

# Posterior cruciate ligament reconstruction in skeletal immature children

Ole Gade Sørensen<sup>1</sup> · Peter Faunø<sup>1</sup> · Svend Erik Christiansen<sup>1</sup> · Martin Lind<sup>1</sup>

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## Abstract

**Purpose** Rupture of the posterior cruciate ligament (PCL) is a rare knee injury in children with open growth plates. The follow-up results of six patients with open physes treated with PCL reconstruction are presented. The objective is to evaluate the clinical outcomes of PCL reconstruction for six skeletally immature patients.

**Methods** Between 2006 and 2010, six skeletally immature patients were treated with PCL reconstruction. At the time of surgery, the median age was 9 years (range 6–14). The median follow-up time after surgery was 50 months (range 41–90). Outcomes were evaluated by KOOS and Tegner scores, instrumented knee laxity, and radiologic long-axis leg length measurements.

**Results** The median KOOS score at follow-up was 88 (range 26–98). The median Tegner score was 6 (range 4–7). The median side-to-side difference in laxity according to KT-1000 was 2 mm (range 1–5) at 25° of flexion and 3 mm (range 3–6) at 70° of flexion. A median side-to-side difference in flexion of 8° was found. All but one patient had returned to playing sports at follow-up. One patient's index leg had a length discrepancy of 16 mm.

**Conclusions** PCL reconstruction resulted in fair to good clinical outcomes for skeletally immature children. Clinically relevant leg length discrepancy was found in one of the six patients examined in this study.

**Level of evidence** Level IV.

**Keywords** Posterior cruciate ligament reconstruction · PCL · Adolescents · Children · Open physes

## Introduction

Rupture of the posterior cruciate ligament (PCL) in children is a rare condition compared to anterior cruciate ligament tears [6, 19, 20, 27, 31]. Both conservative and surgical treatments after PCL rupture are described. The appropriate surgery is often determined by the type of PCL lesion in a patient. Often, PCL avulsions are treated by either proximal or distal reattachment [7, 9, 11, 12, 16, 18, 21, 22, 26, 30], whereas augmentation [15] and PCL reconstruction are favored in cases with intra-substance tears and chronic instability [1–3, 13]. The literature on this topic is sparse and dominated by case reports. Only two studies [13, 24] investigated the outcomes of PCL reconstruction for a series of pediatric patients. Shah et al. [24] reported a series of three patients, and Kocher et al. [13] reported the results of eight patients with a mean age of 16.5 years. The mean Pedi-IKDC and Lysholm scores in those studies were 81.3 and 80.1, respectively. No growth disturbances were found. However, the majority of patients were likely to have closed physes, which diminishes the risk of injury to the growth physes and subsequent growth disturbances for this cohort. The aim of the present study was to evaluate clinical and radiological outcomes after PCL reconstruction in six skeletally immature children.

✉ Ole Gade Sørensen  
olegades@hotmail.com

Peter Faunø  
petefaun@rm.dk

Svend Erik Christiansen  
sec@dadlnet.dk

Martin Lind  
martilin@rm.dk

<sup>1</sup> Department of Sportstraumatology, University Hospital of Århus, Tage Hansens Gade 2, 8000 Århus C, Denmark

## Materials and methods

Between 2006 and 2010, a total of six patients (one girl and five boys) with open physes were treated with PCL reconstruction. Patient characteristics and causes of injury are shown in Table 1. Four patients had an intra-substance tear of the PCL. One patient suffered from distal avulsion of the PCL and one patient had a peel-off PCL injury at the femoral insertion site.

## Surgical technique

Reconstruction was performed with a trans-tibial hamstring graft single tunnel PCL reconstruction technique. Physis-sparing drilling of the bone tunnels was performed in both the tibia and the femur using fluoroscopy. The tibial bone tunnel was drilled from the antero-medial part of the tibia to the posterior cortex ending distal to the physis. The femoral bone was drilled inside out via the antero-lateral portal.

## Intraoperative findings

None of the patients had cartilage lesions. Two patients had radial lesions on the medial meniscus. Both were treated with minor partial resection. The chosen grafts are shown in Table 1.

## Rehabilitation

All patients were immobilized with a hinged brace for 8 weeks after surgery. Flexion from 0° to 90° was allowed in the first 6 weeks. In the last 2 weeks, motion from 0° to 120° was allowed.

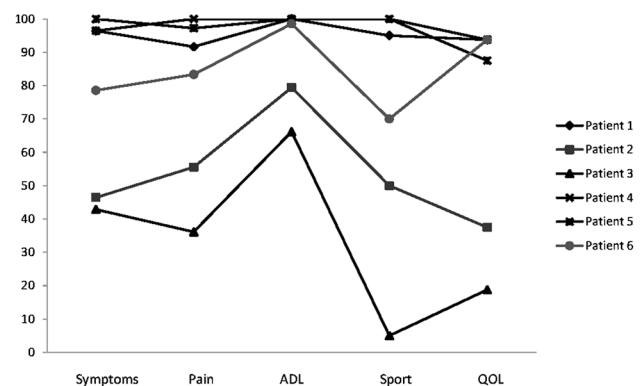
Physiotherapist-guided stabilizing exercises were performed during the first 6 months after surgery.

Follow-up was performed at a median of 50 months (range 41–90) after surgery. Outcomes at follow-up were

evaluated using patient-reported outcome measures (KOOS and Tegner scores) [23, 29]. Knee laxity at 20° and 70° of flexion was measured with a KT-1000 arthrometer (Medmetric Corp, San Diego, CA). The patients were tested for leg length discrepancies using full-length standing anterior-posterior radiographs. The angle between the joint line and the tibia axis and the angle between the joint line and the femur axis were measured for both knees, and side-to-side differences were calculated. Patients' range of motion was measured with a goniometer. The study was approved by the Central Denmark Region Committee on Health Research Ethics (ID number: 1-10-72-621-12).

## Results

Four patients reported high KOOS scores at follow-up ranging from 70 to 100 (Fig. 1). Two patients reported fair symptom, pain, and activity of daily living (ADL) subscores and fair to poor scores on the sports and quality of life (QOL) subscales (Fig. 1). The patients' Tegner scores ranged from 4 to 7 (Table 2). Knee laxity measurements were performed using KT-1000 for five patients.



**Fig. 1** KOOS profile of six patients after PCL reconstruction

**Table 1** Patient characteristics and graft choice in six patients undergoing PCL reconstruction

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Gender	Male	Male	Male	Male	Male	Female
Age at surgery (years)	14	6	13	6	10	8
Period from injury to surgery (months)	5	2	2	2	17	4
Cause of injury	Gymnastics	Soccer	Motor-cross	Traffic	Trampoline	Traffic
Meniscal lesion	–	–	Medial	Medial	–	–
Graft	Hamstring (autograft)	Hamstring (autograft)	Hamstring (allograft)	Tibialis ant (autograft)	Hamstring (autograft)	Hamstring (autograft)
Follow-up (months)	90	66	51	49	42	41

Both the semitendinosus tendon and the gracilis tendon are used in hamstring autograft

**Table 2** Tegner score, laxity measurements, flexion, and leg length discrepancies at follow-up in six patients undergoing PCL reconstruction

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Tegner score	7	7	4	6	6	4
KT1000 (25° flexion) <sup>a</sup>	1	1	3	–	5	2
KT1000 (70° flexion) <sup>a</sup>	3	3	3	–	6	3
Flexion deficit <sup>b</sup>	10	10	10	0	5	10
Femur length <sup>c</sup>	–3	–2	6	–	3	6
Tibia length <sup>c</sup>	2	–4	3	–	3	10

<sup>a</sup>Side to side difference in laxity (mm)<sup>b</sup>Side to side difference (°)<sup>c</sup>Side to side difference (mm)

Side-to-side differences of 3 mm or less at both 25° and 70° of flexion were found in four of the five patients (Table 2). None of the patients had a flexion deficit of more than 10° in the index knee compared to the opposite knee, and none suffered from a side-to-side extension deficit. Five patients had side-to-side leg length differences of less than 10 mm. Patient 6 had a leg length discrepancy of 16 mm (Table 2).

## Discussion

The main finding of the present study was that four of the six investigated patients had good to excellent KOOS and Tegner scores following PCL reconstruction. Patient 2 had fair KOOS scores. In this patient, the ADL subscore was acceptable, in contrast to the other subscores. Confusingly, patient 7 had a Tegner score of 7. The KOOS and Tegner scores of patient 3 were both low and had good correlation. At follow-up, he complained of pain during most activities and was the only patient that was not able to return to playing sports. Initially, he was diagnosed with a tibial avulsion fracture and a medial meniscus lesion after undergoing an MRI prior to surgery. He underwent partial resection of the meniscus and removal of the avulsed bone stock (15×12 mm) during PCL reconstruction. No further explanation for the pain this patient experienced could be found. Overall, PCL reconstruction in children and adolescents resulted in fair to good outcomes both subjectively and functionally.

Treatment of knee ligament injuries in patients with open physes always poses a dilemma. Ideally, ligament reconstruction results in a stable knee and therefore prevents future damage to the menisci and cartilage and further degeneration of the knee. On the other hand, conservative treatment prevents damage to the physes and subsequent growth disturbances. In this study, we found no axis deviation around the knee. Patient 6 had a side-to-side difference in leg length of 16 mm, with the index leg being the longer of the two. No pre-surgery long radiographs exist for this patient, which makes it impossible to conclude whether

surgery is responsible for the difference in leg length. Hesse et al. [10] and Shen et al. [26] also reported elongation of the affected knee, indicating that PCL injury and the following surgery may stimulate rather than arrest growth. Therefore, leg length discrepancy may be a possible complication that should be taken into account when determining whether to perform surgery for similar patients, even when physis-sparing techniques are used.

In all six patients, the tibial bone tunnel was drilled distal to the physis at the posterior cortex to prevent damage to the posterior part of the tibial physis. As a result, the tibial bone tunnel will migrate distally over time, and the PCL graft along the posterior border of the tibia will elongate. It has been reported that tibial drilling through the physis results in very low risk of growth disturbances after ACL surgery in children and adolescents [5, 8, 14]. Theoretically, central damage to the tibial physis would be more benign than peripheral damage due to trans-physis tibial drilling during PCL reconstruction. According to Bovid et al. [3] and Accadbled et al. [1], PCL reconstruction involving drilling through the posterior part of the tibial physis is not a problem. This could indicate that sparing the tibial physis is not necessary, but further clinical studies are needed to confirm this.

In adults, non-surgical treatment of PCL injuries seems to be widely accepted, although focus on long-term degeneration due to osteoarthritis in the medial and patello-femoral compartments has increased [4, 25, 28]. The literature on non-surgical treatment of PCL lesions in children and adolescents is sparse. Macdonald et al. [17] reported good short-term outcomes for a child with combined PCL and postero-lateral instability after non-surgical treatment, but the child complained of anterior knee pain at the long-term follow-up. In another study, 11 patients treated conservatively after PCL injuries were reported to have good outcomes without residual knee laxity [13]. However, 8 of these 11 patients suffered from partial PCL lesions, and the authors concluded that the non-surgically treated group was not comparable to the group undergoing surgery. In our study, two patients were initially treated conservatively but

had to undergo surgical reconstruction due to functional instability. Theoretically, the potential for non-surgical treatment must be higher in children than adults due to children's better intrinsic healing capacity.

A limitation of the study is that no pre-operative patient-reported data exist, meaning that improvements in subjective outcomes could not be assessed; only the patients' status could be determined at the follow-up. Furthermore, the study is limited by its small patient cohort, which restricts the statistical background for the data.

From a clinical perspective, PCL reconstruction using the physis-sparing technique in patients with open physes seems to result in acceptable subjective and knee stability outcomes, with five of the six patients participating in this study experiencing acceptable outcomes. Surgical impact on physal growth seems to be limited, with only one of the six patients demonstrating a clinically relevant leg length discrepancy. Therefore, surgical management of symptomatic PCL injuries in children using the physis-sparing single-bundle PCL reconstruction technique can result in acceptable outcomes.

## Conclusions

The physis-sparing single-bundle PCL reconstruction technique resulted in fair to good clinical outcomes for skeletally immature children. A clinically relevant leg length discrepancy was found in one of the six patients examined in this study.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no competing interests.

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