

Current trends in Anterior Cruciate Ligament reconstructions

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Abstract

The rupture of the Anterior Cruciate Ligament (ACL) is a common complication of knee trauma. Arthroscopic ACL reconstructive surgery is the method of choice in most of these cases. This is an increasingly common procedure due to low invasiveness, good treatment results and a constantly growing number of operators able to perform them.

The aim of the study is to review currently used methods for the reconstruction of the Anterior Cruciate Ligament. There are many types of transplants, and the choice depends on individual factors (including gender, age, occupation, physical activity) and the patient's expectations. The operator's

skills and preferences also determine the choice of therapy. Considering the above-mentioned aspects, authors of the study will analyze ACL reconstruction methods based on the latest literature.

Currently, the basic treatment of ACL injuries are arthroscopic procedures. Due to the various types of transplants, the procedure, result and complications may vary depending on the choice. An autograft is the preferred treatment for this injury. Autografts that are preferred are the ligaments of the semitendinosus muscle and the patellar tendon. Less frequently used autografts include ligaments of the quadriceps muscle of the thigh and gastrocnemius muscle (Achilles tendon). Another type of transplant is an allograft. The graft is taken from a donor (a deceased donor in cases of ligament transplants). It is less frequently used due to its high cost, lower strength compared to an autograft and a greater number of complications. The third type of transplants are synthetic grafts. These are fibers made of materials such as Gore-Tex. Synthetic grafts are also rarely used for the same reasons as allografts. Internal Bracing (IB) is becoming a more popular procedure. This method allows you to re-attach broken ligaments in their original position. This is possible if only one end of the ligament is broken. An important issue is the number of bundles (single-bundle, double-bundle), the position and the type of attachment (titanium screws, absorbable, endobutton).

The final choice of the treatment method depends on the operator's skills and preferences.

Introduction and the purpose of the paper

The rupture of the Anterior Cruciate Ligament (ACL) is a common complication of a knee trauma. Usually, young, physically active people and pro athletes suffer from it. In this paper authors will attempt to outline recent trends in ACL reconstruction.

In a relation to the level of a rupture, three types of ACL trauma has been found:

Type I: Strained ACL with stable knee joint.

Type II: Strained or partially ruptured ACL. Instability of knee joint may occur.

Type III: Complete rupture of ACL to two separate fragments with knee joint instability. The most common type [1].

A surgical reconstruction of a ruptured ACL is the most common practice in type III and sometimes type II injury [2]. The torn ligament is replaced with either autograft (semitendinous or patellar ligament) allograft from the dead donor or with synthetic graft. The last two types of grafts are recently not commonly used due to high costs and overall worse outcomes in comparison to autografts [4]. A new trend that is recently getting more and more attention is using so called “Internal Bracing” in order to attached torn ACL to its origin on the condyle. To perform this type of operation it is essential that only one end of the ligament is detached from its insertion.

Authors' main focus in this paper is to outline the most common ACL reconstruction techniques, that is reconstruction with semitendinous ligament and patellar ligament.

Current state of knowledge

Anatomy of the ACL

Ligamentous complex of a knee consist of inner and outer parts. The latter strengthens synovial capsule and the former (ACL, PCL and meniscal ligaments) prevents from excessive rotational movements and in sagittal plane. Authors will concentrate mainly on the ACL due to the topic of this paper.

The superior origin of the ACL is located in a central part of the lateral femoral condyle. The inferior one inserts to the medial part of tibial eminence, next to the frontal horn of a lateral meniscus. ACL consist of two bundles, frontolateral and posterolateral. Both of them play a different role during knee movement.

Frontolateral bundle is fixated to the intercondylar fossa of the femur and on the tibial end next to frontal horn of lateral meniscus. The posterolateral bundle lies next to the border of femoral condyle cartilage and posteriorly to the latter bundle on the tibial end [2,3].

The shape of the ACL is oval-like. It has a profound impact on a knee stabilization during flexion, extension and rotation of the knee. The nerves, collagen fibers and mechanoreceptors located inside this ligament are responsible for proprioception. In a brief summary, an ACL prevents knee joint from dislocation in a sagittal plane, excessive flexion, extension and rotational movements [9].

In order to qualify a patient to an operational reconstruction of ACL physician is obliged to collect medical history, perform physical examination and refer the patient to get USG, or more favorably, of the affected knee [5].

Another important factor is the proper timing of the operation. Both immediate and delayed reconstructions have pros and cons. Some of the clinical aspects such as swelling or restriction of movement are taken under the consideration when deciding about the right timing.

An early reconstruction, that is up to three weeks after injury increases the risk of developing arthrofibrosis of the knee [7].

The strength of the quadriceps muscle below 80% of the initial strength prior to injury seems to be related with worse outcomes 2 years after the operation [8]. Therefore, prior to the operation the quadriceps strength should be at least 80% of the initial strength [8]. The delayed reconstruction (3-52 weeks) creates lower risk of arthrofibrosis, however, there is a significant risk of meniscal, cartilage and collateral ligaments injuries, especially after 1 year from the ACL rupture [6,7]. Taking under consideration pros and cons of early and delayed procedures, the early reconstruction is proved to be the better option.

In combination with early and intensive physiotherapy it reduces the risk of arthrofibrosis, results in greater flexion and extension, the recovery time is shorter and the risk of articular elements damage is smaller [6,7]. After qualifying patient to the operation a decision has to be made regarding the number of graft bundles. Recently, the double-bundle graft is being used more often, since it is believed to reconstruct the anatomical two-bundle ACL. It has been proven that this type of graft provides better stability during rotation and lesser displacement in sagittal plane. Additionally, the recovery time is shorter in comparison to one-bundle surgery. On the other hand, the duration of two-bundle surgery is significantly greater and is associated with higher risk of many complications, especially when a reoperation is needed [4,9].

Graft fixation methods

There are many types of graft-fixating devices. Due to that, the best method can be chosen, taking under consideration factors such as bone density. Graft can be fixated inside or on the outside of the tunnel. There are no major differences in effectiveness between those methods, however, graft fixation on the inside has been found more preferable by the patients in terms of overall satisfaction. Another important issue is the type of fixating screw. The most popular being used are metal and resorbable.

Both of them have similar therapeutic results, nevertheless, metal fixating screws have been proved to cause more post-op complications, for instance, haemarthrosis or widening of the graft tunnel.

As far as the method of graft fixation is concerned, there are several important types that are to be presented. First of them is interference screws system. It is one of the most popular, since it can be used with both semitendinous and patellar tendons and also it is suitable for both femoral and tibial tunnel [12].

Next one is Suspensory fixation, of which Endobutton is the most commonly used nowadays [6]. There is no evidence that interference screws system is superior to Endobutton and vice versa. Complications are similar in both methods and some of them are fixation outside the bone tunnel or migration towards the joint cavity.

EzLoc is a metal fixation system composed of the loop and the lever adjusted at a proper angle. The lever lies on the cortical bone and provides rigid fixation, whereas the loop is connected to the graft. Some of the other fixation systems that are also currently used by the orthopaedic surgeons are, for instance, Linx, Bone Mulch Screw or WasherLoc. Nevertheless, thorough description of all of them extends beyond the capacity and the purpose of this paper.

Patellar tendon and Semitendinous tendon grafts

The most crucial decision that is to be made before ACL reconstruction is the selection of the most

suitable graft type. The most commonly used are patellar tendon and semitendinous tendon (so called “hamstrings”). There have been conducted a plethora of studies that compare those grafts in terms of durability, comfort of the patient, functionality, pain after the procedure and complications [4]. According to those studies, both of those grafts can provide similar therapeutic results. However, after using patellar tendon as a graft, anterior knee pain during squatting or kneeling has been reported in many studies [7].

Therefore, if there is anterior knee pain reported in patient’s medical history, it is advised to dismiss patellar tendon as a graft source. As far as hamstrings are concerned, it has been proven that semitendinous tendon is not the best choice of graft type when simultaneously ACL and medial collateral ligament were ruptured [14]. One of many advantages of semitendinous graft is the fact that it can be folded into two or even four parts. It obviously results in grater thickness, therefore, it can be adjusted and preferable diameter of graft can be obtained. Nonetheless, there has not been proven a correlation the thicker the graft the more durable it is. On the other hand, it has been presented in many studies that two times folded semitendinous grafts results in better KOOS score than four times folded and are associated with fewer pain symptoms [15,16].

Summary

Choosing the most suitable method of ACL reconstruction is obviously a tough challenge. What really makes it difficult is the fact that majority of the ACL injuries are associated with other traumas such as meniscal injuries. It clearly affects the steps in the therapy and rehabilitation and can alter final results. Bearing in mind that delayed operations may result in further meniscal injuries or rapidly progressing knee arthrosis, the decision about operational ACL reconstruction should be made rather expeditiously. Withdrawal from the operation results in meniscal injuries in about 40% of patients 12 months after injury and in 80% after 10 years [17].

As it has been previously stated, patients with ruptured ACL are usually young people that are physically active or even pro athletes. It comes as no surprise, that they clearly expect full recovery, given that they decide for an operative ACL reconstruction in combination with comprehensive rehabilitation.

Despite of many graft types currently available, the most commonly used are definitely one bundle grafts made of either semitendinous or patellar tendons. Two bundle grafts has been proven to result in worse outcomes. They are less cost effective and elongate the duration of the procedure.

Nonetheless, there is no one superior technique to all of the others. What seems to be crucial are the surgeon abilities combined with his experience and identifying unique characteristics of injury of every single patient.

References:

1. Pawiła M, Kałużny K, Kałużna A, Hagner W, Zukow W. Proceedings physiotherapy in damage to the anterior cruciate ligament. *Journal of Education, Health and Sport*. 2017;7(6):77-87. eISSN 2391-8306.
2. Reicher M, Bochenek A: *Anatomia człowieka*. Wyd. 8. T. I: *Anatomia ogólna. Kości, stawy i więzadła. Mięśnie*. Warszawa: PZWL, 2008. ISBN 9788320038460.
3. Drake RL, Vogl AW, Mitchell AWM: *Gray: Anatomia*. Wyd. III. T. 1. Wrocław: Edra Urban & Partner, 2008. ISBN 9788365373595.
4. Vaishya R, Agarwal A, Ingle S. Current Trends in Anterior Cruciate Ligament Reconstruction: A Review. *Cureus* 7(11): e378. DOI 10.7759/cureus.378.
5. Czyrny Z: MRI diagnostics of cruciate ligaments, Carolina Medical Center, Warszawa.
6. Mayr HO, Weig TG, Plitz W. *Archives of Orthopaedic Trauma Surgery*. 2004 Oct; 124(8):518-22.
7. Smith TO, Davies L, Hing CB, *Knee Surgery Sports Traumatology Arthroscopy*. 2010 Mar; 18(3):304-11.
8. Eitzen I, Holm I, Risberg M. *A British Journal of Sports Medicine*. 2009 May; 43(5):371-6.
9. Anderson MJ, Browning WM, Urband CE, Kluczynski MA, Bisson LJ. A Systematic Summary of Systematic Reviews on the Topic of the Anterior Cruciate Ligament, State University of New York at Buffalo, Buffalo, New York, USA.
10. Mandal A, Shaw R, Biswas D, Basu A. Transportal versus transtibial drilling technique of creating femoral tunnel in arthroscopic anterior cruciate ligament reconstruction using hamstring tendon autograft. *Journal of the Indian Medical Association*. 2012 Nov; 110(11):773-5.
11. Ilahi OA, Nolla JM, Ho DM. Intra-tunnel fixation versus extra-tunnel fixation of hamstring anterior cruciate ligament reconstruction: a meta-analysis. *Journal of Knee Surgery*. 2009;22:120-129.
12. Sharpa JW, Kanib KK, Geec A, Mulcahy H, Chewa FS, Porrinoa J. Anterior cruciate ligament fixation devices: Expected imaging appearance and common complications: *European Journal of Radiology* 99 (2018) 17-27.
13. Domnick C, Raschke MJ, Herbolt M. Biomechanics of the anterior cruciate ligament: Physiology, rupture and reconstruction techniques. *World Journal of Orthopedics*, 2016 February 18; 7(2): 82-93 ISSN 2218-5836.
14. Paschos NK, Howell SM. Anterior cruciate ligament reconstruction: principles of treatment. *EFORT Open Reviews*. 2016;398-408. DOI: 10.1302/2058-5241.1.160032.
15. Piech P, Polak P, Koziół M, Rasoul K, Koziół J, Neścior M, Łuczyk R. Comparison of treatment outcomes in isolated injuries of anterior cruciate ligament (ACL) and injuries of ACL connected with damages of menisci, conducted with use of KOOS scale. *Journal of Education, Health and Sport*. 2017;7(4):29-37. eISSN 2391-8306.
16. Piech P, Polak P, Koziół M, Obierzyński P, Staśkiewicz G, Neścior. The influence of thickness of ACL tendon graft on long-term results of treatment. *Journal of Education, Health and Sport*. 2018;8(02):214-230. eISSN 2391-8306.
17. Levy AS, Meier SW. Approach to cartilage injury in the Anterior cruciate ligament deficient knee. *Orthopedic Clinics of North America*. 2003;34:149-167.