Original Article

Results of ACL reconstruction in skeletally immature patients

Mahendra Kumar Gupta[1*], P K Gupta[2]

Department of Orthopaedics, Sir Ganga Ram Hospital New Delhi, INDIA.
Email: drpg21@ymail.com

Abstract

We report on the clinical and radiographic outcomes of arthroscopically-assisted ACL reconstruction in a cohort of patients 13 years of age and younger. A retrospective chart review of skeletally immature patients, aged 13 and under (mean: 12.7 years, range: 8-13), identified 34 patients that underwent 35 ACL reconstructions (33 unilateral and 1 bilateral reconstruction). The indication for ACL reconstruction was acute ACL rupture (34/35 reconstructions) and congenital ACL insufficiency (1/35). All patients underwent a standard preoperative physical examination including Lachmann and pivot-shift testing. Minimum two-year clinical and radiographic follow-up was available for all patients (mean: 3.5 years, range: 3.5-10.1). All patients underwent arthroscopically-assisted ACL reconstruction. At the most recent clinical follow-up, all patients were assessed with a standardized physical examination in which active and passive range of motion, knee stability, and angular growth disturbance was evaluated. Additionally, the International Knee Documentation Committee (IKDC) subjective form was completed for all patients. The mean postoperative IKDC score was 83.4 (+/- 14.9), with normal or nearly normal Lachmann testing and pivot shift in 89% of patients. Three patients (8.6%) underwent revision ACL reconstruction during the study period. No angular growth deformities related to transphyseal drilling were noted in radiographic analysis.

Keywords: Arthroscopically, skeletally, transphyseal, Lachmann, ACL reconstruction

[*]**Address for Correspondence:**
Dr. Mahendra Kumar Gupta, Senior Resident, Department of Orthopaedics, Sir Ganga Ram Hospital New Delhi, INDIA.
Email: drpg21@ymail.com
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INTRODUCTION

Once considered rare injuries in children, anterior cruciate ligament injuries have become increasingly common in the pediatric athlete. An ACL tear has been shown to account for up to 31 percent of all knee injuries in soccer players between the ages of 5 to 18 years old[1] and was found in 47 percent of preadolescents and 65 percent of adolescents who present with an acute knee hemarthrosis.[2] The increased participation in organized cutting and collision sports at an early age combined with improved clinical examination and diagnostic modalities have contributed to the greater awareness of this injury. While few question the efficacy and safety of surgical reconstruction of an ACL tear in adults, the remaining growth potential of the skeletally immature knee makes surgical intervention in children more controversial. Several surgical techniques have been described to address the problem of ACL injury in children and to minimize the risk of growth plate injury. Despite the growing number of ACL reconstructions being performed in the pediatric population, there is no clear consensus on the optimal surgical technique. Furthermore, many previous clinical studies have included adolescents who are near the end of their skeletal growth. Throughout our center, a large number of ACL reconstructions are performed in the pediatric population. The purpose of this study is to report our institution's experience with ACL reconstruction in patients 13 years of age and younger to assess the technique used as well as to report clinical and radiographic outcomes.

TECHNIQUE

After obtaining approval from the institutional review board, a retrospective review of skeletally immature

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patients 13 years of age or younger undergoing ACL reconstruction between 2002 and 2012 at our institution was performed. Thirty five ACL reconstructions were performed in 34 patients; one patient sustained bilateral injuries during the study period. These patients were followed clinically and radiographically for at least two years. Eighteen patients were female and 16 were male; the mean age at the time of surgery was 12.7 years (8-13). Four reconstructions were performed in patients 10 years of age or younger, three were in patients 11 years old, seven were in patients 12 years old, and 21 were in patients 13 years old. The indication for ACL reconstruction was an acute ACL rupture in 34 cases and congenital ACL insufficiency in one. All patients underwent a standard preoperative physical examination including Lachmann and pivot-shift testing. Preoperative radiographs were obtained and a preoperative MRI was performed to confirm the presence of a torn ACL and also to evaluate for concomitant injuries. The surgical technique consisted of arthroscopically-assisted ACL reconstruction. Thirty one of the reconstructions involved a transphyseal technique with soft tissue grafts and metaphyseal fixation, two were performed with transphyseal tunnels and bone-patellar tendon-bone grafts with interference fixation with bone plugs and interference screws inserted so as to avoid the physes, and two involved a partial transphyseal technique utilizing a soft tissue graft with a transphyseal tibial tunnel and a physeal-sparing epiphyseal femoral tunnel. Overall, 16 grafts were hamstring autograft, 11 were hamstring autograft with allograft supplementation, six were soft tissue allograft, one was patellar tendon autograft, and one was patellar tendon allograft. The size of the graft and tunnels varied from 6 to 10 millimeters, with an average size of 8.3 millimeters. Femoral fixation consisted of a cortical button in 33 cases and an interference screw in two. Tibial fixation consisted of a post and washer in 27, an interference screw in six, a screw and sheath in one, and a cortical button in one. Concomitant meniscal injuries were addressed with a meniscal repair or partial meniscectomy as appropriate. Twenty two patients had an associated meniscal tear that consisted of 16 with lateral meniscal tears, three with medial meniscal tears, and three with tears of both menisci. Fourteen partial meniscectomies were performed and 11 meniscal repairs were performed. Patients began weight bearing as tolerated with crutches immediately postoperatively unless a meniscal repair was performed. They weaned off of crutches by two weeks once adequate quadriceps control was achieved. If a concomitant meniscal repair was performed, then crutches were used for 4 weeks touch down weight bearing followed by progression to full weight bearing. The first 16 weeks of rehabilitation focused on closed- chain quadriceps strengthening, regaining full range of motion with an emphasis on full extension early on, and proprioception exercises. Straight ahead jogging and progressive functional activities were initiated at 16 weeks with return to full activity usually allowed at 6 months postoperatively. The average length of clinical and radiographic follow up was 3.5 years (2.0-10.1). At the time of most recent clinical follow up a standardized physical examination was performed. Active and passive range of motion was recorded and knee stability was assessed with Lachman and pivot-shift tests. The International Knee Documentation Committee (IKDC) subjective knee form, a validated outcome measure with a scale of 0 to 100 was completed as well. Hip to ankle full length standing radiographs were obtained at final follow up to evaluate the femorotibial angle, distal femoral angle, and proximal tibial angle and to compare these to the contralateral limb to evaluate for angular growth disturbance. A significant growth disturbance was defined as greater than a 5 degree difference between the operative and contralateral side. Clinical failure was defined as undergoing revision ACL reconstruction. The mean postoperative IKDC subjective knee score was 83.4 +/- 14.9. According to IKDC criteria, the Lachman test was normal in 14 (40%) knees, nearly normal in 17 (49%) knees, and abnormal in 3 (9%) knees. There were no severely abnormal knees in the study cohort. The pivot shift test was normal in 22 (63%) knees, nearly normal in 9 (26%) knees, and abnormal in 2 (6%) knees. One patient (3%) who rated abnormal on the Lachman test was unable to perform the pivot test. One patient (3%) did not have the physician objective IKDC completed. Radiographic assessment demonstrated no cases of iatrogenic postoperative angular deformity of the distal femur or proximal tibia. The mean postoperative distal femoral angle was 3.7 degrees of valgus (11 degrees of valgus to 1 degree of varus), mean postoperative proximal tibial angle was 1.7 degrees of varus (3 degrees of valgus to 8 degrees of varus), and the mean postoperative femorotibial angle was 0.7 degrees of valgus (8 degrees of valgus to 6 degrees of varus). The mean side-to-side difference in the femorotibial angle was 1.4 degrees (0-9), in the distal femoral angle was 1.4 degrees (0-7), and in the proximal tibial angle was 1.5 degrees (0 to 8). There were two cases in which a greater than 5 degree difference was noted on the operative extremity compared to the contralateral extremity, but in neither case was the difference due to transphyseal drilling. There was one case involving a patient with a congenital ACL deficiency where a difference of nine degrees of increased valgus of the operative distal femur compared to the contralateral femur was observed. However, this deformity in the

femur was present preoperatively and not related to the transphyseal femoral tunnel. There was a second case in which there was a nine degree increase in varus of the femorotibial angle on the operative extremity compared to the contralateral side. This involved the case detailed above with a repeat injury causing a rupture of the ACL graft and an associated posterolateral corner injury. The side-to-side difference was not related to growth deformity from transphyseal drilling. There were three (8.6%) revision ACL surgeries performed at an average of 2.8 years (1.5-4.8) following the index procedures. One additional patient sustained a repeat injury involving a rupture of the ACL graft and an associated posterolateral corner injury at 1.8 years. This patient and their family chose not to undergo revision surgery due to a lack of symptoms. Four other patients underwent an additional procedure on the same knee; one underwent a closed manipulation for arthrofibrosis, one underwent a manipulation and operative release for arthrofibrosis, one underwent a microfracture chondroplasty after a new injury, and one underwent a meniscal repair after a repeat injury.

DISCUSSION

In young children with open physes, iatrogenic damage to the growth plate from surgery can cause a growth disturbance resulting in angular deformities which can be very difficult to manage. Many have traditionally advocated a non-operative approach in younger patients consisting of rehabilitation, bracing, and activity modification in order to avoid this risk of iatrogenic bone-growth disturbance.[3,4, 5] However, the results of nonsurgical treatment of complete ACL tears generally are poor. Bracing is ineffective in providing knee stability, and young athletes are unlikely to modify activities given their constant exposure to sports and their difficulty understanding the adverse effects of repeated knee instability events.[6] Moreover, it is now evident that most skeletally immature patients treated non-surgically experience repeated episodes of instability and secondary meniscal tears and chondral injuries.[7,8,9,10] Several surgical techniques have been described to address the problem of ACL injury in children and to minimize the risk of growth plate injury. Physeal-sparing reconstructions that avoid both the proximal tibial and distal femoral physes or cross only one physis have been developed and reported with good results.[3,11,12,13,14] The drawback with these techniques is their relative increased complexity compared to routine ACL reconstruction and potential for less anatomic and isometric tunnel positioning. [15,16] Adult-type transphyseal techniques that traverse both the proximal tibial and distal femoral physes have been performed in children.[15, 16, 17,18,19] This approach is often tailored to each patient, taking into account the child's maturation level. Fixation does not typically cross the physis. Most of the current literature translating adult-type ACL reconstruction techniques is focused on post-pubescent skeletally immature patients with little remaining growth. In our cohort, we demonstrated that transphyseal ACL reconstruction in skeletally immature patients is effective in restoring knee stability without causing clinically significant injury to the physes about the knee. Our cohort is younger than the patients in most of the current literature, with the average age 12.7 years (8-13) and so had significant growth remaining. Overall normal or nearly normal Lachmann testing was noted in 31 (89%) out of 35 knees and normal or nearly normal pivot shift testing was found in 31 (89%) out of 35 knees. Only three out of 35 knees (8.6%) underwent revision ACL reconstruction. Radiographic analysis demonstrated no angular growth deformities related to transphyseal drilling. This is a large series of skeletally immature patients that underwent ACL reconstruction with either transphyseal drilling or partial transphyseal drilling. The strengths of this study include the relatively younger age of patients at the time of surgery in this pediatric cohort, the volume of patients in the study, the combination of clinical and radiographic data, and the duration of follow up. Weaknesses of the study are the retrospective nature of the study and the lack of a comparison cohort. An additional weakness is the variety of graft types and surgical techniques utilized. Our study compares closely to two recently performed studies on transphyseal ACL reconstruction in a younger pediatric population. Liddle *et al* performed transphyseal drilling with soft tissue graft placement and metaphyseal fixation in 17 children of Tanner stage 1 or 2.[20] The mean age was 12.1 years. One patient sustained a rerupture. One patient had a mild valgus deformity at final follow up with no functional limitation. They concluded that transphyseal reconstruction was safe in this patient population. Cohen *et al* similarly reported on a cohort of 26 skeletally immature patients with an ACL injury that were a mean age of 13.3 years old at the time of surgery[21]. They reported good clinical outcomes with no growth abnormalities at a mean follow up of 45 months. This study adds to this previous literature and suggests that an adult-type ACL reconstruction using a transphyseal drilling technique may be safely performed skeletally immature patients with significant growth remaining.

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