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Physeal Sparing ACL Repair using Knotless Suture Anchor Technique for Pediatric ACL Injuries

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Abstract

Pediatric ACL injuries are rising, and the ACL tear in an open physis is becoming more common. Traditional ACL reconstruction techniques, whether physeal sparing or transphyseal, are associated with good outcomes but carry the risk of growth arrest due to femoral and tibial bone drilling. We describe a novel technique for ACL repair in pediatric ACL patients, which prevents tibial bone drilling completely and is physeal sparing in the femur. This technique is suitable only for ACL injuries near ACL's femoral attachment. The technique is well established and documented in adult population. For the femoral fixation Swivelock anchor screw is used. This provides a stable fixation of the ACL in femur with no risk of violating the growth plate through drilling or hardware. This should theoretically minimize the risk of growth plate arrest.

Keywords: Pediatriac, ACL, ACL injuries, physis

Introduction

It has been shown in recent studies that the incidence of adolescent ACL injury is clearly rising [1-3]. The main reasons for the rising incidence of adolescent ACL injury is likely to be the increased participation in organized youth sports, increased female participation in high-risk sports, and the more accurate diagnosis of ACL injuries. A recent meta-analysis showed the superiority of operative treatment over conservative treatment [4], with instability symptoms present in 75% of non-operative patients and in operative group only 13.6%. Smith et al. [5] in their review of comparative studies investigating operative (140 knees) versus non-operative (110 knees) treatment provided evidence in favor of the surgery, in reducing instability and meniscal tears and improving return to previous activity. The risk of growth disturbance in Smith's review remained low. Clearly, there are superior results for operative management of such injuries versus non-operative treatment based on these reviews.

The ACL injury with open physes is relatively rare, and due to this there is a lack of high-quality outcome studies [6]. Therefore, there is a lack of hard evidence on the best treatment method for these injuries. The method of surgical management of such injuries has remained controversial, with both physeal sparing and transphyseal techniques been discussed, with a focus on the role of growth plate arrest [7,8]. Both of these techniques are ACL reconstruction techniques, and both have been shown to risk growth disturbance.

Trivedi et al. [9] in their review suggested that different age groups should have different ACL techniques. In the study from Fauno et al. [10] transphyseal ACLR has satisfactory clinical outcomes, with good subjective outcomes, function level, and knee stability. The risk of growth disturbance in Faunos series was 24%. There has been a recently published international guideline for pediatric ACL injury treatment (Ardern et al. 2018 [11]. There have been numerous experimental studies on growth plate injuries in pediatric ACL injuries. Seil et al. 2015 [12] reviewed this subject extensively. Recent meta-analysis [13] stated that the risk of growth disturbance due to growth plate injury is 4.1%, of which 27.6% needed corrective surgery. Mostly, the growth disturbance causes a leg length discrepancy. This review concentrates on growth plate injury that is caused by the operative treatment. Most of the conclusions of the growth plate trauma come from experimental animal studies, with very little human evidence. The permanent hardware implantation in the growth plate bears a high risk of growth disturbances. In animal experiments [12,14-16], the placement of

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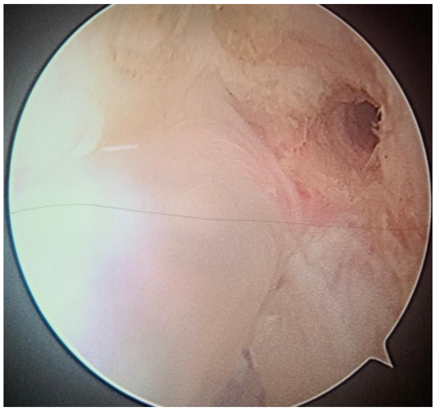
Figure 1: insertion site and drillhole for swivelock anchor


Figure 2: Swivelock insertion below the growth plate

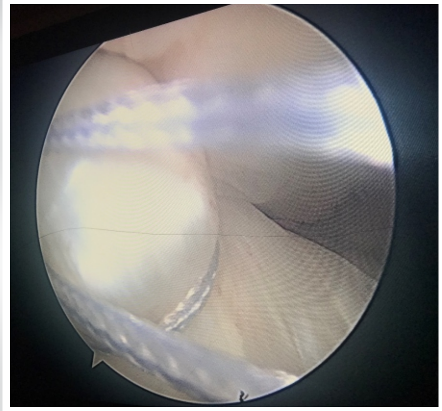
Figure 3: Arthroscopic view of anchorsutures in ACL

biodegradable material in the growth plate caused a growth arrest similar to a drill hole which was left empty. It seems that the implant size has a role, but it is advised not to leave any implanted hardware in the growth plate.
In contrast to ACL reconstruction techniques in the pediatric age groups, ACL repair may offer an alternative. The open ACL repair was the most common treatment in the 1970s and 1980s for ACL injury. Multiple studies noted deterioration of outcomes at mid-term follow-up in open ACL repair. At the same time, several randomized clinical trials noted better outcomes following ACL reconstruction, which led to abandoning the open primary repair technique [17]. In the last few years, there have been a number of papers in International literature showing a rising interest in direct ACL repair using new surgical materials and devices that enable arthroscopic repair [18-20]. Theoretically, repair techniques would propagate the need to drill the femur bone to the opposite cortex and also totally prevent tibial drilling. This should minimize the risk of growth arrest. This technique is suitable only for ACL injuries near ACL's femoral attachment.
Our hypothesis is that the pediatric ACL patient would most likely, due to great growth potential, be the most suitable for ACL repair in selected cases with proximal injuries of ACL. We prescribe in this article a pediatric ACL technique with no physical involvement.

Surgical Technique

The patient's leg is prepared in a surgical leg holder or with a side post and tourniquet over the edge of the table with the extremity draped free. Standard anteromedial and anterolateral portals are made for the knee arthroscopy.
The ACL tear is identified and mobilized with a soft-tissue grasper to assess tissue quality and feasibility for repair. The lateral wall of the intercondylar notch is cleaned with an RFA device and a shaver, and microfracture is performed to provide a bleeding base for the repair. It is very important during this procedure that as much as remaining femoral insertion of the native ACL is preserved.
The knee is taken to 120° of flexion to ascertain the entry point for the SwiveLock device. The respective straight awl with double marking is used to create a pilot or entry hole for the SwiveLock device (Fig. 1). The second laser marking is breached, and the awl is withdrawn. The entry point should be at the base of the native ACL insertion respectively to the entry for a single bundle ACL technique. If an isolated bundle repair is being performed, the entry point should correspond to the anatomical entry point for the bundle on the wall of the notch.
In the setting of a pediatric ACL with viable growth plates, an image intensifier is used to ascertain the complete passage of the 4.5 mm straight awl with reference to the growth plate. The image intensifier helps confirm whether the awl has passed through the growth plate or is completely sparing the physis. Ideally, we aim to create a parallel track between the awl and the growth plate with at least 5–10 mm of separation (Fig. 2).
A passport-type cannula is then introduced through the AM portal, and a Firstpass Mini device is used with a loaded suture to take sequential bites of the remnant ACL stump. The type of suture can be either a standard suture, such as Fiberwire or a tape suture, such as fibertape. The fiberwire suture is easier to pass through and easier to unknot, but carries the risk of cutout. The fibertape suture is harder to pass and harder to unknot, but provides less cutout risk.
The first bite using the Firstpass Mini™ device (Smith and Nephew©, USA) is taken at the midsubstance of the native ACL, and the second bite is taken with the same thread of suture approximately 2-3 mm proximal to the first bite. The third bite is taken with the opposite suture strand approximately 6–7 mm proximal to the first bite (Fig. 3). Typically, three passes are enough to allow good mobility of the remnant ACL and prevent overextension. Further bites can be taken more proximally for

larger ACLs or for ACLs with mucoid changes that need better hold. A surgical tip here is that extension of the knee separates the ACL and PCL and allows better bites of the ACL. It is important to avoid taking the PCL synovium into the bites. Further, the First pass mini is pliable to breakage of the device axis or the needle, and should not be over-rotated or the needle should not be passed too close to the bone so that it may break.

Once the bites are taken both strands are passed through the swivel Lock device eyelet, and the knee is taken back to 120° flexion to align the pilot hole. The eyelet is pushed into the pilot hole, and tensioning of sutures is performed to allow for adequate apposition of the ACL stump to the notch wall. Once adequate tension has been achieved, the anchor is inserted. The remaining sutures ends are cut, and stability is checked with a probe and an on table ACL dynamic test.

Discussion

ACL reconstruction techniques, trans-physeal or physeal sparing, are based on drilling the bone on the femoral and tibial side and have a potential for growth arrest. Our described ACL technique circumvents tibial drilling completely and provides an attractive option for femoral negotiation. This should theoretically minimize growth arrest.

The arthroscopic ACL repair is still a new surgery with quite little published outcomes. Recently reported outcomes are still highly conflicting with acceptable outcomes ranging from 40 to 90% [21, 22, 23, 24]. The injury location is of great importance when planning ACL repair. The suitable injury type is type I injury where the rupture is proximal and over 90% of ACL remnant is intact. In the age group of 11–13 years, the injury location is according to van der List et al. [25] 32% proximal and suitable for repair. True pediatric ACL injury with open physes is still rare and only one third of them can be considered for repair. The pediatric ACL surgery is demanding and should be done in centers with great experience in ACL surgery. The repair can be quite accurately planned after MRI imagining, but the readiness and skill set to do the reconstruction in pediatric patient should be guaranteed. Further, proper patient selection based on tear characteristics and patient biology is paramount in planning ACL repair.

Conclusions

Modern ACL repair is a decent option in proximal ACL tears. In pediatric patients the healing potential due to better blood circulation and omnipotence of the cells should be most optimal for ACL repair. Too little due to small patient numbers and lack of high-quality publications is known of the management of pediatric ACL injuries. ACL repair offers a new solution for the treatment of pediatric ACL injuries. Technique does not violate the growth plates, no graft harvesting is needed and there are no problems related to graft harvesting. The revision rate in patients under 18 is relatively high compared to older patients [26, 27]. The repair in this group with naturally high tendency for renewed injury would offer a plausible option with excellent possibilities for revision surgery.

The theoretical advantages of repair versus reconstruction:

- No drill injury to the growth plate
- No risk of hardware in growth plate
- Smaller risk of heat injury due to drilling in the growth plate proximity
- No need for graft No graft related problems
- Risk of growth disturbance due to over tensioning the graft should be smaller.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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