

Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction in Pediatric Patients: Surgical Technique



Vincent Morin, M.D., Laurent Buisson, M.D., Alban Pinaroli, M.D., Gilles Estour, M.D., Maureen Cohen Bacry, M.D., and Clément Horteur, M.D.

Abstract: Anterior cruciate ligament (ACL) rupture is a common affliction in the athletic population. In pediatric patients, the immature skeleton with active growth plates is an issue that makes ACL reconstruction surgery technically challenging. The rerupture rate after ACL reconstruction is higher in the pediatric population than in the adult population. The addition of anterolateral ligament (ALL) reconstruction has been shown to be an effective way to reduce the rate of graft rupture and to control rotatory instability (pivot shift). Therefore, it appears necessary to combine ACL and ALL reconstruction in the pediatric population. We describe the surgical steps for combined ACL and ALL reconstruction adapted for young patients with active growth plates.

With the development of sports activities, rupture of the anterior cruciate ligament (ACL) in children and young adolescents who have not completed their growth is becoming increasingly frequent. Reconstruction of the ACL in these young patients with open growth plates carries the risk of growth disturbances. Length discrepancies of more than 10 mm have been reported in 2.1% of cases.¹ The surgical technique, transphyseal or physeal sparing, does not seem to have any influence on the occurrence of these growth disturbances.² Most of these length inequalities are located in the femur.¹ The use of intra-physeal

fixation increases this risk.³ Another important issue in this population is the risk of reinjury, with very high rates of graft or contralateral ACL rerupture.⁴⁻⁷ Thus, these young patients are particularly at risk because of their high propensity to return to sports.^{8,9}

The addition of an anterolateral tenodesis significantly reduces the rate of graft rerupture.^{10,11} The purpose of this article is to present a combined ACL and anterolateral ligament (ALL) reconstruction technique for skeletally immature patients (Video 1).

Surgical Technique

In our surgical technique, ACL reconstruction associated with ALL reconstruction is performed using a continuous graft of semitendinosus and gracilis tendons adapted for pediatric patients. The technique consists of 8 steps. Pearls and pitfalls are described in Table 1.

Patient Setup and Anatomic Landmarks

The patient is placed in the supine position with lateral and distal wedges to maintain 80° of knee flexion and allow free mobility during the surgical procedure. The surgical technique for pediatric patients is inspired by the combined ACL and ALL reconstruction technique described by Sonnery-Cottet et al.¹²

The main anatomic landmarks for performing ALL reconstruction are marked on the lateral aspect of the knee with a dermatographic pen. These include the lateral epicondyle, the joint line, the fibular head, and the Gerdy tubercle (Fig 1).

From Hôpital Privé Médipole de Savoie, Challes-les-Eaux, France (V.M., L.B., A.P., G.E.); Département de Chirurgie, Hôpital Couple Enfant, CHU Grenoble Alpes, La Tronche, France (M.C.B.); and Département de Chirurgie Orthopédique et Traumatologie du Sport, Hôpital Sud, CHU Grenoble Alpes, Échirolles, France (C.H.).

The authors report the following potential conflicts of interest or sources of funding: A.P. receives nonfinancial support from Smith & Nephew, outside the submitted work. G.E. receives nonfinancial support from Dedienné Santé, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received February 16, 2022; accepted March 11, 2022.

Address correspondence to Vincent Morin, M.D., Hôpital Privé Médipole de Savoie, 300 Avenue des Massettes, 73190 Challes les Eaux, France. E-mail: dr.vincentmorin@gmail.com

© 2022 THE AUTHORS. Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/22237

<https://doi.org/10.1016/j.eats.2022.03.023>

Table 1. Pearls and Pitfalls

Step	Pearls	Pitfalls
1. Graft harvesting	The gracilis tendon is harvested first, followed by the semitendinosus tendon. Two O'Shaughnessy dissectors are used: 1 dissector for the tendon and 1 dissector to exteriorise the gastrocnemius expansion. One expansion is cut for the gracilis, and 2 expansions are cut for the semitendinosus.	Early amputation of the graft during harvesting will not provide the minimum length required to perform the technique.
2. Graft preparation	The graft consists of a tripled semitendinosus and single gracilis with bioresorbable wire (No. 2 Vicryl). The ACL length measures 11-13 cm (triple semitendinosus + single gracilis) The ALL length measures 12-15 cm (single gracilis).	Poorly performed graft preparation can lead to graft passage difficulties. Inappropriate graft lengths can jeopardize graft fixation.
3. Drilling of ALL tibial tunnels	Two converging guidewires (2.4 mm) are placed 1 cm distal to the joint line under radiographic control. Each tunnel is drilled to 4 mm in diameter and 20 mm in depth.	Poor positioning of the converging tibial tunnels can lead to iatrogenic intra-articular lesions (too proximal) or iatrogenic growth plate lesions (too distal).
4. Positioning of femoral and tibial guide pins	Using a 90° femoral guide to be horizontal under growth cartilage and a 75° tibial guide to be vertical. After placement of the 2 guide pins, the surgeon should ensure the correct positioning from the cartilage growth plate by means of control radiographs.	Incorrect tunnel placement can lead to iatrogenic damage to the growth plate, poor laxity control, and disruption of the physiological knee kinematics.
5. Drilling of femoral and tibial tunnels	Drilling is performed in 2 steps: first at 6 mm and then with the final diameter (8 or 9 mm). Drilling should be performed slowly to avoid damage to the growth plate.	A high-speed drilling process can lead to growth plate damage and poor ACL tibial stump preservation.
6. Fixation of femoral ACL graft	Fixation of the ACL graft on the femur is performed with a screw (FastThread Interference Screw Arthrex) at 90° of flexion. For easy insertion into the bone tunnel, the ALL graft should be pulled posteriorly with a retractor to remove the iliotibial band.	Lack of iliotibial band retraction can impede screw insertion.
7. Fixation of ALL graft	Fixation of the ALL graft on the femur is performed with an ACL traction wire with the knee in full extension and neutral rotation.	Fixation in flexion and/or external rotation can lead to knee stiffness.
8. Fixation of tibial ACL graft	Fixation of the ACL graft on the tibia is performed with a 4.75-mm SwiveLock at 20° of flexion to achieve appropriate tension. A tibial tunnel, 5 mm in diameter, is drilled distal to the growth plate for double fixation.	The placement of an interference screw inside the trans-epiphyseal tibial tunnel can cause growth disturbances.

ACL, anterior cruciate ligament; ALL, anterolateral ligament.

Step 1: Graft Harvesting

Through a 2-cm-long vertical incision located medially to the anterior tibial tuberosity, the tendon grafts are successively harvested with an open stripper. The gracilis tendon is harvested first by cutting a

gastrocnemius medial expansion with 2 O'Shaughnessy dissectors. The first O'Shaughnessy dissector is used to pull the tendon; the second is used to catch and exteriorise the gastrocnemius medial expansion. The semitendinosus tendon is harvested the same way, with

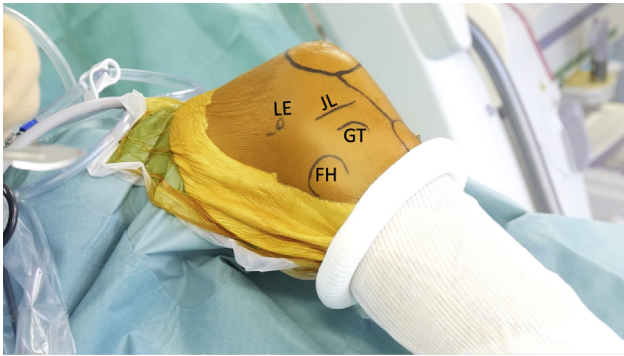


Fig 1. Anatomic landmarks in right knee. (FH, fibular head; GT, Gerdy tubercle; JL, joint line; LE, lateral epicondyle.)

care taken to cut the 2 expansions before harvesting it. Once removed, the 2 tendons are not detached but are left pedicled on their tibial insertion (**Fig 2**).

Step 2: Graft Preparation

The ACL graft is prepared using No. 2 Vicryl absorbable suture (Ethicon, Somerville, NJ) over its entire length. In the case presented, it measures 12 cm because the patient is 165 cm tall. The ACL graft is folded to obtain 3 strands from the semitendinosus and 1 strand from the gracilis. The ALL graft should measure more than 13 cm on the basis of our patient's height (**Fig 3**). The recommended ACL and ALL graft lengths according to patient size are given in **Table 2**. The diameter of the ACL graft is usually between 8 and 9 mm. A No. 2 TigerWire (Arthrex, Naples, FL) is placed at the tibial end of the graft for tibial double fixation to control the tension during tibial fixation.

Step 3: Drilling of ALL Tibial Tunnels

Three skin incisions are made: One incision is made at the level of the lateral epicondyle of the femur so that the femoral tunnel of the ACL is positioned below the growth plate cartilage. Two incisions are made at the Gerdy tubercle according to the principles of Sonnery-Cottet et al.,¹² 1 cm below the joint space and above

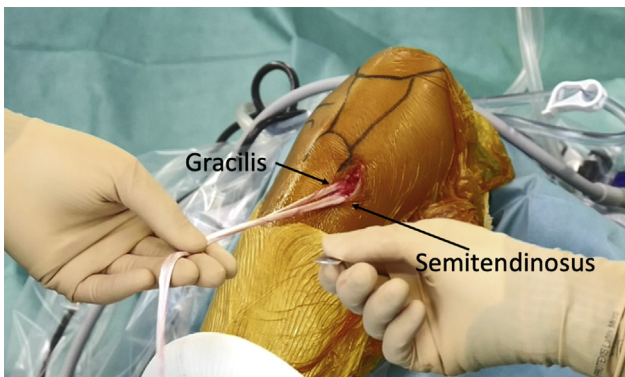


Fig 2. The gracilis and semitendinosus are harvested and are left pedicled on their tibial insertion in a right knee.

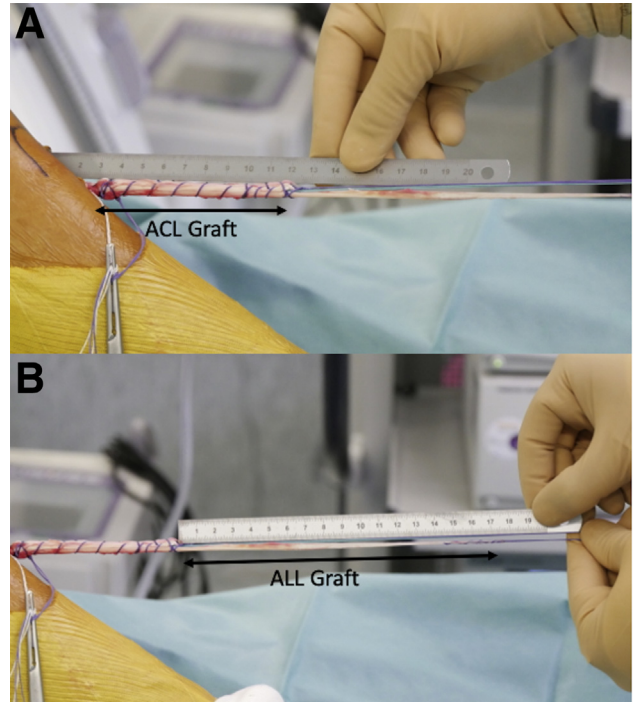


Fig 3. Anterior cruciate ligament (ACL) graft and anterolateral ligament (ALL) graft in right knee. (A) The ACL graft consists of 3 strands of semitendinosus (tripled semitendinosus) and 1 strand of gracilis. In this example, the graft measures 12 cm in length from its tibial insertion. (B) The ALL graft should measure more than 13 cm on the basis of this patient's height. In this example, the graft length measures 17 cm.

the growth cartilage. The tunnels for the ALL in the tibia are created in a convergent way using a guidewire placed under fluoroscopic control (**Fig 4**). Each tunnel is drilled around the guidewire with a 4-mm cannulated reamer up to 20 mm long or deep. A shuttle suture is then placed through the tunnel with a dedicated device (transosseous obturator; Arthrex).

Step 4: Positioning of Femoral and Tibial Guide Pins

Under double arthroscopic and fluoroscopic control, the femoral pin is positioned horizontally, with the Arthrex ACL Femoral Guide (outside-in). The intra-articular target of the femoral guide is positioned at the anteromedial area of the ACL femoral footprint. The angulation of the femoral guide is then adjusted to

Table 2. Recommended ACL and ALL Graft Lengths According to Patient Size

Patient Height	ACL Length, cm	ALL Length, cm
<160 cm	11	>12
160-170 cm	12	>13
170-180 cm	12.5	>14
>180 cm	13	>15

ACL, anterior cruciate ligament; ALL, anterolateral ligament.

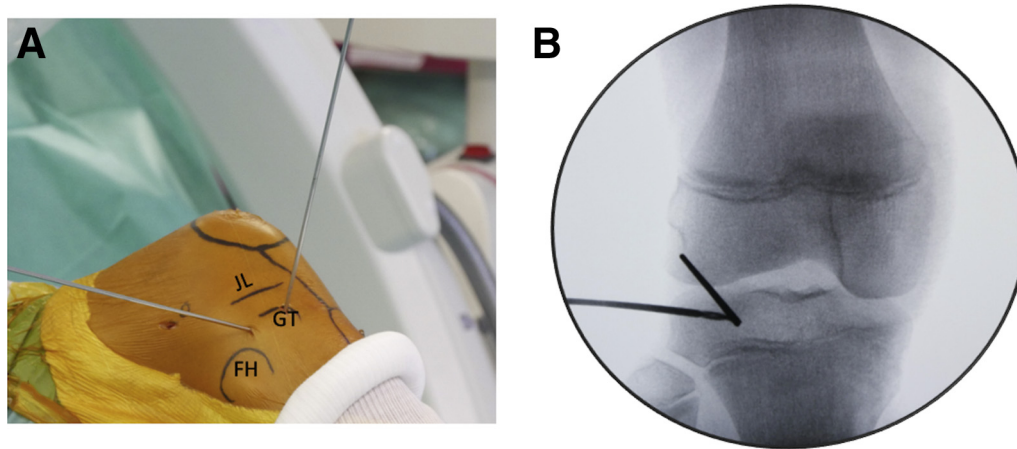


Fig 4. Guidewire placement in right knee. (A) Placement of 2 convergent guidewires 1 cm below joint line. (B) Fluoroscopic control of guidewire placement. (FH, fibular head; GT, Gerdy tubercle; JL, joint line.)

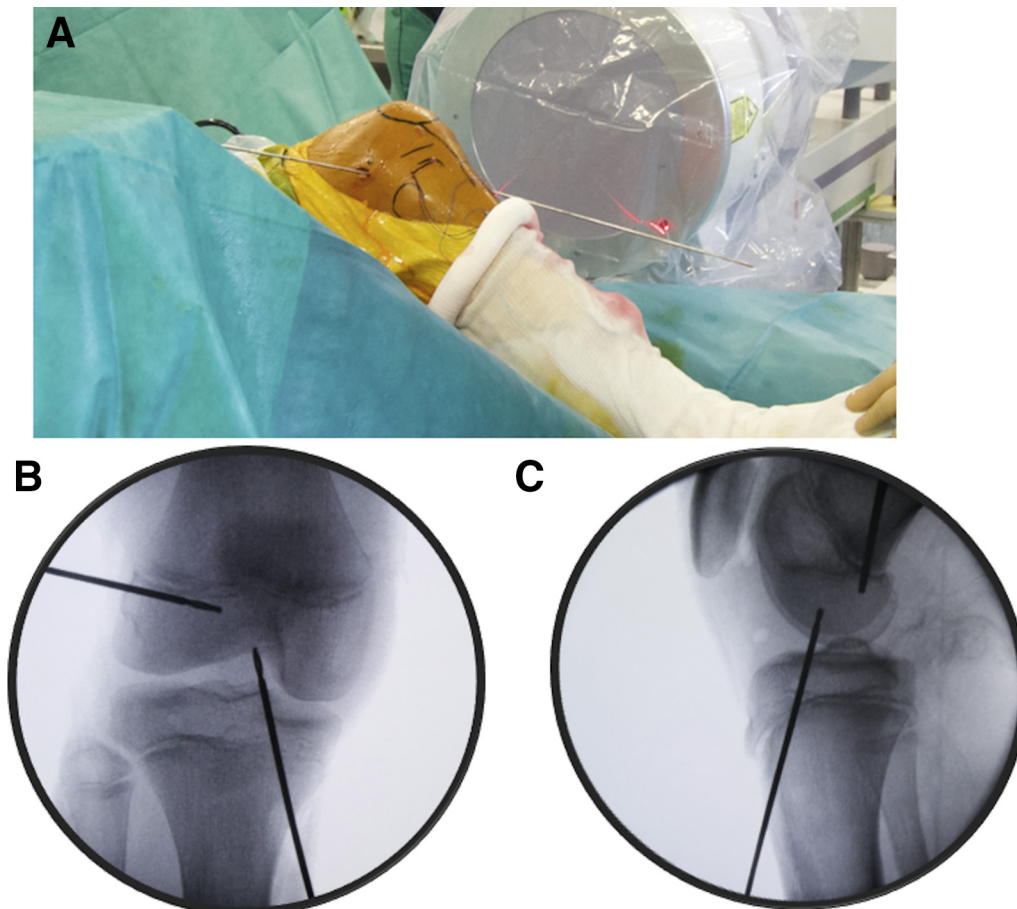


Fig 5. Guide pin placement in right knee. (A) Femoral and tibial guide pin placement. (B) Fluoroscopic control. (C) The femoral wire has a very horizontal orientation and does not cross the growth plate, whereas the tibial wire has a very vertical orientation in order to cross the growth plate as perpendicularly as possible.

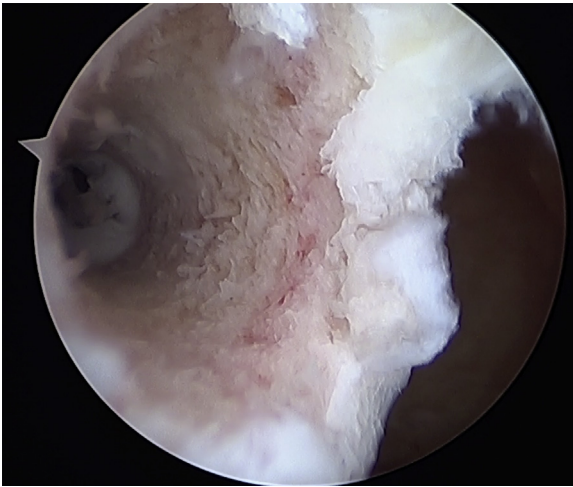


Fig 6. In a right knee with the scope in the anteromedial portal, femoral tunnel exploration shows the absence of iatrogenic growth plate lesions.

position the entry point of the wire in the femoral insertion zone of the ALL, just distal to the growth plate and just proximal and posterior to the femoral epicondyle. The tibial pin is positioned with the ACL tibial guide. The angulation of the tibial guide is set at 75° to drill the tunnel as vertically as possible. Therefore, the tibial tunnel crosses the growth plate more perpendicularly and reduces iatrogenic damage to the growth plate (Fig 5).

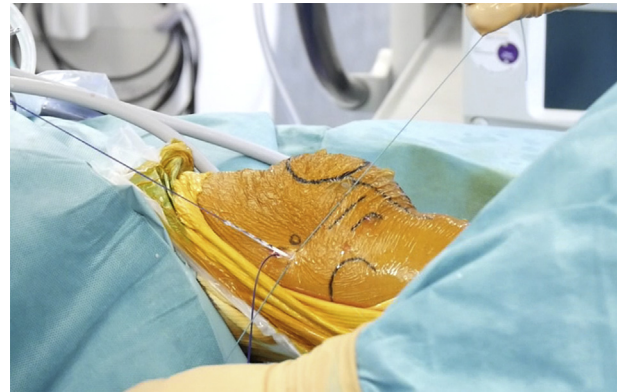


Fig 8. In a right knee, the anterolateral ligament graft is attached to the anterior cruciate ligament traction suture with the knee in full extension.

Step 5: Drilling of Femoral and Tibial Tunnels

Each tunnel is drilled in 2 steps: first with a 6-mm reamer and then with the final diameter (8 or 9 mm, corresponding to the graft calibration), with great care taken to avoid damage to the growth plate. After creation of the femoral tunnel, the tunnel is inspected with the scope to confirm the absence of growth plate injury (Fig 6).

Step 6: Fixation of Femoral ACL Graft

After the graft is passed from the tibia to the femur with a No. 0 FiberStick (Arthrex), the femoral ACL graft

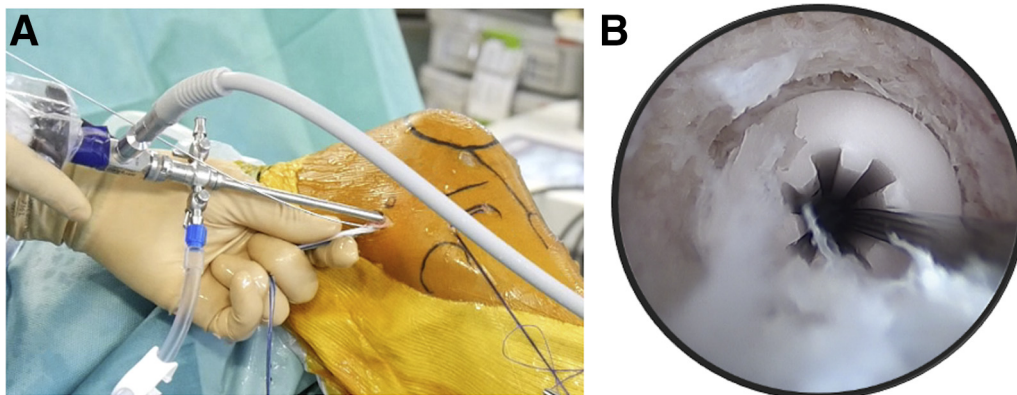


Fig 7. (A) The scope is placed at the entrance of the femoral tunnel to check the femoral screw position in a right knee. (B) Arthroscopic view of positioning of screw in its bone tunnel in right knee.

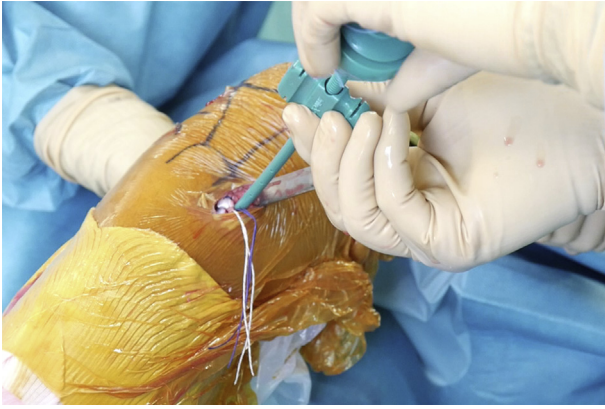


Fig 9. Backup fixation of anterior cruciate ligament graft at tibia with SwiveLock device in right knee.

is fixed with a FastThread BioComposite Interference Screw (Arthrex) in the femur. The size of the screw corresponds to the tunnel's diameter and is inferior to its length to avoid any protrusion out of the tunnel. The femoral screw position inside the femoral tunnel is checked by introducing the scope at the femoral tunnel entrance (Fig 7).

Step 7: Fixation of ALL Graft

The ALL graft is passed under the iliotibial band and then through the Gerdy tunnel in a posteroanterior fashion and back up under the iliotibial band to be attached to the ACL traction wire with the knee in full extension and neutral rotation (Fig 8).

Step 8: Fixation of Tibial ACL Graft

The tibial tunnel is drilled to 5 mm in diameter distal to the growth plate for double fixation and to avoid any growth cartilage damage. The ACL graft is fixed on the tibia with a No. 2 TigerWire with the use of a 4.75-mm SwiveLock (Arthrex) at 20° of flexion to achieve appropriate tension (Fig 9).

Discussion

The described surgical procedure allows one to perform ACL reconstruction in a patient with an immature skeleton with a limited risk of growth plate injury (Fig 10), which could lead to growth troubles.² The graft fixation in the femur is entirely located in the epiphysis, distally from the growth plate. In terms of the tibia, this technique offers double fixation, comprising fixation from the native insertion of the hamstring tendons and fixation achieved with a screw below the growth plate.

The position of the femoral tunnel under the growth plate with a horizontal orientation makes its lateral exit easily located at the isometric point for ALL reconstruction. Recent publications have shown the benefits of ALL reconstruction in achieving knee stability as well as reducing the iterative rupture rate.¹³⁻¹⁵ Considering the high rerupture rate in the pediatric population,^{6,7} reconstruction of both the ACL and ALL appears essential to us. To conclude, the described technique of combined ACL and ALL ligament reconstruction can be

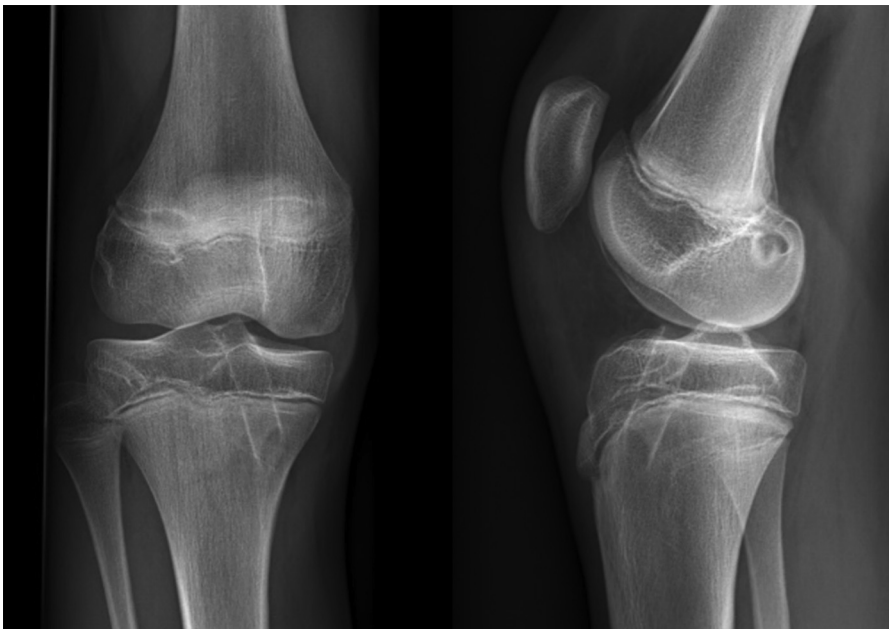


Fig 10. Radiographs of right knee 6 months after surgery.

safely performed under fluoroscopic control in the pediatric population.

References

1. Fury MS, Paschos NK, Fabricant PD, et al. Assessment of skeletal maturity and postoperative growth disturbance after anterior cruciate ligament reconstruction in skeletally immature patients: a systematic review. *Am J Sports Med* 2022;50:1430-1441.
2. Pierce TP, Issa K, Festa A, Scillia AJ, McNerney VK. Pediatric anterior cruciate ligament reconstruction: A systematic review of transphyseal versus physeal-sparing techniques. *Am J Sports Med* 2017;45:488-494.
3. Gicquel P, Geffroy L, Robert H, et al. MRI assessment of growth disturbances after ACL reconstruction in children with open growth plates—Prospective multicenter study of 100 patients. *Orthop Traumatol Surg Res* 2018;104:S175-S181.
4. Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2827-2832.
5. Zacharias AJ, Whitaker JR, Collofello BS, et al. Secondary injuries after pediatric anterior cruciate ligament reconstruction: A systematic review with quantitative analysis. *Am J Sports Med* 2021;49:1086-1093.
6. Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: A systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861-1876.
7. Barber-Westin S, Noyes FR. One in 5 athletes sustain reinjury upon return to high-risk sports after ACL reconstruction: A systematic review in 1239 athletes younger than 20 years. *Sports Health* 2020;12:587-597.
8. Dekker TJ, Godin JA, Dale KM, Garrett WE, Taylor DC, Riboh JC. Return to sport after pediatric anterior cruciate ligament reconstruction and its effect on subsequent anterior cruciate ligament injury. *J Bone Joint Surg Am* 2017;99:897-904.
9. Morvan A, Bouguennec N, Graveleau N. ACL injuries before 15 years of age: Could the young become an athlete? *Arch Orthop Trauma Surg* 2020;140:1055-1063.
10. Sonnery-Cottet B, Saithna A, Cavalier M, et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 years: A prospective comparative study of 502 patients from the SANTI study group. *Am J Sports Med* 2017;45:1547-1557.
11. Getgood AMJ, Bryant DM, Litchfield R, et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-Year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285-297.
12. Sonnery-Cottet B, Daggett M, Helito CP, Fayard JM, Thaumat M. Combined anterior cruciate ligament and anterolateral ligament reconstruction. *Arthrosc Tech* 2016;5:e1253-e1259.
13. Hurley ET, Fried JW, Kingery MT, Strauss EJ, Alaia MJ. Antero-lateral ligament reconstruction improves knee stability alongside anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2021;29:764-771.
14. Hurley ET, Bloom DA, Hoberman A, et al. There are differences in knee stability based on lateral extra-articular augmentation technique alongside anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2021;29:3854-3863.
15. Ariel de Lima D, de Lima LL, de Souza NGR, et al. Clinical outcomes of combined anterior cruciate ligament and anterolateral ligament reconstruction: A systematic review and meta-analysis. *Knee Surg Relat Res* 2021;33:33.