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Augmentation technique with semitendinosus and gracilis tendons in chronic partial lesions of the ACL: clinical and arthrometric analysis

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Abstract Most of the techniques described in the literature for the repair of chronic partial ACL tears, don't spare the intact portion of the ligament. The aim of this study was to perform a prospective analysis of the results of augmentation surgery using gracilis and semitendinosus tendons to treat partial sub-acute lesions of the ACL. This technique involves an ''over the top'' femoral passage, which enables salvage and strengthening of the intact portion of the ACL. The study included 47 patients treated consecutively at our institute from 1993 to 1998, with a mean injury-surgery interval of 18 weeks (range 12–36). The patients were followed up by clinical and instrumental assessment criteria at 3 months, 1 and 5 years after surgery. Clinical assessment was performed using the IKDC form. Subjective and functional parameters were assessed by the Tegner activity scale. Instrumental evaluation was done using the KT-2000 instrument: the 30-pound passive test and the manual maximum displacement test were performed. We obtained good or excellent results in 95.7% of cases. No recurrences in ligamentous laxity were observed. We believe that the described technique has the advantage of being compatible with ACL anatomy, and enables very rapid functional recovery.

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Introduction

ACL partial tears commonly associate with hemarthrosis of the knee; they include various types of ligament lesions: from intrasynovial hemarthrosis with damage to some fiber bundles, to damage to 3/4 of the entire structure [28, 36].

The rate of partial tears ranges from 28% [27] to 35% [23] of distortional traumas of the knee with hemarthrosis, and from 10 to 28% of all other ACL lesions [20].

According to Noyes [28], 38% of partial lesions evolve into complete tears, whereas Fruensgaard et al. put this rate at 50% [12]. Danylchuk et al. [8] reported that partial ACL tears can evolve into complete because of interruption of blood vessels and thus necrosis of the intact fibers. The amount of initial ligament damage is a statistically significant predictive factor of evolution into complete tear [28, 42].

Conservative treatment can be successful in patients not participating in strenuous physical activity. In patients with a high functional demand, even after a conservative program, surgical treatment is often required, because of the persistence of symptomatic instability [3, 28].

When ACL reconstruction is required, a standard procedure is generally used, thus sacrificing the residual portion of the ACL. In the literature we didn't find a technique which considered and spared the intact portion of the ACL.

For the last ten years we have been using a surgical technique of augmentation with semitendinosus and gracilis tendon in the treatment of partial ACL tears. This technique enables the intact portion of the ACL to be spared and provides a tendinous support structure that strengthens the residual portion of the ligament.

Materials and methods

Forty-seven patients with chronic unilateral partial ACL tear were consecutively treated between 1993 and 1998. Partial ACL tears were defined according to the clinical and arthroscopic criteria described by Barrack et al. [4]:

- Lachman test scores zero or 1+ (less than 5 mm);
- Pivot shift test is negative or only trace-positive;
- With diagnostic arthroscopy a significant portion of at least one bundle is healthy and is potentially functional as judged by palpation with a probe and arthroscopic anterior drawer testing.

In 12 cases the lesion involved the antero-medial band of the ACL (Fig. 1), whereas in the remaining 35 cases it involved the postero-lateral band (Fig. 2).

With regards to associated lesions, in one case there was a lesion of the posterior horn of the medial meniscus, in three cases a lesion of the posterior horn of the lateral meniscus, and in six cases a grade I–II chondropathy of the patello-femoral joint. All patients had no radiographic signs of knee joint degeneration, and they had healthy contralateral knees.

Thirty-two of the 47 patients were men and 15 were women. Mean age was 23.3 years (range: 16–27). The mean injury–surgery interval was 18 weeks (range: 12–36). Before trauma, 25 patients were involved in competitive sports (soccer, basketball, volleyball, tennis, skiing), whereas the remaining 22 practiced recreational sports. Both groups were involved in high demanding sports activities. According to the Tegner activity scale, the mean pre-injury sports activity level was 6.8 (range: 4–8).

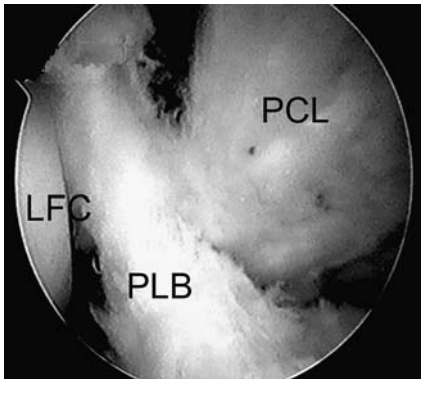

Fig. 1 Lesion of the AMB. The intact PLB is evident after debridement of the torn AMB. (*LFC* Lateral femoral condyle)

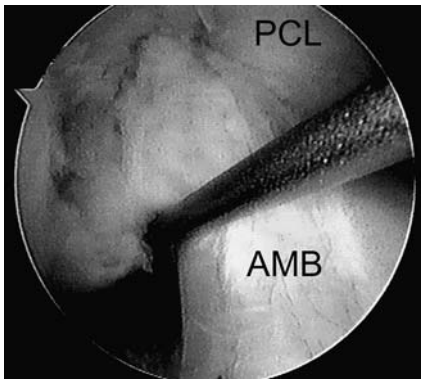

Fig. 2 Lesion of the PLB. The torn PLB is evident with the help of a hook probe keeping apart the healthy AMB

Before surgery, all patients underwent a non-standardized rehabilitation program for 8–12 weeks; after the rehabilitation program the patients were not able to resume their sports activity.

Surgical technique

Preliminary arthroscopic evaluation was performed by antero-lateral and antero-medial portals, under general or peripheral anesthesia, with the use of a tourniquet.

The entire ACL was examined to assess the extent of ligament damage, with special attention to its proximal portion. Palpation of the residual ligament enabled mechanical strength to be assessed, while the anterior drawer maneuver performed under arthroscopic control provided a functional evaluation.

During the arthroscopic examination, any combined intra-articular lesion was treated: chondral debridement of the patello-femoral joint was performed in six cases; three patients underwent arthroscopic lateral release; four partial meniscectomies were performed.

Accurate cleaning of the periligamentous structures allowed the graft passage points to be identified and freed, both at the tibial and femoral level.

A vertical incision in the proximal medial metaphysis of the tibia was made to isolate the semitendinosus and gracilis tendons. The tendons were harvested carefully with a tendon stripper. As much of the tendon portion as possible was obtained, while preserving the tibial insertion. After removing the residual muscle tissue, the proximal third of the two tendons was

tacked with four non-reabsorbable suture threads (Ethibond n°2).

The tibial tunnel was performed with a guide wire starting 5 mm medially and 5 mm superiorly to the bone insertion of the gracilis tendon. The emergence of the tibial guide wire in the joint was found close to the peripheral fibers of the residual portion of the ACL: if the AMB had to be restored, the tibial tunnel was in the anatomic footprint of this bundle (Fig. 3); in case of PLB reconstruction, the tibial tunnel emergence was just postero-lateral to the insertion of the AMB (Fig. 4). The tibial tunnel was drilled using a 7 or 8 mm cannulated reamer, depending on the size of the graft. Then the intra-articular passage for the graft was identified between ACL and PCL at the level of the intercondylar notch: this passage was not dependent from the bundle which had to be reconstructed. Through this passage, the lateral surface of the distal femur was reached, where the tendon graft was anchored by two metal staples in an ''over the top'' position. The remaining portion of the tendons was taken backwards anchored to a thread and fixed by tenodesis on the anatomical insertion of the hamstring tendons.

In case of AMB replacement we obtained an anatomic reconstruction, with the graft placed in an 11 o'clock position, running parallel to the residual PLB (Fig. 5). In case of PLB replacement, we had not an anatomic placement, with the graft not placed in a 10 o'clock position because of the presence of the residual AMB: we obtained a more vertical graft bridging and tensioning the AMB (Fig. 6).

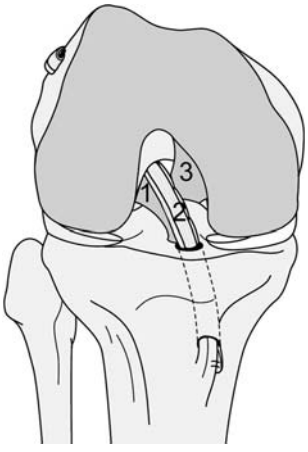

Fig. 3 Reconstruction of the AMB. The intact portion of the ACL (*1*: PLB) is preserved. The intra-articular emergence of the tibial tunnel is in the antero-medial region of the ACL insertion. The quadrupled hamstring graft (*2*) is placed in the over the top position leaving intact its distal insertion. The graft is passed between the intact portion of the ACL and the PCL (*3*), in an 11 o'clock position

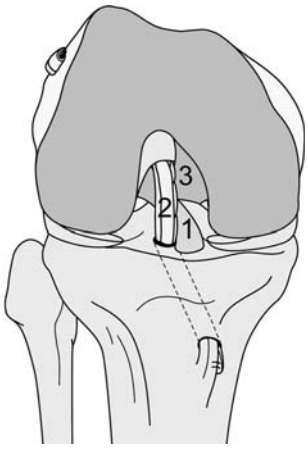

Fig. 4 Reconstruction of the PLB. The intact portion of the ACL (*1*: AMB) is preserved. The intra-articular emergence of the tibial tunnel is just postero-lateral to the insertion of the AMB. The quadrupled hamstring graft (*2*) is placed in the over the top position leaving intact its distal insertion. The graft is passed between the intact portion of the ACL and the PCL (*3*)

Postoperative treatment

After surgery a rigid extension brace is worn overnight to avoid joint flexion contracture. The morning after surgery, the drainage is removed and the patients begin continuous passive motion (CPM): the degree of joint movement allowed on the first day is between 0° and 40° and can be increased according to the conditions and tolerance of the patient. Thirty-six hours after surgery the patient is discharged and allowed to load the limb progressively, using the brace and two forearm crutches. The patient starts a home rehabilitation for the following 15 days. After 2 weeks full weight bearing is allowed without the brace.

With the help of a physical therapist, the patient begins rehabilitation by performing closed chain kinetic exercises for the third and the fourth week; then

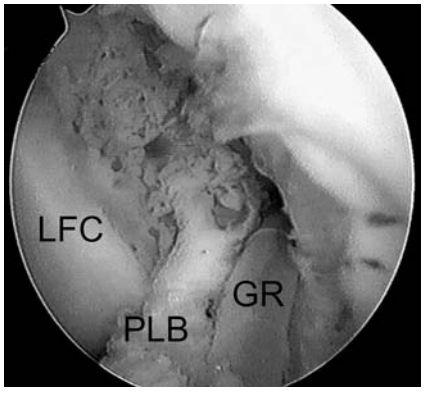

Fig. 5 Final result in case of AMB replacement. The graft (*GR*) runs parallel to the native PLB, and is placed in an 11 o'clock position. (LFC: Lateral femoral condyle)

open chain kinetic exercises are performed. Return to competitive sports is allowed 3 months after surgery.

Patient assessment

Clinical assessment was performed by the IKDC score 3 months, 1 and 5 years after surgery. The subjective and functional parameters were measured by the Tegner activity scale 1 and 5 years after surgery.

Arthrometric instrumental assessment was carried out by KT-2000. The 30-pound passive test and manual maximum displacement test were performed post-operatively and 1 and 5 years after surgery.

All data recorded at follow-up were analyzed statistically with the chi-square test and the Student's *t* test for independent data. P=0.05 was assumed as the significance cut-off.

Results

At the final follow-up no case of re-rupture was observed. In four patients surgery had to be repeated: in two cases to remove the staples in the lateral femoral condyle (2 and 3 years after surgery respectively); in one case for a patellar lateral release (9 months after surgery), and in the last one to perform a partial medial meniscectomy (3 years after surgery).

Table 1 shows the results of the pre- and post-operative tests with the IKDC score and Tegner activity scale. We did not notice any difference in the overall results between the AMB and PLB reconstruction groups. The two cases classified as C by the IKDC score had knee pain, due to patello-femoral chondropathy in one case; in the other case a femoro-tibial chondropathy of the lateral compartment occurred, which produced joint effusions under stress which, however, did not prevent from amateur sports participation. In one case with an IKDC score of B, the patient complained of posterior pain in the tendon graft harvest site, due to retracting muscle scar. All patients regained full joint movement in extension, whereas there was a reduction in flexion of less than 5° in three patients.

According to the Tegner Activity Scale the mean pre-lesional sports activity level was 6.8, whereas it was 6.4 1 year after surgery and 6.1 at the final follow up. None of the patients gave up with sports. Five patients took up different sports for fear of re-injury. Four patients resumed their previous sport at a lower level. The remaining 38 patients resumed their sport at previous level. A detailed analysis of the return to sports activity is summarized in Table 2. There is not a statistically significant relationship between the age of patients and the time needed for return to contact sports participation.

Table 3 shows the side-to-side difference in anterior tibial displacement with KT-2000.

We had no complications, such as DVT or post-operative infection. In eight patients in the immediate post-operative period we observed hematoma in the distal thigh, due to the tendon harvest, which resolved with rest and medical treatment.

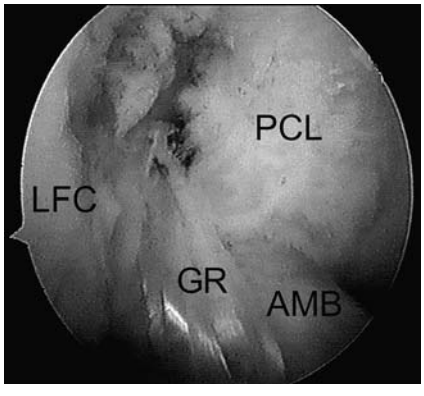

Fig. 6 Final result in case of PLB replacement. The graft (*GR*) runs in front and stretches the native AMB, passing between the AMB and the PCL. (*LFC* Lateral femoral condyle)

Discussion

In order to preserve the residual portion of a partially torn ACL, arthroscopic techniques with the use of radiofrequencies have been proposed [19, 40]. Although thermal shrinkage of a lax ACL is effective in shortening the ligament in the short term, longer term follow-up suggests an extremely high failure rate [16, 33, 37, 38].

Previous reports on primary repair of a torn ACL showed that, despite encouraging short-term results

Table 1 IKDC and Tegner evaluation

IKDC	Repaired bundle	Pre-operative	Post-operative follow-up		
			3 months	1 year	5 years
A	AMB	0	7	7	7
	PLB	0	22	25	24
B	AMB	8	4	4	4
	PLB	20	9	9	10
C	AMB	4	1	1	1
	PLB	15	3	1	1
D	AMB	0	0	0	0
	PLB	0	1	0	0
Tegner	AMB	6.6	–	6.3	6.0
	PLB	6.9		6.4	6.1

[30], 40–50% of the repairs failed over time [1, 2, 9, 11, 13, 29, 38].

Numerous authors proposed surgical techniques to attempt reconstructing the two-bundle anatomy of the ACL [7, 15, 17, 18, 24, 26, 32, 39, 43]. Unfortunately all these techniques require a single or even a double femoral tunnel. In the specific treatment of ACL partial tears, however, performing a femoral tunnel would mean to sacrifice the femoral origin of the intact portion of the ACL: if we want to spare this residual bundle, an ''over the top'' femoral placement is the only possible technique. On the femoral side, the passage between the residual portion of the ACL and the PCL is the only one which can be used, because of the presence of the intact bundle of the ACL: if we have to reproduce a torn AMB, this passage allows us to place the graft in the 11 o'clock position (for the right knee), restoring the normal two-bundle anatomy of the ACL; but if we have to reconstruct the PLB, an anatomic passage of the graft is not permitted because of the presence of the intact AMB: in this case we have not an anatomic placement.

Even on the tibial side, an anatomic placement is always possible for the reconstruction of the AMB; in PLB reconstruction the articular emergence of the tibial tunnel was not on the anatomic footprint of this bundle, but just lateral and posterior to the insertion of the intact AMB. This provides a more vertical graft placement, with the graft passing just in front of the AMB, with tensioning of the native AMB.

Table 2 Return to sports activity

Months after surgery	Patients	Mean age	Same sport		Other sport
			Same level	Lower level	
3	18	23.5 (SD = 3.8)	16	2	
4–5	19	22.4 (SD = 3.5)	16	1	2
6–8	10	24.7 (SD = 3.0)	6	1	3

Table 3 KT-2000 post-operative and follow-up evaluation

Displacement (mm)	Post-operative	1 year	5 years
30 pounds displacement test (side-to-side difference)			
0–3	44	42	41
3–5	3	5	6
>5	0	0	0
Manual maximum displacement test (side-to-side difference)			
0–3	41	40	39
3–5	6	7	8
>5	0	0	0

The PLB is proven to have an important role when the knee is subjected to combined rotatory loads as produced for example in a pivot shift, and especially with the knee near full extension [14, 21, 25, 41, 44]: so an anatomic reconstruction of the PLB would be advised. A classical ACL reconstruction technique, which focuses primarily on reproducing the antero-medial bundle is proven to restore the antero-posterior stability [6, 14, 41]; moreover, classical single-bundle reconstruction techniques provided good long-term clinical results [5, 10, 31, 34, 35]. Secondly, in a partial ACL tear the rotatory instability is minimal or absent (the Pivot shift test is always negative or only trace positive), so we think that an anatomic reconstruction of the PLB is not strictly required in this case.

In our opinion, several factors contributed to achieving such favorable results, despite the non-anatomic placement in case of PLB replacement. We think that sparing the residual portion of the ACL is important for various reasons: (a) this assures mechanical strength in the immediate post-operative period, while the graft strength depends primarily on the fixation device: this allows an accelerated rehabilitation and a rapid return to sports; (b) the residual portion maintains its blood supply, providing a support for the healing process in the graft [22]; (c) some proprioceptive innervation is maintained with evident benefits for the subjective outcome and for a safer return to sports.

Another important factor is the low number of meniscectomies required during ligament reconstruction.

In conclusion we think that the described technique is compatible with the ACL anatomy and provides good results thanks to the maintenance of the intact bundle, with its mechanical support and vessel and nerve supply.

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