

## PEDIATRIC ACL RECONSTRUCTIONS USING TRANSPHYSEAL HAMSTRINGS

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### Abstract

Anterior cruciate ligament (ACL) injuries are increasing in skeletally immature patients. In the adult population management is fairly standardized with surgical reconstruction using hamstrings autograft being the most common current treatment. However, for the pediatric population with open physes concern exists regarding surgical management since the distal femur and proximal tibia accounts for an important lengthening and alignment of the lower limb.

For this purpose we performed a retrospective evaluation of our cohort of pediatric ACL reconstructions. 4 girls and 3 boys met the inclusion criteria out of 628 consecutive cases operated by a single surgeon over the last 5 years.

The girls were 13, 14 and two 15 respectively and the boys were 15 and two 16. All were competing athletes coming from: one girl volley and three hand-ball and the boys soccer. All had subjective instability and received single bundle transphyseal primary ACL reconstruction performed by the same surgeon using quadruple hamstrings (semitendinosus and gracilis) with cortical femoral and absorbable interference screw tibial fixation. All patients had associated lesions: 5 chondral, 3 internal 2 external and one both menisci; Time from injury to surgery was on average 9.1 weeks (5 to 17).

6 out of seven were available for a final follow-up of 1.9 years. All had returned to sports at preinjury activity levels and had IKDC (international knee documentation committee) scores for excellent (A) and good (B) outcomes. No clinical and radiographic growth arrests could be identified.

We conclude that single bundle transphyseal ACL reconstructions using hamstrings autografts for skeletally immature patients yields favorable outcomes. However, only small portions of estimate incidence undergo specialist evaluation and surgical treatment. Further collaborations should be encouraged to allow more pediatric patients to benefit from surgical ACL reconstruction. In addition, for such cases, exact height and Tanner skeletal maturity should be noted at the time of index surgery in order to improve retrospective evaluations.

**Key words:** pediatric, ACL reconstruction, transphyseal, hamstrings

### Clinical background

Anterior cruciate ligament (ACL) injuries are increasing in skeletally immature patients. In the adult population management is fairly standardized with surgical reconstruction using hamstrings autograft being the most common current treatment. However, for the pediatric population with open physes concern exists regarding surgical management since the distal femur and proximal tibia accounts for an important lengthening and alignment of the lower limb.

Historically there have been large practice variations in initial management and reconstruction techniques. Surgeons feared growth disturbance complications such as: distal femoral valgus deformity with arrest of the lateral distal femoral physis, tibial recurvatum with arrest of the tibial tubercle apophysis, genu valgum without arrest and leg length discrepancy. Based on this experience, a guarded approach to ACL reconstruction in the skeletally immature patient was advocated [1].

Nevertheless, over the years attitudes have changed towards favoring early surgical treatment as opposed to conservative management. Clear evidence shows that the same correlations from the adult populations exist in the skeletally immature patients regarding increase meniscal and chondral injuries with delayed treatment. This is concerning because studies have shown that, regardless of knee stability obtained after ACL reconstruction, meniscectomy accelerates degenerative joint changes. Lawrence et al [2] found that out of 70 young patients who underwent surgical reconstruction of an acute ACL tear more than 12 weeks after the injury (odds ratio 4.1) more were noted to have a significant increase in irreparable medial meniscal tears and lateral compartment chondral injuries (odds ratio 11.3) at the time of reconstruction. When a subjective sense of knee instability was present, this association was even stronger (odds ratio 11.4). Dumont et al [3] performed a retrospective chart review of 370 pediatric patients undergoing primary arthroscopic ACL reconstruction. They identified that index ACL reconstructions after more than 150 days since injury have a higher rate (odds ratio 1.8) of medial meniscus tears than those treated earlier. Increased age (odds ratio 1.6) and weight (odds ratio 2.2) are independently associated with a higher rate of medial meniscus tears.

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Patients with ACL tears and a medial or lateral meniscus tear are more likely to have a chondral injury in that particular compartment than those without meniscal ruptures.

Regarding the most appropriate graft choice there is growing support in favor of autologous hamstrings (semitendinosus and gracilis) and concern with bone – patellar tendon – bone since the bone plugs have led to premature physal ossifications in animal models. Gebhard et al [4] analyzed twenty-eight patients who underwent ACL reconstruction with hamstrings, 16 patients with bone-patella-bone, 12 patients with quadriceps grafts and 12 patients with fascia lata. The mean follow-up was 32 months. Neither leg length discrepancy nor angular deformities were noted. None of the four methods studied showed major differences in outcome compared to the other.

Thus, surgical stabilization should be considered as the first line of treatment for immature patients with ACL tears. The existing literature suggests that transphyseal reconstruction can be safely done in this population if a few rules are considered, and there are physal-sparing procedures that provide excellent results with less theoretical risk to the growth plate. Conservative or delayed surgical treatment, which carries an increased risk of secondary joint injury, should be reserved only for selected cases [5].

This change of perspective has not been fully agreed upon especially regarding surgical procedure with respect to physal growth plates. Moksnes et al [6] performed a recent literature review and found that there is no consensus on the management of anterior cruciate ligament injuries in

skeletally immature children, and the methodological quality of published studies is questionable. The transphyseal reconstructions, physal-sparing reconstructions, and nonoperative treatment algorithms that are advocated have little supportive data.

In our center we have been performing over 150 ACL reconstructions every year. A recent analysis has revealed an increase in the percentage of skeletally immature which has led us to perform a review of the literature and our cases in order to evaluate our current standard of treatment.

**Material and Method**

For this purpose we performed a retrospective evaluation of our cohort of pediatric ACL reconstructions. Criteria for inclusion were up to 15 years of age for girls and 17 for boys at index surgery and open physis evaluated using postoperative x-rays. These were the only reliable measurements available, even though in the literature the standard bone age evaluation for pediatric ACL reconstructions is the one proposed by Tanner and Whitehouse; this system scores 20 indicators on hand and wrist radiograph, yielding total scores ranging from 0 to 100. However, we were not able to use this scale in retrospect. 4 girls and 3 boys met the inclusion criteria out of 628 consecutive cases operated by a single surgeon over the last 5 years. The girls were 13, 14 and two 15 respectively and the boys were 15 and two 16. The probable estimate Tanner stage was III and IV. Example of MRI appearance can be seen in fig.1 - 3.



Fig.1 RISE and fig. 2 T1 sagittal and fig. 3 T1 coronal views of 16 years old boy with open physis and ruptured ACL.

**Results**

All had subjective instability and received single bundle transphyseal primary ACL reconstruction performed by the same surgeon using quadruple hamstrings (semitendinosus and gracilis) with cortical femoral and absorbable

interference screw tibial fixation (fig.4 – 9). All patients had associated lesions: 5 chondral, 3 internal 2 external and one both menisci; all meniscal lesions were addressed by partial resection. Time from injury to surgery was on average 9.1 weeks (5 to 17).

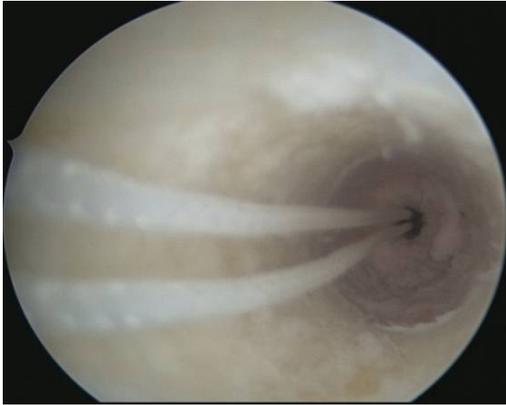


Fig.4 and 5: femoral tunnel of two cases showing the arthroscopic view of the transphyseal ACL reconstruction.

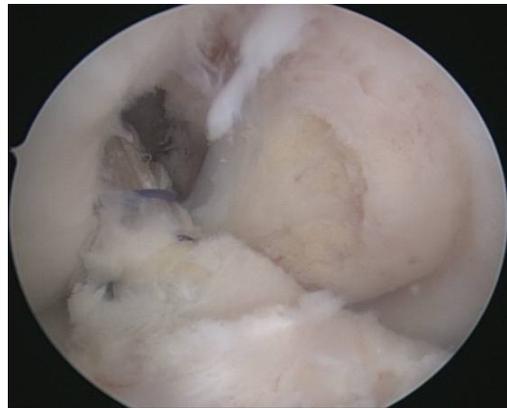


Fig.6 medial and fig.7 lateral portal views of the case above of 16 years old boy with anatomic single bundle (transphyseal) ACL reconstruction using ipsilateral hamstrings (semitendinosus and gracilis) autograft (quadruple).



Fig.8 and 9 show AP and lateral radiographs of a 16 years old boy with open physis and ACL reconstruction using transphyseal technique with hamstrings autograft, cortical femoral fixation and absorbable tibial interference screw.

All were competing athletes coming from: one girl volleyball and three handball and the boys soccer. Postoperative regimen also resembled that of adult population and began with partial weightbearing for the first 3 weeks with passive and active ROM exercises followed by progression to complete return to sports at an average of 5.5 months (4 to 7).

6 out of seven were available for a final follow-up of 1.9 years. All had returned to sports at preinjury activity levels.

AP knee radiographs showed no degenerative progression comparative to immediately postoperatively and no visible signs of tunnel enlargement. No clinical and radiographic growth arrests could be identified. However, no exact estimate of height increase could be made due to inaccurate height recordings at index surgery. One case had had persistent pain and stiffness until approximately one year postoperatively which resolved spontaneously with inconclusive MRI findings.

### Discussions

Similar studies have found favorable results for autologous hamstrings grafts using transphyseal techniques (7,x,9). Redler et al [10] showed that transphyseal ACL reconstruction with autogenous quadrupled hamstring graft with metaphyseal fixation in skeletally immature (14.2 years) patients yielded excellent functional outcomes in a high percentage of patients without perceived clinical growth disturbance at a mean of 43.4 months.

Drill hole placement during ACL reconstruction produces a zone of physeal injury. The overall volume of injury is relatively low, which reduces the risk of physeal arrest. With careful placement, the region of injury is central on the tibia, and the total volume of injury can be less than 5.0% of the physeal volume. For the femur, the total volume can be less than 5.0% as well. However, the region of injury is peripheral, which carries a higher risk of physeal arrest. For the tibia, drill holes that started more medial, distal, and with a steeper angle of inclination reduced the amount of physis and apophysis violated when compared with holes placed more lateral, proximal, and with a shallow angle of inclination [11,12].

Other authors [13] have used MRIs to identify physeal sparing directions of the femoral tunnel using transphyseal techniques and proposed drilling from the center of the ACL femoral footprint to the insertion of the popliteus tendon; this could result in a mean tunnel length of 27 to 30 mm, and it might allow the safe placement of a femoral tunnel at least 7 mm in diameter in patients six to seventeen years old. The center of the ACL femoral footprint and the popliteus insertion are easily identifiable landmarks and will allow safe, reproducible, anatomic ACL reconstruction in the skeletally immature patient.

A retrospective case series of 933 knees with a mean age at the time of surgery of 15 years and an average follow-up from index surgery of 6.3 years evaluated the overall prevalence of arthrofibrosis and found it to be 8.3%; 77 knees had at least one procedure to treat arthrofibrosis after

ACL reconstruction. Arthrofibrosis was defined as a loss of 5 degrees or more of extension or a loss of 15 degrees or more flexion compared with the contralateral knee that required a follow-up procedure. Risk factors for arthrofibrosis were female sex, higher age (16 to 18 years odds ratio 3.51), patellar tendon autograft (odds ratio 1.7), and concomitant meniscal repair (odds ratio 2.08). Prior knee surgery and ACL reconstruction within one month of injury were not significantly associated with arthrofibrosis after ACL reconstruction [14].

Frosh et al [15] identified a total of 55 articles reporting on 935 patients (median age 13 years) with a median follow-up of 40 months; their review found the weighted rate of leg-length differences or axis deviations was 1.8% and that of reruptures was 4.8%. Excellent or good function (International Knee Documentation Committee grade A or B) was achieved in 84.2% of knees and Lysholm scores averaged 96.3. Transphyseal reconstruction was associated with a significantly lower risk of leg-length differences or axis deviations compared with physeal-sparing techniques (1.9% versus 5.8%; relative ratio 0.34) but had a higher risk of rerupture (4.2% versus 1.4%; relative ratio 2.91). Sutures did not result in any growth disturbances, with a weighted rerupture rate of 4.6%. Fixation far from the joint line fared better than close fixation with regard to this endpoint (1.4% versus 3.2%; relative ratio 0.42). Bone-patellar tendon-bone grafts, which are also less likely to fail, were associated with higher risks of leg-length differences or axis deviations than were hamstrings (3.6% versus 2.0%; relative ratio 1.82). Meta-regression did not show a significant impact of the publication year on event rates.

Kaeding et al [16] aimed to determine whether any anterior cruciate ligament reconstruction technique is clinically superior in skeletally immature patients having at least one of the following criteria: chronologic or bone age of less than 15 years in boys or less than 14 years in girls, Tanner stage I, II, or III and at least 10 cm of total growth after the reconstruction. Thirteen case series were included. Four studies used physeal-sparing techniques. Six studies used transphyseal techniques. Two studies used a combined technique, and a multicenter study reported results of both techniques. Within the physeal-sparing group, there were 2 studies that used an entirely extra-epiphyseal technique and 2 studies that used intra-epiphyseal techniques. Overall clinical outcomes were excellent, with growth complications being very rare in all of these series. The authors concluded that both physeal-sparing and transphyseal reconstructions can produce excellent clinical outcomes with a very low incidence of growth complications in Tanner stage II and III patients. Tanner stage I patients had excellent clinical results with physeal-sparing techniques (both extra- and intra-epiphyseal techniques). Not enough Tanner stage I patients underwent transphyseal techniques to support or discourage their use. This evidence supports considering the expansion of transphyseal reconstruction indications from Tanner stage IV patients to Tanner stage II and III patients.

**Conclusions**

In our clinical setting we conclude that single bundle transphyseal ACL reconstructions using hamstrings autografts for skeletally immature patients yield favorable outcomes. However, only a small portion of estimate incidence undergoes specialist evaluation and surgical

treatment. Further collaborations should be encouraged to allow more pediatric patients to benefit from surgical ACL reconstruction. In addition, for such cases, exact height and Tanner skeletal maturity should be noted at the time of index surgery in order to improve retrospective evaluations.

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