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RESEARCH ARTICLE

Anterior Cruciate Ligament Ruptures in Adolescent Athletes

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Abstract

Introduction: Anterior cruciate ligament reconstruction in children is a highly sophisticated procedure that might lead to unintended complications. Following such an operation, each patient should receive increased attention during the rehabilitation and recovery process. Achieving the best possible functional outcome after surgery depends on a variety of factors, including biological maturity, emotional stability, and surgical procedures.

Materials and Methods: The study population is comprised of 23 skeletally immature patients with a complete rupture of the anterior cruciate ligament, broken down by sex as follows: 18 boys and 5 girls. The average age in the group was 14.1 years. The anterior cruciate ligament reconstruction was performed with bicortical fixation using the tendon of the m. semitendinosus as a graft.

Discussion: Skeletal immaturity is identified as a risk factor for postoperative complications that can arise after anterior cruciate ligament reconstruction. Cases of deformities or limb-length discrepancies formed during the course of skeletal growth have been observed. Furthermore, rehabilitation involves a number of issues, and the risk of graft rupture in children is substantially higher than that in the adult population.

Keywords: Skeletal Immaturity, Acl, Transphyseal Reconstruction

1. Introduction

The incidence of anterior cruciate ligament (ACL) injuries in the skeletally immature population has been increasing over the last two decades. This type of injury is a therapeutic challenge resulting from both the open physes in the distal femur and proximal tibia and the imminent growth. When choosing surgical treatment for such patients, the significant longitudinal growth in the knee area should be taken into account.

While the transphyseal technique for anterior cruciate ligament reconstruction is the most common procedure in patients with nearly complete skeletal growth, alternative treatment methods—conservative and surgical—should be considered with patients at an earlier age.

Knee injuries in childhood result from a variety of complex reasons. On the one hand, there are rising expectations for achievements in sports from early childhood, when the child‘s physical and mental development has not yet reached the required levels to support loads. In recent decades, the age of professional sports has dropped, including to the point that 13- to 14-year-old children compete alongside their adult teammates and opponents. All this leads to increased traumatism and, in some sports, injuries to the knee joint and, in particular, ruptures of the anterior cruciate ligament. Knee injuries are particularly common in sports such as football, volleyball, basketball, skiing, gymnastics, badminton, handball, rugby, American football, combat sports, etc.

The accurate and prompt diagnosis of anterior cruciate ligament injuries is of key importance for

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proper treatment and, above all, for the prevention of subsequent injuries to the rest of the knee structures. In childhood, additional cartilage damage or meniscus tear in an unstable knee has catastrophic consequences for the future sports career and for the life of the knee joint in general.

Anamnesis is critical in establishing the diagnosis of the injury to knee joint structures. Patients who suffer from ACL injuries usually report a twisted knee or a valgus injury to the knee; they hear a loud "pop" and are unable to continue playing afterward. Immediately after the trauma, swelling occurs and gets worse over the next several hours to a day or two. The range of motion of the joint is limited, making it hard to fully bend and extend the knee. A limping gait is observed, protecting the injured limb. In some cases, the pain is very strong; in others, it is moderate to barely noticeable.

The physical examination is an indispensable part of the diagnosis of "intra-articular injury to the knee joint". First of all, an inspection of the knee, palpation, and assessment of the passive and active range of motion are performed. The joint is tested for injuries to the collateral ligaments, anterior cruciate ligament, and posterior cruciate ligament. Specific tests for assessing ACL injury are the anterior drawer test, the Lachmann test, and the Pivot-shift test. It should be noted that, although specific for such an injury, the indicated tests are not always positive, even in the case of a complete ACL rupture. In this situation, it is important to determine whether there is resistance from the patient to performing the tests, which is common in the paediatric population and aggravated by the current oedema and pain.

In such circumstances, an X-ray diagnostic is required immediately following the trauma in order to rule out bone damage and fractures in the area of the growth zones. This examination is available and inexpensive, and when performed correctly and necessarily in two projections, it provides information about bone pathology. Particular attention should be paid to the integrity of the intercondylar eminence, which often accompanies this mechanism of trauma to the knee joint in childhood and adolescence. Also, in some cases, an osteochondral fracture is present, which can be detected by radiographic examination, most often by applying a profile projection.

Nuclear magnetic resonance imaging is still the primary method for assessing soft tissue damage in the knee joint. It can be used to detect connective tissue injury, meniscal tears, and hyaline cartilage damage, as well as examine the presence and degree of development of growth zones in the joint area. The exam is safe and does not expose the patient to radiation. The only disadvantages are the exorbitant cost and restricted availability. Inhomogeneity and lack of traceability in the anterior cruciate ligament with sagittal and coronal projections, the presence of bone marrow oedema in the area of the lateral femoral condyle, and oedema in the ACL attachment location on the axial projection are the signs of injuries to the anterior cruciate ligament obtained by MRI imaging. (Fig. 1)

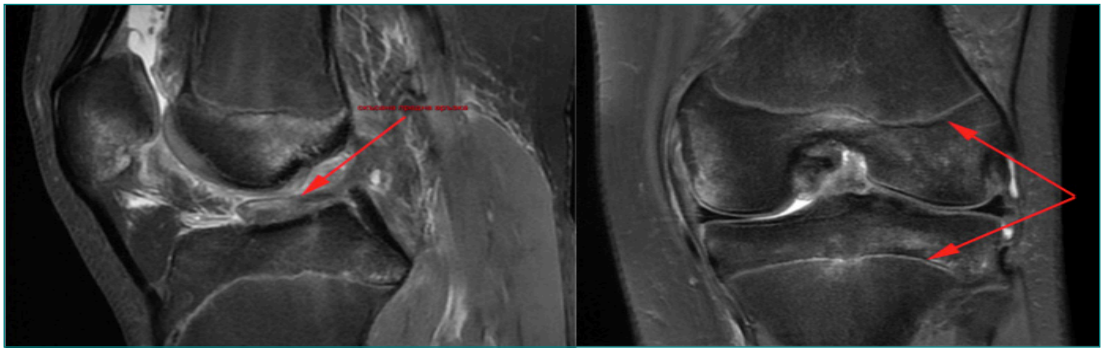

Figure 1. *MRI data of anterior cruciate ligament rupture in skeletal immaturity.*

1.1 Skeletal Maturity and Bone Growth in the Area of the Knee Joint

Skeletal maturity and the degree of residual bone growth in the distal femur and proximal tibia are important criteria in determining the type of treatment in patients with ACL ruptures in the bone growth phase. Radiography of the left hand and wrist is a useful tool to assess bone maturity. Evaluation techniques rely on comparing the number and features of ossification foci to the Greulichand Pyle atlas. Skeletal maturity can also be measured using the same radiography with a bone-specific scoring system of Tanner.

The determination of the stages of pubertal development is carried out according to the Tanner scale by assessing the development of the mammary glands in girls (B); genital development and testicular volume in boys (G); pubic hair (P); and axillary hair (A). According to Tanner's scoring system, five stages

are distinguished depending on a combination of the above maturity criteria.

The growth in the proximal tibia and distal femur areas contributes significantly to the overall growth of the lower limbs. The regions of the proximal tibial physis (28%) and distal femoral physis (37%) account for around 65% of the lower limb‘s overall growth. Genu valgum or genu recurvatum are probable problems following ACL reconstruction because the bone tunnel in the femur is positioned eccentrically in the bone, in the posterior area of the lateral femoral condyle.

Refixation, extra-articular reconstruction, and intra-articular reconstruction—which might be non-physeal, partly transphyseal, totally transphyseal, or transepiphyseal—are surgical therapy options for ACL injuries in skeletal immaturity. The preferred fixation treatment for Tanner 3/4/5 stages is a transphyseal approach using a soft tissue graft that passes up to 8 mm further vertically relative to the limb‘s axis. (Figure 2)

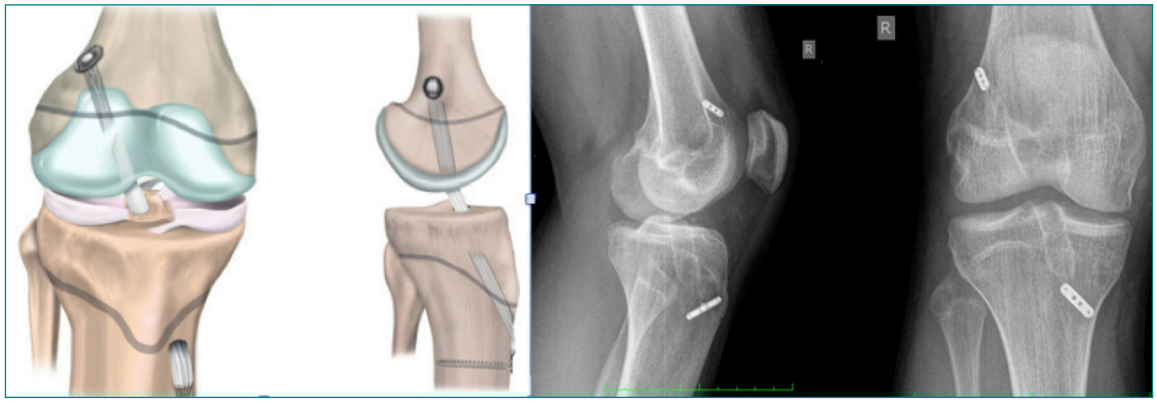

Figure 2. *Schematic and radiographic representation of a transphyseal ACLt reconstruction technique with cortical plate fixation*

2. Materials and Methods

During a period of 2 years, 23 skeletally immature patients with ACL ruptures were treated. They were broken down by sex as follows: 18 boys and 5 girls. The average age in the group was 14.1 years (11–17 years). All patients in the operative treatment group underwent reconstruction with a tendon of the m. semitendinosus and bicortical fixation, as well as therapy for the accompanying injuries (suture or resection of damaged menisci) and chondroplasty if necessary. The operative procedure involves first harvesting a tendon from the m. semitendinosus through a 2 cm anterior-medial access to the knee joint, its processing, and its inclusion in a construction with 2 pieces of cortical fixation titanium plates with a length of 12 mm for the femoral fixation and 20 mm for the tibial fixation. This is followed by arthroscopic examination via anteromedial and anterolateral access of the knee joint and repair of any further meniscal or chondral injuries. Femoral and tibial tunnels of corresponding diameters are drilled with the first placement of guides and K-needles under visual control. The goal is to achieve a graft thickness of up to 8 mm. Using a transport thread from distal to proximal end, the graft is passed, and the ends of the construct are adapted using the system of self-tensioning sutures connected to the titanium plates of the femur and tibia. The range of motion and the presence of impingement of the implanted graft are checked arthroscopically, a drain is placed, and postoperative cryotherapy and patient anaesthesia are administered (Fig. 3).

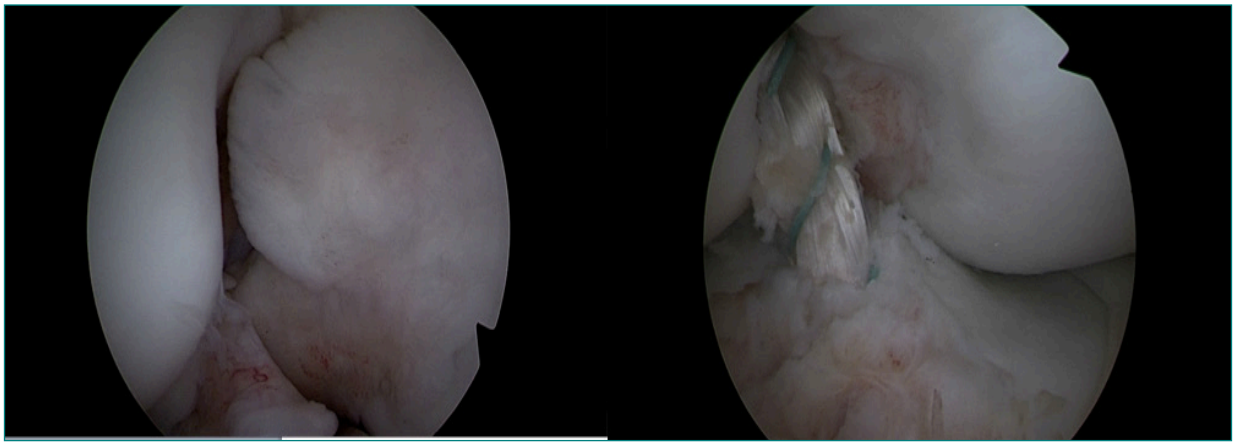

Figure 3. *Arthroscopic image showing ACL tear (left) and ACL after reconstruction with graft of m.semitendinosus (right)*

3. Results

The results of operative treatment were evaluated as function and stability compared to the unoperated joint, degree of recovery to return to pre-injury activity, and according to the modified paediatric IKDC (pedi-IKDC) scale.

In the group, meniscal injury was detected in six patients, and damage to cartilage in Grade IV according to the Outerbridge classification was found in two patients. The IKDC score preoperatively averaged 56 in the patient group, with values ranging from 42 to 71 points. Preoperatively, the patient group had an average IKDC score of 56, with values ranging from 42 to 71 points. The postoperative IKDC score averaged 87, with values ranging from 63 to 94. The final postoperative evaluation in the patient group was done at least 8 months after the operation (from the 8th to the 12th postoperative month). 20 out of 23 patients with ACL rupture postoperatively returned to sports, with 13 of them returning to a level that permitted them to resume their former training in the different activities they had played prior to the injury.

3.1 Rehabilitation After Anterior Cruciate Ligament Reconstruction in Children

The rehabilitation process after ACL reconstruction is critical for achieving full postoperative knee joint functionality. Rehabilitation in children and adolescents is even more important since the recovery in this population necessitates a personalised approach to each patient.

To date, few rehabilitation protocols after ACL reconstruction in skeletally immature patients have been designed. The majority of these are based on a limited number of patients and are contingent upon the distinct features of the clinical practice of the surgical and rehabilitation teams operating inside the corresponding centres. The fundamental aims of all procedures are to minimise postoperative pain and oedema and restore range of motion to the operated joint, with a focus on restoring terminal extension in the knee. Another essential consideration is the degree to which the limb is burdened by the body weight when the patient walks with walking aids. In principle, the construct obtained immediately postoperatively can be loaded with body weight without risk of damaging the graft. However, most authors recommend the use of aids with full or partial off-loading of the limb for a period of 3 to 6 weeks postoperatively in order to reduce the burden on the traumatised growth zone of the tibia and femur. The same goes for using a post-operative knee brace. Children are recommended to use it due to the necessity of keeping the injured bone ends at rest and providing the child with a sense of security during the early stages of recovery and verticalization.

The graft-bone tunnel healing, along with the transformation of the graft into a functional connection, is a strictly individual process. It has been even less studied in adolescent patients. This requires tailoring the rehabilitation programme to each individual patient, as well as strong coordination between parents and children and the medical staff during the postoperative recovery period. It is vital for the patient to be emotionally integrated into the treatment process and to sustain his motivation throughout time. Children and parents should be informed about the stages and duration of the rehabilitation process in order to acquire a realistic picture of postoperative recovery.

4. Conclusion

Anterior cruciate ligament reconstruction in children is a procedure that has become more common in recent years, and sports traumatologists have continued to encourage it due to its effectiveness. This is also because it makes sure that the knee becomes stable and shields the joint from additional harm until skeletal maturity occurs.

Surgical therapy creates prerequisites for possible complications, such as disruption of growth in the physis area, resulting in angular deformities and limb length discrepancies. Conservative treatment in this age group increases the risk of further cartilage or meniscus damage to the knee, keeping patients from going back to their pre-treatment levels of activity and sports.

The degree of emotional maturity and stability among trauma patients should be considered when choosing surgical treatment. The surgeon, physical therapist, and parents must team up and support young patients on their path to an injured knee recovery. In all cases, a well-chosen and performed operative intervention followed by a timely and high-quality rehabilitation programme gives the skeletally immature patients with a rupture of the anterior cruciate ligament the opportunity to resume their normal lives.

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