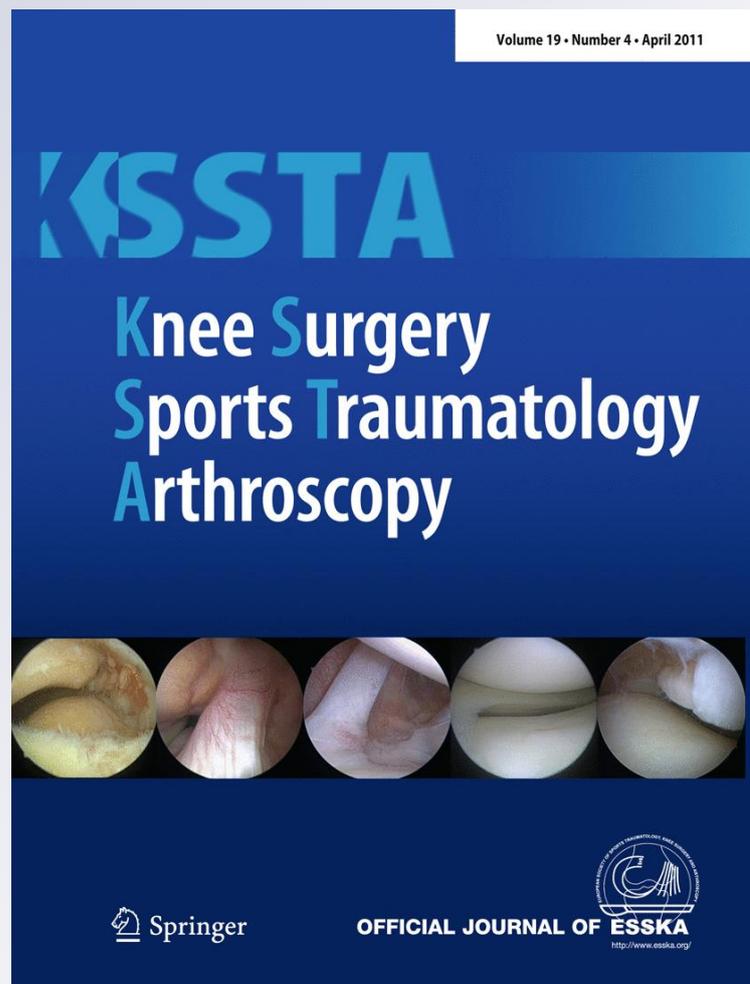


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Good surgical outcome of transphyseal ACL reconstruction in skeletally immature patients using four-strand hamstring graft

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Abstract

Purpose Our purpose was to evaluate the clinical and radiological outcome at maturity of an « adult-like » transphyseal anterior cruciate ligament (ACL) reconstruction performed in skeletally immature patients using four-strand hamstring graft.

Methods The records of all skeletally immature patients who underwent transphyseal ACL reconstruction between 2004 and 2006 at our institution were reviewed. Inclusion criteria were age less than 16 years and radiographic evidence of open physes. Thirty-eight children and prepubescents were identified. All underwent postoperative clinical evaluation with International Knee Documentation Committee scores and long leg radiographs. Each patient was followed up until skeletal maturity was confirmed.

Results Twenty-eight patients were scored A, four B, and five D according to IKDC. At last follow-up, there was no radiographic evidence of malalignment in any of the patients. Five underwent a reoperation. Three patients suffered traumatic graft disruption and two from postoperative knee instability.

Conclusion Early operative treatment by means of the quadruple hamstring free graft appears to be a safe and relevant procedure for ACL reconstruction even in skeletally immature patients.

Keywords Anterior cruciate ligament · Open physes · Quadruple hamstring graft · Children

Introduction

Reconstruction of ACL in skeletally immature patients is now established in order to avoid/decrease degenerative meniscal lesions and subsequent degenerative changes in the knee [1, 5, 7, 12].

However, the treatment dilemma for ACL reconstruction in skeletally immature patient has not been yet elucidated. The surgeon has to balance the generally accepted principles of anatomic ACL reconstruction to the risk of iatrogenic bone growth disturbance caused by surgical intervention [2, 22].

In the previous reported series, authors have recommended non-operative or operative procedures that are non-anatomic and physeal sparing as a means of minimizing the risk of growth disturbance. These procedures are technically demanding, and efficiency of these reconstructions on chronic laxity and pivot shift has been poorly investigated [3, 6, 8, 13, 14, 16–18, 21].

Other authors have reported adult-like ACL reconstructions, but large series are not available in the literature to assess the innocuity of these surgical procedures [4, 5, 10].

The purpose of this study was to evaluate the clinical and radiological outcome at maturity of an « adult-like » transphyseal ACL reconstruction performed in skeletally immature patients using quadruple hamstring free graft.

Materials and methods

The records of all skeletally immature patients who underwent transphyseal ACL reconstruction between 2004 and 2006 at our institution were reviewed. Inclusion criteria were age less than 16 years and radiographic evidence of wide open physes. Thirty-seven children and prepubescent

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were identified. The population included 17 boys and 20 girls.

All patients had complete anterior cruciate ligament disruptions proven by MRI.

The median age at the time of surgery was 14 years [11–15] for the girls and for the boys.

The delay between injury and reconstruction was 4 months [2–8].

Thirty-four patients were injured while skiing, three while playing soccer, and one while playing handball.

A tear in the lateral meniscus was observed during the index procedure in 6 cases and in the medial meniscus in two cases and both menisci in two cases.

All patients were followed until skeletal maturity which corresponds to a minimum 2-year follow-up. The median follow-up was 3 years [2–4].

Surgical procedure

An arthroscopic transphyseal ACL reconstruction using quadruple hamstring graft was used for all patients. The median diameter of the gracilis and semitendinosus muscle tendons was 7 mm [6–8]. The femoral fixation used was an Endobutton (Smith&Nephew) of 20 or 25 mm. A tibial aimer set at 55 degrees was used for the placement of tibial tunnel guide wire. At the femoral level, the femoral aimer was placed at the “over the top” position, but the offset hook used was higher than that used in adults to avoid drilling the perichondrial ring. We used a 5 mm offset hook. For tibial fixation, an interference screw 1 mm larger than the tunnel diameter was used. All unstable meniscus tears were sutured. A long leg splint was applied after surgery. Weight bearing was allowed on the surgically treated leg by using crutches for the first 10 days after surgery.

Follow-up assessment

Postoperative evaluation included the International Knee Documentation Committee (IKDC) knee form.

The objective examination included a comprehensive physical examination of the knee, laxity testing with the KT-1000 arthrometer (MEDmetric, San Diego, California).

The KT-1000 arthrometer was used to measure anterior–posterior displacement of the tibia on the femur. A force of 134 N was applied, and the difference between the involved and uninvolved knees was recorded in millimeters.

Bilateral standing long-leg radiographs with a radiographic ruler were also made to assess tibial and femoral mechanical axis. Frontal femoral and tibial growth deformities were evaluated considering the non-operated contralateral side as the reference. Measurements were performed according to Paley's technique [15]. The mechanical Lateral Distal Femoral Angle (mLDFA) and mechanical Medial

Proximal Tibial Angle (mMPTA) were measured in the involved and the uninvolved side. No test–retest reliability measurements were made.

Results

Clinical assessments

The mean KT 1000 anterior drawer test was 2 mm (SD 1.7) with a mean difference of 1 mm (SD 1.5).

According to the IKDC, 28 patients were classified A, 4 were classified B, and 5 were classified D. Among these patients, two had a difference of 6 and 7 mm at the anterior drawer test with the KT 1000 after the first operation and underwent a second ACL reconstruction procedure. Three re-tears occurred and one cyclops lesion. Three post-operative hematomas were evacuated. There were no infection complications.

Radiological assessments

The mean mLDFA on the involved side was 87° (SD 1.5), and the mean mMPTA was 88° (SD 1.2). The mean mLDFA on the uninvolved side was 87° (SD 1.6), and the mean mMPTA was 88° (SD 1.5).

Discussion

The most important finding of the present study was that trans-physeal ACL reconstructions by means of quadruple hamstring graft do not lead to clinically relevant growth disturbances. Our series in many ways is similar to the previously published studies previously recorded by Gaulrapp and Haus [5] and recently published [7, 10], in terms of patient demographics but of particular interest is the fact that it is a continuous series with the same type of autologous graft material and placement. Initial injuries were mainly ski injuries reflecting the location of our unit.

Good functional results were obtained in most of the cases. All patients resumed their previous active lifestyles and sport level. Three re-tears were observed with a need of iterative reconstruction. The stability outcome obtained here was comparable to those achieved in adults.

Interestingly, we did not observed significant growth defects development following transphyseal drilling. Mechanical LDFA and MPTA were similar in the involved and the uninvolved sides.

Our findings sustain recent animal studies which report that despite consistent physeal damage, ACL reconstructions do not lead to clinically relevant growth disturbances [11, 19]. Principles of ACL reconstruction to avoid growth

disturbance in skeletally immature animals were enlightened by Meller et al. [11]. They state that (1) the tibial tuberosity should be spared to prevent a genu recurvatum, (2) the thermal damage to the growth plates should be avoided, (3) a small-diameter drill should be used in the center of the growth plate, (4) a soft tissue graft should be used, (5) the graft fixation should be achieved far from the growth plates, (6) the perforated growth plates should be filled by the soft tissue graft, and (7) the graft should be moderately pretensioned before fixation.

Regarding the results of our series, it seems that these principles are also relevant in skeletally immature patients. Small diameter drills were used. The mean diameter was 7 mm [Range 6–8 mm]. The use of the tendon semitendinosus or gracilis muscle is the most commonly described technique for reconstruction of ACL tear in children. It is also our preferred method of primary reconstruction of ACL in adults. The technique was not modified for its use in the reported series. The femoral graft fixation was performed with a 20 mm Endobutton* CL (Smith&Nephew) which is a cortical-only fixation. The tibial fixation was performed using a BioRCI* bioabsorbable screw (Smith&Nephew). The transphyseal drilling was performed at the center of the growth plate at the tibial level as it has been recently pointed out [20]. At the femoral level, the femoral aimer was placed at the “over the top” position, but the offset hook used was higher than in adults to avoid drilling the perichondrial ring [20]. We used a 5-mm offset hook. The pretension of the graft was not evaluated by a dynamometer in this study. After cycling the knee, the pretension of the graft was manually held, as the tibial interference screw was placed in the tibia at 30° of flexion.

Transphyseal ACL reconstruction with hamstrings showed good results in this study and in the recent literature [4, 5, 9, 10] and might be the treatment of choice in immature patients. The complication rate was low, and there were no postoperative growth deformities.

The major limitation of this study is the lack of validation of our statement in a population of very young patients (below 8). ACL tears in such a population are rare, and it is difficult to collect a large amount of data. To our knowledge, only sporadic data are available in the literature. Moreover, this is a small series of patients with a short follow-up period. Clinical and radiological examinations were recorded by one surgeon only, which can lead to some measurement uncertainties.

Conclusion

There is now considerable evidence in the literature that conservative management of ACL tears in children produces poor results with subsequent instability. This study

confirms that early operative treatment of ACL ruptures using four-strand hamstring graft is a relevant procedure even in skeletally immature patients.

References

- Arbes S, Resinger C, Vecsei V, Nau T (2007) The functional outcome of total tears of the anterior cruciate ligament (ACL) in the skeletally immature patient. *Int Orthop* 31:471–475
- Bales CP, Guettler JH, Moonman CT 3rd (2004) Anterior cruciate ligament injuries in children with open physes: evolving strategies of treatment. *Am J Sports Med* 32:1978–1985
- Bisson LJ, Wickiewicz T, Levinson M, Warren R (1998) ACL reconstruction in children with open physes. *Orthopedics* 21:659–663
- Cohen M, Ferretti M, Quarteiro M, Marcondes FB, de Hollanda JP, Amaro JT, Abdalla RJ (2009) Transphyseal anterior cruciate ligament reconstruction in patients with open physes. *Arthroscopy* 25:831–838
- Gaulrapp HM, Haus J (2006) Intraarticular stabilization after anterior cruciate ligament tear in children and adolescents: results 6 years after surgery. *Knee Surg Sports Traumatol Arthrosc* 14:417–424
- Graf BK, Lange RH, Fujisaki CK, Landry GL, Saluja RK (1992) Anterior cruciate ligament tears in skeletally immature patients: meniscal pathology at presentation and after attempted conservative treatment. *Arthroscopy* 8:229–233
- Henry J, Chotel F, Chouteau J, Fessy MH, Berard J, Moyon B (2009) Rupture of the anterior cruciate ligament in children: early reconstruction with open physes or delayed reconstruction to skeletal maturity? *Knee Surg Sports Traumatol Arthrosc* 17:748–755
- Lo IK, Kirkley A, Fowler PJ, Miniaci A (1997) The outcome of operatively treated anterior cruciate ligament disruptions in the skeletally immature child. *Arthroscopy* 13:627–634
- Marx A, Siebold R, Sobau C, Saxler G, Ellermann A (2008) ACL reconstruction in skeletally immature patients. *Z Orthop Unfall* 146:715–719
- McIntosh AL, Dahm DL, Stuart MJ (2006) Anterior cruciate ligament reconstruction in the skeletally immature patient. *Arthroscopy* 22:1325–1330
- Meller R, Kendoff D, Hankemeier S, Jagodzinski M, Grotz M, Knobloch K, Krettek C (2008) Hindlimb growth after a transphyseal reconstruction of the anterior cruciate ligament: a study in skeletally immature sheep with wide-open physes. *Am J Sports Med* 36:2437–2443
- Millett PJ, Willis AA, Warren RF (2002) Associated injuries in pediatric and adolescent anterior cruciate ligament tears: does a delay in treatment increase the risk of meniscal tear? *Arthroscopy* 18:955–959
- Mizuta H, Kubota K, Shiraishi 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
- Mohtadi N, Grant J (2006) Managing anterior cruciate ligament deficiency in the skeletally immature individual: a systematic review of the literature. *Clin J Sport Med* 16:457–464
- Paley D, Tetsworth K (1992) Mechanical axis deviation of the lower limbs. Preoperative planning of multiapical frontal plane angular and bowing deformities of the femur and tibia. *Clin Orthop Relat Res* 280:65–71
- Pressman AE, Letts RM, Jarvis JG (1997) Anterior cruciate ligament tears in children: an analysis of operative versus nonoperative treatment. *J Pediatr Orthop* 17:505–511

17. Schachter AK, Rokito AS (2007) ACL injuries in the skeletally immature patient. *Orthopedics* 30:365–370
18. Schneider FJ, Kraus T, Linhart WE (2008) Anterior cruciate ligament reconstruction with semitendinosus tendon in children. *Oper Orthop Traumatol* 20:409–422
19. Seil R, Pape D, Kohn D (2008) The risk of growth changes during transphyseal drilling in sheep with open physes. *Arthroscopy* 24:824–833
20. Shea KG, Apel PJ, Pfeiffer RP, Traugher PD (2007) The anatomy of the proximal tibia in pediatric and adolescent patients: implications for ACL reconstruction and prevention of physeal arrest. *Knee Surg Sports Traumatol Arthrosc* 15:320–327
21. Steadman JR, Cameron-Donaldson ML, Briggs KK, Rodkey WG (2006) A minimally invasive technique (“healing response”) to treat proximal ACL injuries in skeletally immature athletes. *J Knee Surg* 19:8–13
22. Utukuri MM, Somayaji HS, Khanduja V, Dowd GS, Hunt DM (2006) Update on paediatric ACL injuries. *Knee* 13:345–352