Knee Surg Sports Traumatol Arthrosc (2010) 18:1369–1373
DOI 10.1007/s00167-009-0988-5

KNEE

Valgus and flexion deformity after reconstruction of the anterior cruciate ligament in a skeletally immature patient

Henri Emile Robert · Charles Casin

Received: 26 July 2009 / Accepted: 29 October 2009 / Published online: 28 November 2009

Abstract Anterior cruciate ligament reconstruction in children with open physes is still a topic of debate. We report a unique case of growth disturbance in valgus and flexion of the distal femoral epiphysis, after an ACL reconstruction in a 14.5-year-old boy. The Clocheville technique using the patellar tendon was performed. The femoral tunnel and tibial groove were both positioned above the growth plates. Eighteen months after ACL reconstruction, the patient had to be re-operated on for a valgus and flexion deformity of the femoral epiphysis. The clinical, radiological and aesthetic results were satisfactory. The angular deformity was caused by the fact that either the femoral tunnel was too close to the posterolateral femoral growth plate or an excessive eccentric traction of the graft in relation to the central point of the knee.

Keywords Anterior cruciate ligament · Skeletally immature patient · Open physes · Valgus deformity

Introduction

The treatment of anterior cruciate ligament (ACL) ruptures in children and adolescents remains a controversial topic in literature. Some authors recommend early repair to prevent meniscal and chondral complications [2, 3, 11, 14, 20, 27] while others prefer to wait until the end of knee growth [31]. The natural history of ACL rupture is problematic in children because of instability leading to meniscal tears or even to osteochondral damage and degenerative knees [10, 14, 15, 2425]. ACL surgery at a young age may lead to growth disturbances (leg length inequality, angular deformity) due to epiphysiodesis. We report a unique case of growth disturbance in valgus and flexion of the distal femoral epiphysis after an ACL reconstruction performed upon a 14.5-year-old boy.

H. E. Robert (✉)
Department of Orthopedics and Traumatology,
Hospital of North-Mayenne, 53100 Mayenne, France
e-mail: henri.robert@wanadoo.fr

C. Casin
Department of Orthopedics and Traumatology,
University Hospital, 49000 Angers, France
e-mail: charles.casin@yahoo.fr

Case report

A fourteen-and-a-half-year-old boy sustained an injury to the left knee while driving a scooter. He was seen in the emergency room of a non-specialist clinic for a hemarthrosis without any fracture of the knee. He was given a knee brace in extension to wear for 1 month. Two months later, he was sent to our Orthopaedic Clinic for specialized treatment. The knee remained slightly swollen, flexion was limited to 70°, and testing showed a complete rupture of the ACL: a positive Lachman test with a soft point, a positive drawer test in 90° of flexion and a positive jerk test were recorded. With the KT-1000, the side-to-side difference at maximal manual traction was 9 mm. Bone age according to the Greulich and Pyle atlas was 13.9 years, the Tanner stage was I (Pre-pubertal), and the boy was 162 cm tall.

After 1 month of rehabilitation, the knee recovered a full range of motion but remained lax. An MRI confirmed the midsubstance ACL tear without associated meniscal lesion. An ACL reconstruction was proposed and accepted by the boy and his parents after a complete explanation of the advantages and risks.

The Clocheville technique was performed according to the procedure described in 1999 by one of the authors [27]. We harvested a free, 10-mm-wide graft of the central third of the patellar tendon lengthened by the fibrous-osseous surface of the patella (2 cm long and 2 cm wide) and the periosteum under the patellar tendon. The graft was then rolled like a cigar and gauged with a tendon-sizer, which determines the diameter of the femoral tunnel. To perform the outside-in tunnel, the lateral femur was exposed by a longitudinal incision along the anterior margin of the ilio-tibial band, and the lateral aspect of the metaphysis was exposed. The tip of the guide was positioned above the 'over the top' position under arthroscopic and fluoroscopic control to be sure that the entire tunnel would be above the femoral physis. Arthrotomy through the patellar tendon was necessary for the tibial groove, the groove axis was oriented forward from the anterior tibial tuberosity to the anatomic footprint of the ACL on the anterolateral slope of the medial intercondylar spine eminence. The graft was pulled from outside into the femoral tunnel and fixed with a cannulated absorbable screw of 7 mm in diameter and 20 mm long (SBM, Lourdes; France). The graft was then positioned on the tibial groove, tensioned at 45° and secured to the margins of the groove with multiple number-1 Ethibon sutures. The patient remained in a long, weight-bearing cast immobilizing the knee in extension for 30 days.

At 3 months post-op, the left knee flexion reached 140°, stability was good, but the start of clinical and radiological valgus deformity was observed. At 8 months post-op, the boy was seen again for internal pain and locking in flexion of the knee. Testing revealed some residual anterior laxity during flexion (KT-1000 side-to-side laxity was 3 mm at maximal manual traction). The MRI showed a vertical posterior tear of the medial meniscus. An arthroscopy was performed to suture the meniscus with 2 Fast-Fix anchors (Smith & Nephew, Le Mans; France). At 18 months post-op, the knee was not painful, flexion was 150°, the shortening of the leg reached 10 mm, of which 7 mm was on the femur and 3 mm on the tibia. The valgus of the left leg was quite visible and aesthetically displeasing (Fig. 1). On weight-bearing radiographs, the axis of the left lower limb showed 10° of valgus to the left and 3° of varus to the right, so the total valgus reached 13° (Fig. 2). The distal femoral physis was closed. From the sagittal view, the flexion deformity of the epiphysis was 9°. There was no abnormal flexion on the right knee. At the end of growth, the bone age was 15 years, the boy was 173 cm tall, and the Tanner stage was IV. As the patient was uncomfortable with the appearance of the leg, he requested corrective surgery. A left distal femoral varus osteotomy was suggested and accepted 18 months after the first surgery. The opening-wedge femoral osteotomy was stabilized with a 10-mm-thick bone substitute (SBM, Lourdes; France) and a locking plate (Surfix Technologie, Saint Sébastien sur Loire; France) (Fig. 3). At 2 months post-op, the X-ray showed good consolidation. Full weight-bearing was then allowed. The young man was seen again at the age of 22 when he worked as a bus driver. He had no discomfort in his knee but did no longer practice sports. The knee had a full flexion of 150°, kept a positive Lachman test with 5 mm side-to-side difference on the KT-1000 and was of normal appearance. The final radiological shortening was 2 mm. The subjective IKDC score was 100 points, and the IKDC objective score was "B", due to the side-to-side laxity of 5 mm. The mechanical axis revealed a varus deformity of 3° in the operated leg and of 2° in the contralateral, healthy leg.

Fig. 1 At 18 months post-op, the clinical axis of the left limb was in 10° of valgus

Discussion

The most important finding of the present study was that a femoral tunnel sparing the physis may induce a growth disturbance. This case is the first, to our knowledge, on an 'over the top' femoral tunnel complicated by a major valgus and flexion of the epiphysis.

Many surgical procedures have been described in the literature, and we have classified them into 3 groups according to the position of the graft in relation to the growth plates [4]: the techniques respecting both growth plates, using hamstring tendons [5, 6], the patellar tendon [27] or the ilio-tibial band [23], the techniques going

Fig. 2 At 18 months post-op, the radiological femoral valgus was 13° on the left lower limb, because of 3° of varus in the right femoral epiphysis

Fig. 3 Correction of the valgus through a femoral opening-wedge osteotomy with a screw plate and a bone substitute

through the tibial plate and respecting the femoral plate: the transepiphyseal technique using the hamstrings [2] or the quadriceps tendon [7] and the 'over the top' position on the femur [14, 20, 21], and finally, the most frequently used techniques, are the transphyseal procedures in the tibia and the femur [1, 19, 28].

A great number of authors found no growth disturbances after early surgery. However, long-leg radiographs were not systematically performed in the long-term in these studies [1, 2, 11, 12, 14, 20, 22, 26, 30].

Lipscomb et al. [20] have reported 2 lower limb length inequalities out of 24 patients observed, but no axial malalignment. Koman et al. [18] have reported 1 case of femur valgus of 14° in a boy operated on at the age of 14 years and 4 months, using a transphyseal technique with hamstring tendons. The epiphysiodesis was secondary to a cannulated screw placed across the lateral femoral plate. Kocher et al. have reported 15 growth problems in surgeries performed by 140 American surgeons questioned, or a frequency of 11% [17]. Among these growth problems, there were 11 genu valgum consisting of 5 bone-tendon-bone grafts placed across the physis, 3 transphyseal fixations, 1 'over the top' femoral reconstruction and 2 extra-articular stabilization procedures. In a multicenter French study on 102 patients, Bonnard et al. [4] conducted research on all growth disturbances by studying comparative long-leg radiographs after closure of the knee physis. The sagittal and coronal angular values were measured comparatively for the femur and the tibia. Ten infra-clinical and asymptomatic disorders were found: 3 femoral valgus, 3 tibial valgus, 2 tibial varus and 2 unequal lengths (−13 mm and +11 mm). Only, the patient described in this report presented with an aesthetically displeasing angular deformity leading to re-operation. The overall growth disturbance rate in this study represented 10.7% of all the cases (11 cases out of 102 patients). Radiological abnormalities were seen with all the different surgical techniques described in this study, including physeal sparing or transphyseal techniques.

In our case study, the femoral valgus was noted as early as the 3rd post-operative month and reached 13° at the end of growth. The boy was operated upon at a bone age of 13.9 years with a residual inferior femoral growth potential of 2 cm. The femoral tunnel was not drilled according to the authors' technical recommendations in a 45° oblique direction and sufficiently distant from the femoral plate. The post-op A-P radiograph showed the direction of the K-wire as nearly horizontal to the physis, and at a distance of less than 1 cm, which is not sufficient. A posterolateral femoral epiphysiodesis gradually developed, culminating in a valgus of 13° and a flessum of 9°, over 18 months.

Numerous experimental and clinical studies have underlined the risk of angular deformity of the femur when cross drilling of the femoral plate is performed [9, 16, 28, 29].

The anatomical reconstruction of the ACL, however, demands drilling close to the posterolateral growth plate of the femur and thus close to the perichondral ring, which plays an essential role in the growth in width and length of the femur. The graft radius is the most critical parameter affecting the volume of physeal injury [16]. In the case reported here, the femoral drilling, theoretically above the physis, may have damaged the posterolateral perichondral structures (Fibrous ring of Lacroix and ossification groove of Ranvier) [28]. Another hypothesis would be that the eccentric traction of the graft in relation to the pivot point of the knee caused a rotational deformity of the growing femoral epiphysis [8].

In adolescents close to the end of growth, a precise study of potential residual growth is crucial (height of the patient and parents, bone age, Tanner stage) before performing an ACL reconstruction. In the absence of meniscal lesions, several authors believe it preferable to wait until the end of knee growth rather than undertaking transphyseal femoral surgery [4, 18, 22]. But in a skeletally immature patient, especially if the patient is very young, ACL reconstruction has to be promoted despite growth disturbance risk [13]. Techniques sparing the femoral physis are possible but they assume a perfect execution of the technique and knowledge of the criteria for the prevention of growth disturbances [23].

Conclusion

We present a case of growth disturbance in the femoral valgus and flexion after an ACL reconstruction in a 14.5-year-old adolescent, leading to further surgery via femoral osteotomy at the end of growth. The Clocheville technique uses the patella tendon and spares the femoral and tibial physes. The cause of the femoral epiphyseal growth disorder may have been either an injury of the perichondral ring of the posterolateral growth plate during drilling or an effect of eccentric traction of the graft during the residual growth of the femoral plate.

References

1. Aichroth P (2002) The natural history and treatment of ACL rupture in children and adolescents. J Bone Joint Surg Br 84:38–41
2. Anderson AF (2003) Transepiphyseal replacement of ACL in skeletally immature patients. J Bone Joint Surg Am 85:1255–1263
3. Aranowitz ER, Ganley TJ, Goode JR, Meyer JS (2000) Anterior cruciate ligament reconstruction in adolescents with open physes. Am J Sports Med 28:268–275
4. Bonnard C, Chotel F, Accadbled F, Bergerault F, Gicquel P, Hulet C, Robert H, Seil R (2007) Knee ligament and meniscal injury in children and adolescents. Rev Chir Orthop Reparatrice Appar Mot 93(Suppl):95–139
5. Brief LP (1991) Anterior cruciate ligament reconstruction without drill holes. Arthroscopy 7:350–357
6. Capra J, Fowler P (1994) ACL insufficiency in children. In: Feagin J (ed) The cruciate ligaments. Churchilll Livingstone, New York
7. Chotel F (2004) Entorses du genou de l'enfant et de l'adolescent. In: Cahier d'enseignement de la SOFCOT, vol. 85. Elsevier, Paris, pp 209–240
8. Chudik S, Beasley L, Potter H, Wickiewicz T, Warren R, Rodeo S (2007) The influence of femoral technique for graft placement on ACL ligament reconstruction using skeletally immature canine model with rapidly growing physis. Arthroscopy 23:1309–1319
9. Ford LT, Key JA (1958) A study of experimental trauma to the distal femoral epiphysis in rabbits. J Bone Joint Surg Am 40:887–896
10. Graf BK, Lange RH, Fujisaki C, Landry G, Saluja R (1992) Anterior cruciate ligament tears in skeletally immature patients: meniscal pathology at presentation and after attempted conservative treatment. Arthroscopy 8:229–233
11. Gaulrapp HM, Haus J (2006) Intra articular stabilisation after ACL tear in children and adolescent: results 6 years after surgery. Knee Surg Sports Traumatol Arthrosc 14:417–424
12. Gebhard F, Ellermann A, Hoffmann F, Jaeger JH, Friederich NF (2006) Multicenter study of operative treatment of intraligamentous tears of the ACL in children and adolescent. Knee Surg Sports Traumatol Arthrosc 14:797–803
13. Henry J, Chotel F, Chouteau J, Fessy MH, Berard J, Moyen B (2009) Rupture of the ACL in children: early reconstruction with open physis or delayed reconstruction to skeletal maturity. Knee Surg Sports Traumatol Arthrosc 17:748–755
14. Janarv PM, Nystrom A, Werner S, Hirsch G (1996) Anterior cruciate ligament in skeletally immature patients. J Pediat Ortho 16:673–677
15. Kannus P, Jarvinen M (1988) Knee ligament injuries in adolescents. Eight years follow-up of conservative management. J Bone Joint Surg Am 70:772–776
16. Kercher J, Xerogeanes J, Tannenbaum A, Al-Hakim R, Black JC, Zhao J (2009) Anterior cruciate ligament reconstruction in the skeletally immature. An anatomical study utilizing 3-dimensional MRI reconstruction. J Pediatr Orthop 29:124–129
17. Kocher MS, Saxon HS, Hovis WD Hawkins RJ (2002) Management and complications of ACL injuries in skeletally immature patients: survey of the Herodicus Society and the ACL study group. J Pediatr Orthop 22(4):452–457
18. Koman JD, Sanders JO (1999) Valgus deformity after ACL in a skeletally immature patient. A case report. J Bone Joint Surg Am 81:711–715
19. Liddle AD, Ibuldeniya AM, Hunt DM (2008) Transphyseal reconstruction of the ACL in prepubescent children. J Bone Joint Surg Br 90:1317–1322
20. Lipscomb AB, Anderson AF (1986) Tears of the anterior cruciate ligament in adolescents. J Bone Joint Surg Am 68:19–28
21. Lo IK, Kirkley A, Fowler P, Miniaci A (1997) The outcome of operatively treated ACL disruption in the skeletally immature child. Arthroscopy 13:627–634
22. Mc Carroll JR, Shelbourne D, Porter DA (1994) Patellar tendon graft reconstruction for midsubstance ACL rupture in junior high school athletes. Am J Sports Med 22:478–484
23. Micheli LJ, Rask B, Gerberg L (1999) ACL reconstruction in patients who are prepupescent. Clin Orthop 364:40–47

24. Millet PJ, Willis AA, Warren LJ (2002) Associate injuries in pediatric and adolescent anterior cruciate ligament tears: does a delay in treatment increase the risk of meniscal tear? Arthroscopy 18:955–959
25. Mizuta H, Kotuba K, Shiraischi M, Otsuka Y, Nagamoto N, Takagi K (1995) The conservative treatment of complete tears of the anterior cruciate ligament in skeletally immature patients. J Bone Joint Surg Br 77:890–894
26. Nakhostine M, Bollen SR, Cross MJ (1995) Reconstruction of mid-substance anterior cruciate rupture in adolescent with open physes. J Pediatr Orthop 75:36–40
27. Robert H, Bonnard C (1999) The possibilities of using the patellar tendon in the treatment of ACL tears in children. Arthroscopy 1:73–76
28. Seil R, Pape D, Kohn D (2008) The risk of growth changes during transphyseal drilling in sheep with open physes. Arthroscopy 24:824–833
29. Siffert RS (1956) The effect of staples and longitudinal wires on epiphyseal growth; an experimental study. J Bone Joint Surg Am 38:1077–1088
30. Simonean PT, Metcalf MH, Larson RV (1999) ACL injuries in the skeletally immature patient. Am J Orthop 28:624–628
31. Woods GW, O'Connor DP (2004) Delayed anterior cruciate ligament reconstruction in adolescents with open physes. Am J Sports Med 32:201–210