its tibial insertion to be preserved, thereby improving fixation and vascularization of the graft.<sup>31</sup> The graft was prepared after the bony tunnels were drilled so that its length could be adjusted accordingly. It was then looped over a heavy traction suture and whipped so that more than 2 cm of graft was fixed within the femoral and tibial tunnels.

### Femoral and Tibial Tunnels

To visualize the femoral insertion of the PL and AM bundles of the ACL, the knee was placed at 90° of flexion. The



**Figure 1.** (A1) Arthroscopic aspect of a ruptured PL bundle with continuous AM remnant. (A2) Doubled ST graft routed from the tibia to the femur. (A3) Final view of the selective PL augmentation. (B) Illustration of the outside-in surgical technique. The tibial insertion of the doubled or tripled ST was preserved to improve fixation. PL, posterolateral; AM, anteromedial; ST, semitendinosus tendon.

insertions of the AM remnant were preserved. The PL femoral tunnel was performed using an outside-in technique similar to the double-bundle reconstruction.<sup>44</sup> This enables placement of the femoral guide and drilling of the tunnel with the knee flexed to 90°. The outside-in femoral PL tunnel was placed 6 mm distally and 30° posterior to the AM femoral insertion. This tunnel's diameter was that of the tripled or doubled semitendinosus graft. It was drilled through a small skin incision over the lateral femoral condyle. Specific attention was paid to avoid overstuffing of the notch. Thinner grafts (7 mm in diameter) were used in the presence of a large AM bundle remnant and/or a tight notch. The tibial tunnel was carried out in a standard fashion with a guide close to the lateral tibial spine and posterior to the AM bundle tibial insertion. It was the same diameter as the femoral tunnel.

#### Graft Passage and Fixation

The graft was routed from the tibia to the femur. Tibial fixation was first performed using a bioabsorbable interference screw of the same diameter as the tibial tunnel and 23 mm in length. The graft was tensioned on the femoral side and cycled through several flexion-extension movements. A bioabsorbable interference screw of the same diameter as the

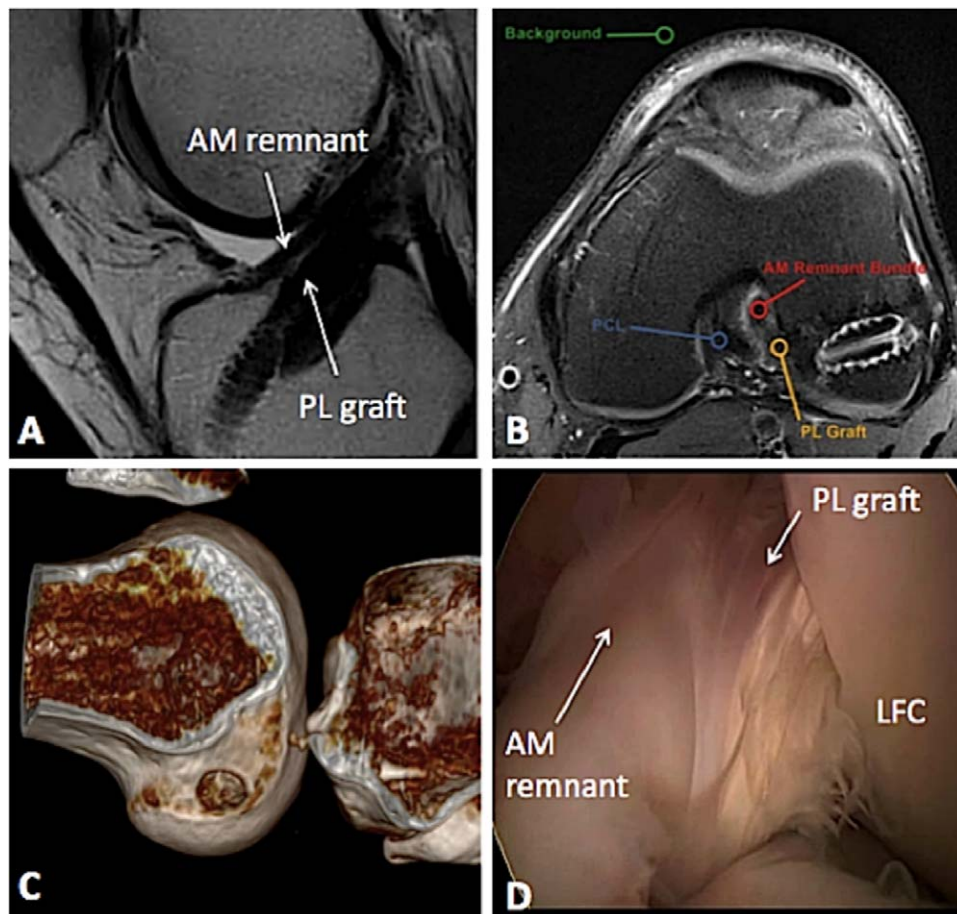
femoral tunnel and 23 mm in length was used to fix the graft in the femoral tunnel in an “outside-in” manner through the lateral incision while keeping the knee in full extension. Once the graft was secured, the PL graft was seen to lie posterior to the AM bundle in the notch (Figure 1).

#### Postoperative Rehabilitation

The rehabilitation protocol was the same as for a standard ACL reconstruction. On the day after surgery, 90° of active flexion was generally obtained. Partial weightbearing was recommended for 3 weeks without a brace. Running was allowed after 3 months and pivot sports after 6 months.

#### Clinical Evaluation

Clinical evaluations of knee function and laxity were performed preoperatively and at a mean follow-up of  $24.2 \pm 4.2$  months. Knee function evaluation was based on the Lysholm and Tegner knee scores and the International Knee Documentation Committee (IKDC) standard evaluation form. Knee stability was assessed by the Lachman and pivot-shift tests. Joint laxity was measured with a Rolimeter arthrometer (Rolimeter; Aircast, Summit, New Jersey, USA) at 20° of knee flexion under maximal manual tension.



**Figure 2.** T2-weighted MRI 2 years after selective PL bundle augmentation. (A) On sagittal view, the graft and AM remnant are both continuous and appear in low-signal intensity. (B) On coronal view, signal intensity was measured in 4 regions of interest located in the graft, the AM bundle remnant, the PCL, and anterior to the patellar tendon for the background. (C) Computed tomography scan demonstrating the PL femoral tunnel location. (D) Second-look arthroscopy at 2-year follow-up demonstrated good synovial coverage of the graft. MRI, magnetic resonance imaging; PL, posterolateral; AM, anteromedial; PCL, posterior cruciate ligament LFC, lateral femoral condyle.

### Magnetic Resonance Imaging Protocols

Thirty-five patients underwent MR scanning at a mean follow-up of  $25.9 \pm 1.7$  months. All scans were performed using a 1.5-T superconducting magnet (Siemens Magnetom 63 SP; Siemens, Erlangen, Germany) with a dedicated surface knee coil (Siemens AG). Imaging was confined to 3-mm-thick slices with a 0.5-mm gap between each slice. Axial, sagittal, and coronal fat-saturated proton density fast spin echo (FSE) sequences were performed (repetition time [TR], 3290 ms; echo time [TE], 51 ms; echo train length, 49; number of excitations [ACQ], 320/320 matrix). Tunnel enlargement was determined by digitally measuring the widths perpendicular to the long axis of the PL tunnels on an oblique coronal and axial plane. The MRI measurements were compared with the intraoperative drill diameter. The integrity of the graft on MRI was noted in all cases. The graft remodeling status was evaluated by measuring the signal intensity (Figure 2) of the PL graft and AM remnant bundle. To quantitatively determine normalized signal intensity of the graft and remnant

bundle, the contrast/noise quotient (CNQ) was calculated as follows<sup>42</sup>:

$$\text{CNQ} = \frac{\text{Signal (ACL)} - \text{Signal (PCL)}}{\text{Signal (background)}}$$

where PCL denotes the posterior cruciate ligament.

Regions of interest (ROIs) were positioned on axial fat-saturated proton density sequences. Circular 5-mm-diameter regions of interest were evaluated at the midsubstance of the graft and AM bundle remnant. The PCL signal was measured with the ROI placed in the midsubstance portion of the ligament. For background measurements, the ROI was placed approximately 2 cm anterior and lateral to the patellar tendon (Figure 2). Each measurement was performed 3 times for each bundle, and the average was recorded.

All measurements were performed by 2 independent radiologists with 9 and 4 years of experience in musculoskeletal imaging, respectively, with any discrepancy resolved by consensus. Both reviewers were blinded to patients' demographic data, clinical examination findings, and CNQ values.

TABLE 2  
Clinical Results<sup>a</sup>

	Preinjury	Before Surgery	Final Follow-up	P
IKDC evaluation				
Subjective, points		43.5 (14.9-77)	89.9 (72.5-100)	<.01
Objective, patients				<.01
A		0	34	
B		17	5	
C		21	0	
D		1	0	
Lysholm score (range)		60.8 (17-89)	94.2 (70-100)	<.001
Tegner scale (range)	6.8 (3-10)	2.3 (1-4)	6.4 (3-10)	<.001
Pivot-shift test		Grade 1: 34 Grade 2: 3 Grade 3: 2	Grade 0: 35 Grade 1: 4	<.01
Rolimeter, mm (range)		5 (4 to 10)	1.5 (-1 to 4)	<.01

<sup>a</sup>IKDC, International Knee Documentation Committee.

## Statistical Analysis

Statistical analysis was performed using SPSS (Statistical Package for Social Sciences; IBM, Armonk, New York). The paired *t* test was used to compare the preoperative and postoperative instrumented side-to-side laxity, preoperative and postoperative tibial tunnel and femoral tunnel diameter, and PL graft and AM remnant bundle CNQ. A marginal homogeneity test was used to compare the preoperative and postoperative pivot-shift testing and IKDC objective evaluation. Analysis of variance and regression model analysis were used to perform correlation studies. The level of significance was set at *P* = .05.

## RESULTS

In this continuous series of 741 ACL reconstructions, 44 patients (6%) underwent selective reconstruction of the PL bundle; 39 of these patients were available for clinical evaluation and 35 for MRI evaluation at the last follow-up. During surgery, 12 patients had a meniscal tear that required treatment: 1 lateral meniscal repair, 3 partial lateral meniscectomies, 7 medial meniscal repairs, and 1 partial medial meniscectomy.

No complications were encountered during surgery. Lack of extension and deficit of range of motion were not noted at the last follow-up. The clinical results are presented in Table 2. Significant differences were found between preoperative and postoperative subjective and objective IKDC evaluations (*P* < .01), Lysholm score (*P* < .001), Tegner scale (*P* < .001), and instrumented laxity testing (*P* < .01).

The mean tibial tunnel diameter increased from  $7.9 \pm 0.5$  mm preoperatively to  $8.9 \pm 1$  mm at MRI evaluation (*P* < .001), with a mean widening of 1 mm. Femoral tunnels increased from  $7.8 \pm 0.4$  to  $8.5 \pm 1.2$  mm (*P* < .01), with a mean widening of 0.7 mm.

The signal of the PL graft was visible and continuous in all cases (100%). The signal of the AM remnant bundle was visible and continuous in 32 cases (91%). No evidence of a

cyclops or cyclops-like lesion was identified. The mean CNQ at the last follow-up for the PL graft and AM remnant bundle was  $3.2 \pm 1$  and  $2.9 \pm 1.2$ , respectively (*P* < .05).

No significant correlation was found between CNQ and clinical results according to the IKDC (*P* > .05), Lysholm (*P* > .05), or Tegner (*P* > .05) scores. There was no relationship between the MRI results and the age and sex of patients. Furthermore, there were no significant correlations between CNQ and increased anterior joint laxity (*P* > .05), measured by the Rolimeter.

## DISCUSSION

In the present study, we found a statistically significant subjective and objective improvement in patient outcome following selective PL bundle reconstruction. These results are similar to those in previously published series of AM augmentation.<sup>27,36,40</sup> At final follow-up, no specific complications with this technique were noted. Moreover, our MRI study showed no evidence of cyclops lesions or dramatic tunnel enlargement and demonstrated that all grafts were intact at a mean follow-up of 2 years.

Recent interest has focused on selective AM bundle augmentation in partial ACL tears.<sup>2,5,26,27,36,39,40</sup> These series demonstrate a good clinical outcome whatever the graft used. Four recent prospective randomized controlled trial studies comparing ACL reconstructions with or without remnant preservations showed similar clinical outcomes at the final follow-up. Hong et al,<sup>12</sup> in their comparative study using a 4-strand allograft, found no evident advantage of the remnant preservation technique over the standard techniques in terms of stability, synovial coverage, and proprioception recovery. Zhang et al<sup>48</sup> showed that remnant preservation prevented tibial tunnel enlargement. Park et al<sup>32</sup> found identical clinical results when compared with a double-bundle reconstruction. In a preliminary French prospective randomized study, the authors found comparable clinical results with improved anterior laxity control with preservation techniques.<sup>33</sup> The superiority of augmentation techniques over

standard ACL reconstruction has not been demonstrated. Current outcome scoring systems do not evaluate the theoretical benefits of improved proprioception, ligamentization, and joint kinematics. The benefit of preservation techniques in keeping mechanoreceptors within the tibial stump has been demonstrated previously<sup>1,9,18,28</sup>; however, its proposed benefit in the biologic integration of the graft was not evaluated in these randomized studies.

Preservation of the ACL fibers that remain in continuity may be mechanically and biologically advantageous. The mechanical benefit of preserving the ACL remnant bridging the femur and tibia is difficult to quantify, but several authors have demonstrated that such scar pattern seems to reduce anterior laxity.<sup>7,20</sup> In our series, 5 patients had a grade 2 or 3 pivot shift preoperatively. From a clinical point of view, these cases cannot be considered as partial tears. Even if an AM remnant bridging the femur to the tibia was observed arthroscopically, the structural integrity of this remnant bundle is questionable. Thus, the diagnosis of true ACL partial tears is challenging. In our series, a PL bundle reconstruction with preservation of the AM remnant bundle was performed irrespective of the preoperative clinical test. Biologically, the ACL remnants have the capacity to improve the ligamentization of the graft,<sup>46</sup> and preservation of the synovial sheet seems to play an important role in its vascularization.<sup>11,19,23</sup> In a canine model, Matsumoto et al<sup>21</sup> elucidated that transplantation of ACL-ruptured tissue contributed to early tendon-bone healing. Mifune et al<sup>22</sup> demonstrated an increase in cellularity and angiogenesis and a significantly higher biomechanical strength in the augmentation group compared with conventionally reconstructed grafts in a rat model.

It is therefore logical for surgeons to consider PL bundle augmentation while preserving the AM remnant in an attempt to optimize the mechanical and biological outcome. However, to our knowledge, there are only a few studies presenting the results of a selective PL bundle augmentation.<sup>27,29,36,45</sup> In a retrospective comparative study, Yoon et al<sup>45</sup> reported no differences in clinical evaluation between 3 groups of patients with ACL reconstruction, AM augmentation, and PL augmentation. In an arthroscopic second-look study, including 5 selective AM bundle augmentations and 14 selective PL bundle augmentations, Ohsawa et al<sup>29</sup> reported acceptable synovial coverage and tension of the graft with preservation of the remnant at 1-year postreconstruction. Nevertheless, in their case series, 2 of the PL grafts demonstrated a partial tear at second-look arthroscopy.

According to studies based on second-look arthroscopy after ACL double-bundle reconstruction, Otsubo et al<sup>30</sup> demonstrated that none of the AM grafts showed evidence of rupture, while 11% of the PL grafts had substantial damage around the femoral tunnel aperture. This complication and potential tunnel enlargement due to the nonisometry of this bundle concerned us prior to undertaking this study. Tunnel enlargement after ACL reconstruction is related to mechanical and biological factors.<sup>6,17,37</sup> The mechanical factors include graft motion within the tunnels, the presence of fixation devices within the tunnels, improper tunnel placement, and accelerated rehabilitation.<sup>6,37,41</sup> The literature

reports that tunnel enlargement does not appear to adversely affect the clinical outcome,<sup>6,17,37</sup> even if it complicates revision surgery. In double-bundle reconstruction, Järvelä et al<sup>16</sup> found that the femoral tunnel enlargement was similar for AM and PL bundles. This enlargement was found in 35% and 48% of the AM and PL femoral bone tunnels, respectively, by Siebold.<sup>35</sup> In our study, we compared the diameter of the tunnel at MRI with the diameter of the drill used during surgery. We found minimum widening in the femoral and tibial tunnel sectional areas. This may be explained by a lack of any foreign body reaction related to the use of bioresorbable screws.<sup>34</sup> Furthermore, the out-in femoral fixation with interference screw limits the bungee effect.<sup>15</sup> Finally, doubled or tripled semitendinosus graft has a cross-sectional area that is sufficient to fill an 8- or 9-mm tunnel, thus avoiding synovial fluid penetration.

In this series, we also studied the ACL graft remodeling process by quantifying MRI signal intensity using the CNQ formula.<sup>42</sup> No previous study analyzing the signal of a selective PL augmentation to the AM remnant has been published. In a sheep study, Weiler et al<sup>42</sup> quantified the MRI signals of tendon grafts in relationship to revascularization or mechanical strength. They found a negative correlation between the signal intensity and mechanical properties and suggested that revascularization promotes graft strength. In a prospective randomized study, Gohil et al<sup>11</sup> compared graft revascularization during a standard ACL reconstruction with removal of the torn ACL remnant to ACL reconstruction with retention of the torn ACL. Using this MRI protocol, they showed that preservation of ACL remnant leads to earlier revascularization at 2 months and a significant reduction of ACL graft signal at 6 months within the midsubstance of the ACL graft. In a comparative study with or without ACL remnant preservation, Ahn et al<sup>3</sup> demonstrated that the remnant bundle preservation group showed a lower CNQ, but the difference was not significant. Finally, they concluded that MRI showed significantly larger ACL grafts in the remnant bundle preservation group, and these preserved remnant bundles showed progressive remodeling in the ACL graft. In our series, the mean PL CNQ value was similar to that reported in other studies at a similar follow-up.<sup>3,11</sup> Moreover, the PL CNQs were slightly higher than AM CNQs. These close CNQ values reflect an advanced remodeling process and the absence of tangible graft impingement.

Selective PL bundle augmentation requires a reproducible technique to place the PL tunnel in the anatomic insertion while preserving the AM remnant. In our experience and according to Giron et al,<sup>10</sup> this can be more easily achieved by using an out-in femoral guide. Several reports warn that the ACL remnant may increase the risk for cyclops lesions and impingement.<sup>11</sup> In a previous study,<sup>40</sup> it was demonstrated that special attention must be paid to the size of the graft used. A large graft can result in a loss of full extension postoperatively and pain due to excess tissue in the intercondylar notch. In our series, use of a 7- to 8-mm doubled or tripled semitendinosus graft with minimal debridement of the AM remnant did not lead to an increased incidence of cyclops or limited range of motion.<sup>40</sup> Ahn et al<sup>3</sup> performed ACL reconstruction using the remnant bundle

preservation technique with quadrupled hamstring tendon autograft and found no increase in the incidence of cyclops lesions.

There were several weaknesses in our study. With such a small number of patients and without a control group, we cannot show superiority of selective PL bundle reconstruction over other conventional ACL reconstruction techniques. We did not evaluate proprioception with this augmentation procedure to document improvement with selective reconstruction. No objective evaluation of rotational stability was performed; therefore, the significance of our study regarding knee function and instability is limited. Assessment of the remnant bundle integrity was not possible, and our series includes patients with an anteromedial bundle that was present but not functional. Further comparative studies are needed to show the true efficacy of this procedure. In our MRI protocol, we did not use contrast-enhanced MRI and assessment of imaging parameters over time, such as enhancement index and cross-sectional area, which provide quantitative and comparable information regarding the revascularization rate.<sup>13,14,25</sup> Furthermore, MRI cannot delineate graft viability as well as direct histological examination and was not compared with a control group. Therefore, the CNQ values are only descriptive. Correlation between graft histological features and its MRI signal change would have been of great clinical interest. However, in human studies, this practice cannot be ethically justified. In addition, our protocol allowed only 1 MRI at the last follow-up. Consequently, our study could not prove graft remodeling because graft remodeling is a time-dependent process. Moreover, for tunnel enlargement, we considered the initial diameter of the bone tunnel to be that of the drill diameter used during surgery.

## CONCLUSION

Our study confirms that selective PL bundle reconstruction with preservation of the AM remnant restores knee stability and function. The clinical outcomes were statistically improved and similar to those already published for the selective AM bundle augmentation. MRI analysis at 2-year follow-up demonstrated the continuity of the PL graft in all cases, a normal signal intensity of the graft, and no signs of tunnel enlargement or cyclops syndrome. A longer follow-up is needed to definitively validate this partial ACL reconstruction.

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