Chapter 21

Anterior cruciate ligament repair with LARS artificial ligament augmentation

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1.1 Introduction

Once a sub-acute rupture of the anterior cruciate ligament (ACL) is diagnosed in an active person, the orthopaedic surgeon must decide which option is in the patient's best interest. However voluminous the literature concerning ruptures of the ACL, data remain scarce on their long-term outcome so that even today, deciding remains problematic. Because of the biomechanical importance of the ACL, the surgeon is often inclined to favor surgery as the best option. It has been shown that the ACL contains mechanoreceptors near the surface of the ligament which provide information concerning joint position and interaction between the joint and muscles [1,2]. Their presence which contribute to the dynamic stability of the knee, combined with the mechanical stability provided by the menisci and collateral ligaments support the idea that the knee can function

well following successful ACL repair. It has been shown that morphologically normal mechanoreceptors remain in the ACL stump for 3 months after a complete tear [3]. Therefore, a repair could possibly restore the mechanical and proprioceptive function of the knee by acting on the neuromuscular system.

Most orthopedic surgeons believe a torn ACL can't heal if repaired because the intra-articular location is associated with poor blood supply and hostile biological synovial reaction. Animal models [4,5,6] have documented the healing potential of the repaired ACL augmented by an artificial ligament. The artificial scaffold helps protect the repair and support fibrous growth between the torn end of the ligament and the femoral bone. When supported, the ACL doesn't undergo the processes of necrosis and ligamentization.

The LARS® (Ligament Advanced Reinforcement System, Arc-sur-Tille, France) Terresuisse-polyethylene terephtalate (PET) ligament can support the biological healing of the newly ruptured ACL [7,8]. The LARS® intra-osseous segment is composed of longitudinal fibres bound together by a transverse knitted structure while an intra-articular segment is composed of parallel longitudinal fibres twisted at 90° clockwise or counter-clockwise for use in right and left knees, respectively. The main innovation of this artificial ligament lies in its ability to mimic the natural ligamentous structure and reduce shearing forces by orientating the free fibres of the intra-articular portion of the graft [9,10]. Therefore, every time a knee flexion occur, the LARS ligament unwinds instead of twisting, reducing considerably the combined loading of traction, flexion and torsion, while reducing abrasion [11]. Furthermore, the PET fibres of the intra-articular segment are designed to encourage tissue formation due to the porosity of the material, helping the healing process and creating a stronger and more reliable synthetic graft [12]. Growing tissue around the ligament fibres may contribute to the viscoelasticity of the graft and protect against friction at the opening of the bony canal.

Dr Duval started to use LARS® in 1993 and this chapter presents my current technique of ACL repair augmented by a LARS® artificial ligament. He started to perform this technique in 2004 on every knee when decision was made to perform ACL surgery and a good quality remnant could be stitched to the femur. I found that most ACL remnants could be

repaired within 3 months following rupture or later when healing has taken place between the ACL and the posterior cruciate ligament (PCL).

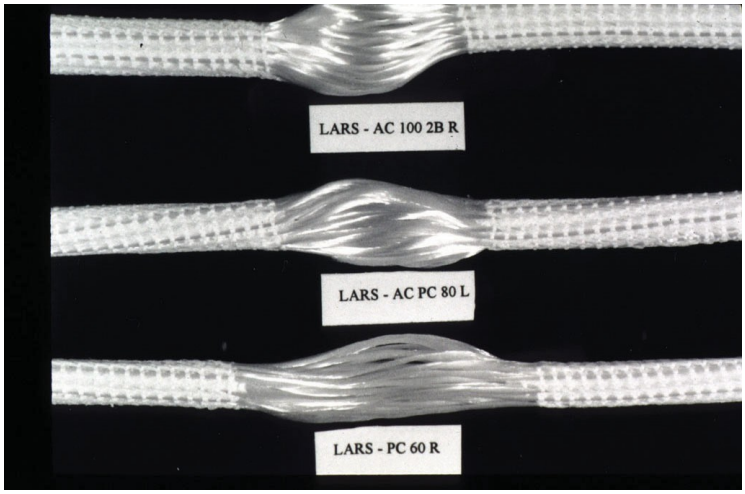

Figure 0.1. LARS® artificial ligaments

1.2 Surgical technique

1.2.1 Placement of the guide pin

After arthroscopic evaluation of the knee joint and assessment of the ACL tear, the technique described by Laboureau [13] is used. With the knee in flexion, a double-pointed K-wire is inserted via an antero-medial portal, aiming at 10 o'clock for the right knee or at 2 o'clock for the left knee and driven just anterior to the over-the-top position in front of the femoral posterior cortical bone. Fluoroscopy is used to check its location. It then goes through the femur and exits the anterolateral skin. The motor is switched to the proximal part to move it further proximal until the distal end of the pin is intra-articular. The knee is brought back to 45 degrees and the pin is driven distally through the posterior tibial insertion of the ACL, just behind the middle of the tibial plateau on a fluroscopic lateral

view. It then goes through the tibia and exits the antero-medial skin. The cannulated drill is passed over the guide pin in the tibia and the femur.

Figure 0.2. Mini C-arm is used to check location of the K-wire

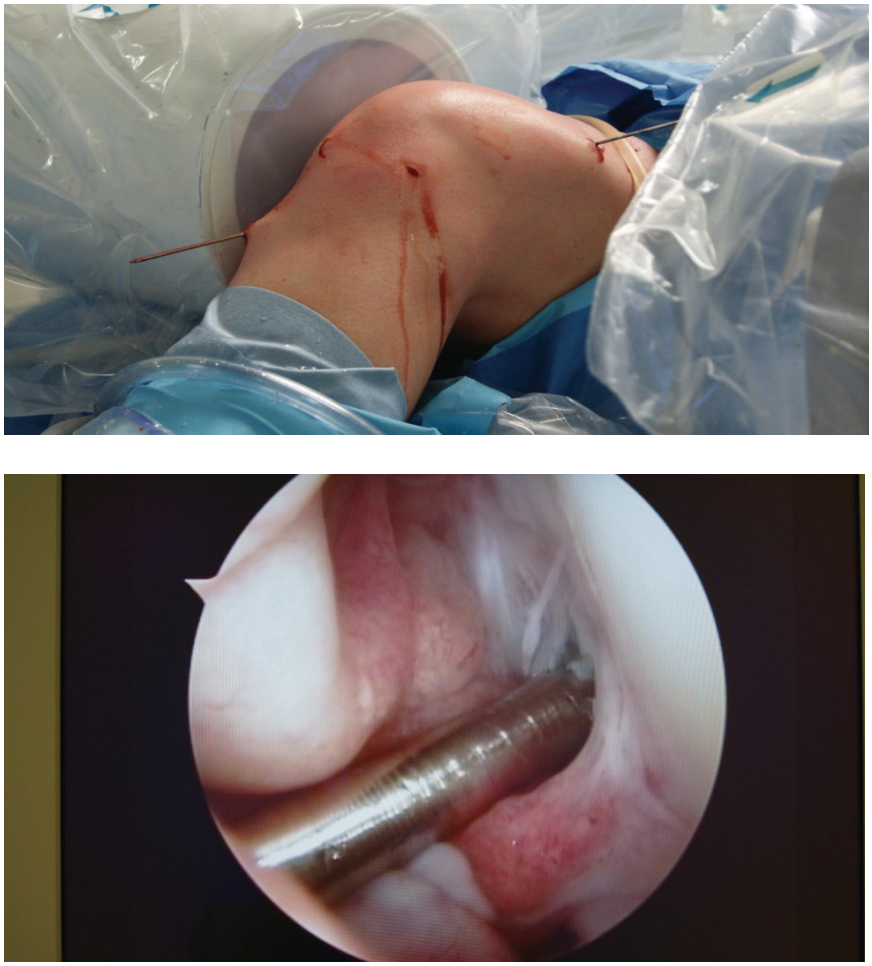

Figure 0.3. Final position of the guide pin

1.2.2 ACL repair

The ACL remnant is stitched to the femur with three or four 2-0 non-resorbable sutures with the Arthrex® Meniscal Viper. Then the LARS® ligament is passed through the tibial and femoral tunnel posterior to the ACL remnant. The LARS® and the sutures are fixed with outside-in metal screws.

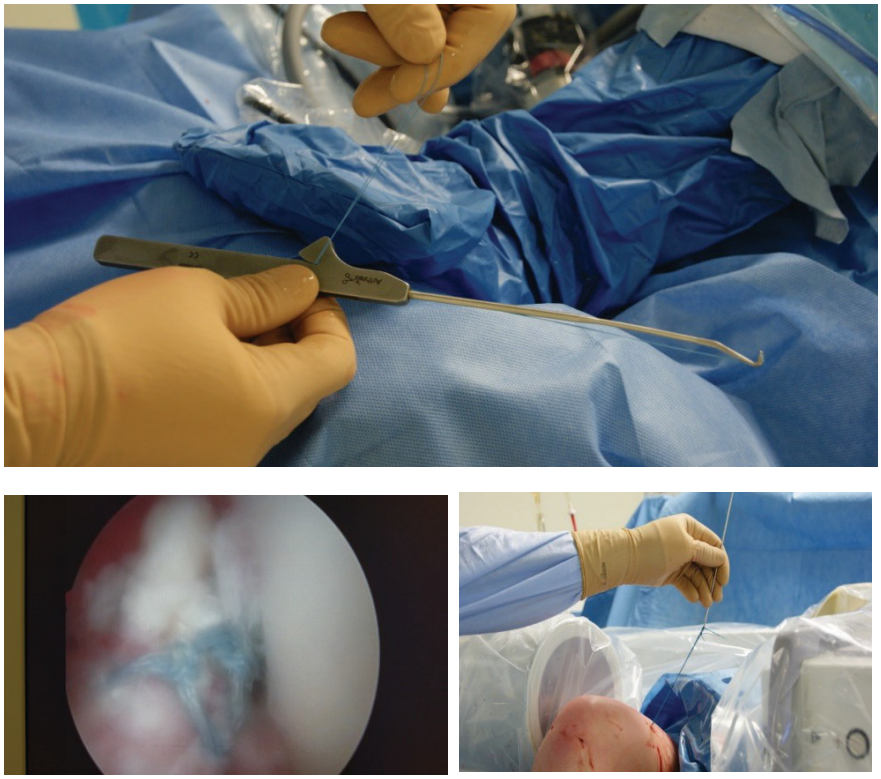

Figure 0.4. ACL repair Arthrex® Meniscal Viper

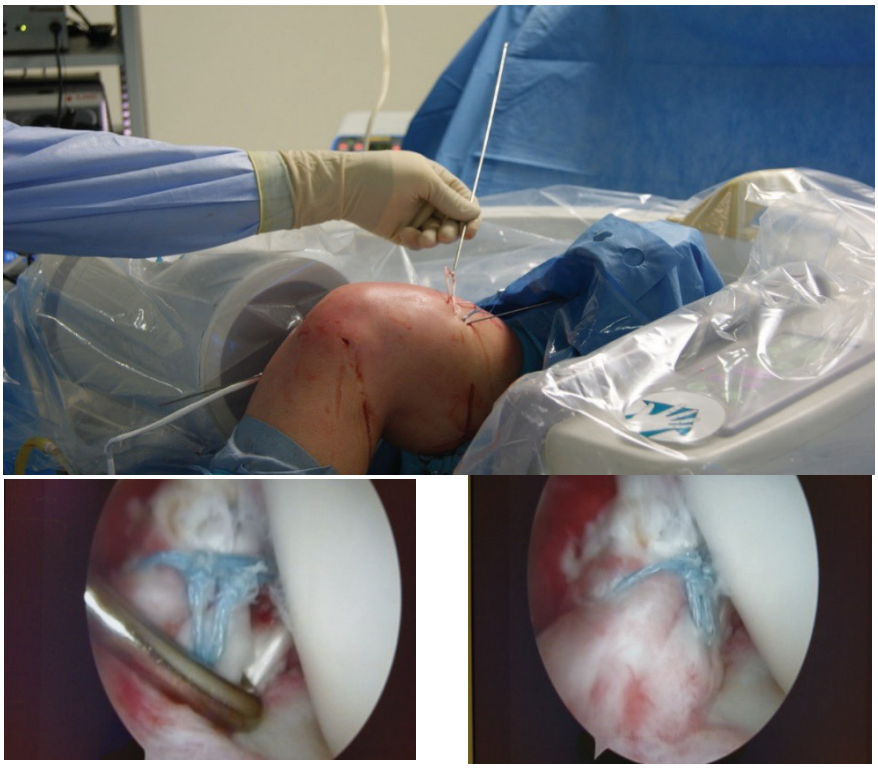

Figure 0.5. LARS® augmentation through tibial and femoral tunnels

1.2.3 Postoperative Protocol

Postoperatively, all patients used crutches weight bearing as tolerated. They are allowed immediate motion without a brace. They are starting physiotherapy at 2 weeks focusing on closed kinetic chain exercises. They are allowed running in straight line at 2 months, figure of 8 at 3 months and hard pivot at 4 months. Return to specific training is started at 4 months and competing is allowed at 6 months.

1.3 Results

Patient satisfaction was high and most patients demonstrated a significant improvement of their knee after surgery [7,8]. The results compared with ACL reconstruction using a standard autograft or allograft technique. Our technique obviously avoids potential graft harvesting complications such as patellar fracture, anterior knee pain, hamstring weakness or rupture of the remaining tendon(s), and potential allograft reduced healing, rejection, and disease transmission [14,15,16,17,18,19]. Full range of motion was the norm, the most common complaint being occasional residual pain around the tibial screw. No patient experienced knee synovitis.

Failure rate was a little less than 10 %. Half of the failures were not related to a new injury and all occurred within two or three years after repair. Not one knee failed beyond 4 years. In all cases the rupture was between the ACL-LARS® structure and the femoral tunnel. Revision surgery using fluoroscopic guidance was usually easy as bone grows on the outer surface but never inside the LARS®. It was easy to pull it out when the screws were removed. The tibial and femoral tunnels, usually 6 or 7 mm wide, were intact and easily enlarged to adapt the new reconstruction graft. Finally, all usual autograft tendons were available for the revision procedure

1.4 Discussion

The analysis of the outcomes in patients afflicted by an ACL sub-acute rupture proved fascinating. A constellation of elements concurs in certain patients treated conservatively to produce satisfactory results whereas in others, the evolution leads to chronic instability and thence to surgery. Once an ACL has ruptured, the purpose of surgery in the sub-acute stage is the stabilization of a not yet unstable knee, to prevent instability, should the conservative treatment fail. Yet, however abundant the published material devoted to the ACL, the lack of knowledge concerning the proprioceptive factors conducing to a functional stability despite a ruptured ACL, it is impossible to conceive a selective, objective prevention of instability. The orthopaedic surgeon is limited to a subjective experience-based prevention.

As Dye proposed [20], the goal of treatment is to maximize a knee's envelope of function as safely and predictably as possible and encourage patient to stay within the range of loading the knee can accept. The natural history of a ruptured ACL is still not clear. Surgical stabilization of a knee which would remain stable after a conservative treatment represents an unnecessary surgery which submits the patient to the complications that may ensue.

A meta-analysis of the literature demonstrates the extent to which the emphasis is directed towards technical surgical details as well as toshort-term outcomes [21]. Few prospective randomized studies have looked at the long-term functional impact. Moreover, data analysis is complicated by a lack of uniformity in reporting of the results, by many patients being lost to follow-up and by the fact that treatment success or failure - asassessed by the surgeon - does not necessarily match that of the patients[7,22].

Long-term ACL reconstruction revision rates have ranged from 5 to 15% [23]. An australian prospective study documented autograft rupture rate of 17 % for hamstring tendon and 8 % for patellar tendon at 15 years [24]. Young cadets at the United States Military Academy (USMA) who undergone ACL reconstruction before entrance to service experienced a failure rate of 12 % following autograft reconstruction and and 44 % following allograft less than two years on average from matriculation [25].

Many past reports disapproved of the utilization of artificial ligaments [26,27,28]. Our experience support the view that an appropriate implant, like the LARS®, supporting ACL healing can provide good results while ACL prosthetic replacement, the presumed role granted artificial ligaments in the past, is unable to offer adequate biofonctionnality and biodurability [29,30]. LARS® ligaments, made of «de-enzymized» polyester, set in multiple intra-articular fibres may be better tolerated than other materials such as carbon fibres and other textile structures like braids. Clinical synovitis, occasionally reported by other surgeons [31], was not observed in our practice, although one cannot exclude microscopic alterations of the synovial membrane. Early stabilization of the knee may favour protection from the mechanoreceptors and the secondary stabilizers of the knee, during the critical period identified as the first two years, when most of the failures take place.

Based on our results, we continue to believe that the future lie in helping the repair and healing of the ACL. The development of bioactive ligaments [32] to enhance cell growth, where nanofibers of polyethylene terephthalate (PET) and bioactive groups attached on the synthetic ligament can link the growth factors, the adhesive proteins, the type I collagen and the fibroblasts is in progress. Other ACL repair techniques were recently developed adding local factors enhancing the biological repair process [33,34,35,36] or using a synovial graft wrap around the repair [37]. The traditional ACL surgery is still an autograft reconstruction but that may change in a near future.

1.5 Conflict of interest statement

Dr Duval LARS® work was supported by a grant from LARS, 5 rue de la Fontaine 21560 Arc sur Tille, France. LARS was not involved in the study design, in the collection, analysis and interpretation of data, in the writing of the chapter and in the decision to submit this chapter for publication.

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