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Injuries of the Anterior Cruciate Ligament (ACL): What is State of the Art?

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Verletzungen des vorderen Kreuzbandes: Was ist state of the art?

Zusammenfassung. *Grundlagen:* Das vordere Kreuzband ist das am häufigsten verletzte Ligament des menschlichen Kniegelenkes.

Methodik: Dieser Review-Artikel setzt sich mit dem derzeitigen Standard der Behandlung von Verletzungen des vorderen Kreuzbandes auseinander.

Ergebnisse: Die Reinsertion des vorderen Kreuzbandes hat sich nicht bewährt. Derzeitiger Standard ist die Rekonstruktion entweder mittels Patellasehnentransplantat (BTB) oder mittels Semitendinosus-Gracilis Transplantat (STG).

Schlussfolgerungen: Rupturen des vorderen Kreuzbandes sollten beim sportlichen Patienten rekonstruiert werden, um Sekundärschäden des Kniegelenkes zu vermeiden. Das STG Transplantat erscheint, aufgrund der geringeren Komplikationsrate und der geringeren Morbidität an der Entnahmestelle (wie z. B. Knieschmerzen nach BTB) von Vorteil zu sein. Für Leistungs- und Spitzensportler jedoch, die so rasch als möglich wieder in den Wettkampfsport zurück wollen, ist sicherlich das Patellasehnentransplantat, aufgrund der raschen Einheilungstendenz, von Vorteil.

Schlüsselwörter: Vorderes Kreuzband, Lachman Test, vordere Schublade, Patellasehnen-Transplantat, Semitendinosus-Gracilic Transplantat, Arthrofibrose, Rehabilitation.

Summary. *Background:* The anterior cruciate ligament (ACL) is the most commonly injured ligament in the knee. However, there is an ongoing debate of when and how to fix an ACL rupture.

Methods: This article reviews common treatment methods of ACL ruptures.

Results: Reinsertion of the ACL does not appear to result in proper ligament healing. There are two methods to reconstruct the ACL: patellar tendon grafts (BTB) and semitendinosus-gracilis grafts (STG).

Conclusions: Ruptures of the ACL should be treated in active people as they require a stable knee. STG grafts seem to have an advantage compared to BTG grafts as far as postoperative pain and complications are concerned. However, competitive athletes will require a BTB, as this graft allows an earlier come-back compared to the STG graft.

Key words: Anterior cruciate ligament, Lachman test, anterior drawer test, patella tendon graft, semitendinosus-gracilic graft, arthrofibrosis, rehabilitation.

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Introduction

Injuries of the anterior cruciate ligament (ACL) are among the most common ligament injuries and are the most common major knee injuries occurring in athletes. Over the last 15 years, ankle sprains have decreased by 86 % and tibia fractures by 88 %, but knee ligament injuries have increased by 172 %. The mechanism of injury is often noncontact, deceleration, valgus and external rotation injury [1, 2, 3]. The ACL is the most extensively studied ligament in the body. Since 1970, more than 2000 basic science and clinical studies have been published dealing with this ligament. However, there is still an ongoing debate whether to treat ACL injuries immediately or treat ACL injuries at all. A further question is the treatment of ACL injuries in children.

This review article intends to give you an overview of injury mechanism, examination techniques and treatment options.

Anatomy

The ACL arises from an elliptical area on the postermedial aspect of the lateral femoral condyle. It passes forward, downward and medially to the anterior intercondylar area of the tibia and inserts directly in front of the medial intercondylar tubercle. It is intimately attached to the anterior horn of the lateral meniscus. The tibial attachment of the ACL is more secure than the femoral attachment, since it occupies a wide, depressed area anterolateral to the anterior tibial spine. This explains why most of the ruptures are localized at the femoral attachment. The ligament consists of two fiber systems known as the smaller antero-medial bundle and the larger, bulky postero-medial bundle. These bundles intertwine in their in-

Fig. 1. The Lachman test is a clinical test with high sensitivity in the hands of the experienced examiner. Residents should therefore examine every knee properly, step by step, even when no ACL injury is suspected, to get the feeling for a normal and a pathological Lachman.

Fig. 2. The Posterior Drawer Sign, a posterior translation of the tibia in a 90-degree flexed knee indicates a rupture of the posterior cruciate ligament (PCL).

traarticular course, resulting in a triangular area of insertion in the anterior intercondylar area.

In the extended knee, the anterior side of the antero-medial bundle limits further extension by engaging against the roof of the intercondylar notch. As the knee is flexed, the bundles twist around each other, the postero-medial bundle rotating beneath the antero-medial bundle [3].

The blood supply to the anterior cruciate ligament is classically attributed to vessels entering the intercondylar notch near the femoral attachment, but more recently a significant and more important contribution from anterior vessels in the soft tissues and synovium from the region of the retropatellar fat pad has been described [4].

Mechanism of Injury

ACL ruptures are often the result of rotational injuries (forced external rotation of the body, with the foot fixed to the ground, ski etc; flexion-valgus-external rotation in skiers) and of hyperextension injuries (not as common as rotational injuries).

Examination of the Knee

The examination starts with the history of the accident. The main question guided at the patient should be "Describe what happened to your knee". If the patients talks about a torsional injury, when his leg was stuck to the ground, and he maybe even heard a pop or cracking noise, you have a clear idea that a rupture of the ACL is highly probable. Another mechanism of injury is the flexion-valgus-external rotational mechanism in skiers, as well as the mechanism of hyperextension. If the patient keeps telling you that he had the sensation that something tore in his knee, believe him!

The next step is inspection. You are interested in the amount of soft tissue swelling as well as where the swelling occurs. Before I start the physical examination I always examine the other knee. This gives me an impression of ligament laxity and range of motion, but also shows the patient that the examination is going to be less painful than expected. During the examination I continuously explain what I am going to do next as I do not want to frighten the injured patient. An injury of the ACL is defined by either the Lachman [1] or the Anterior Drawer Test (Fig. 1).

The Anterior Drawer Test may be done with the leg hanging or with the examiner stabilizing the lower leg with the knee in 90-degree flexion. The Anterior Drawer Test is far less specific compared to the Lachman test and painful in acute injuries. However, it is important to place the knee in a 90° position to recognize a Posterior Drawer Sign, indication of a rupture of the posterior cruciate ligament (Fig. 2).

The Lachman test is an active antigravity test that requires the patient to be relatively relaxed. It is especially useful when the knee is swollen and painful. The patient's thigh should be placed on the thigh of the examiner. While pressing the patient's thigh down against his own thigh, the examiner grasps the proximal lower leg and pulls it forward to test the amount of anterior tibial displacement. In the hands of the skilled examiner it is the most sensitive test, because it is minimally affected by hemarthrosis. Another advantage is the fact that it can be performed even in acute injuries with relatively little pain, because the slightly flexed position relaxes the muscles about the knee. This position also permits greater anterior translation than when the knee is flexed to 90° [3].

Some people also use the pivot shift test, which is aimed at combining translation with rotation. Lift the foot with the knee extended, internally rotate the leg, and apply a valgus stress to the lateral side of the leg. Slowly flex the knee while valgus and internal rotation are maintained. With the knee extended and internally rotated, the tibia is subluxed anteriorly. As the knee is flexed past approximately 30°, the ilio-tibial band passes posterior to the centre of rotation and provides the force that reduces the lateral tibial plateau on the lateral femoral condyle. One has to admit that most patients with acute injury, don't tolerate the pivot shift test. However, it is a good test to evaluate chronic instability of the knee.

The examiner should also pay attention to the medial and lateral collateral ligament as additional ligament injuries are quite common in ACL injuries (for example the

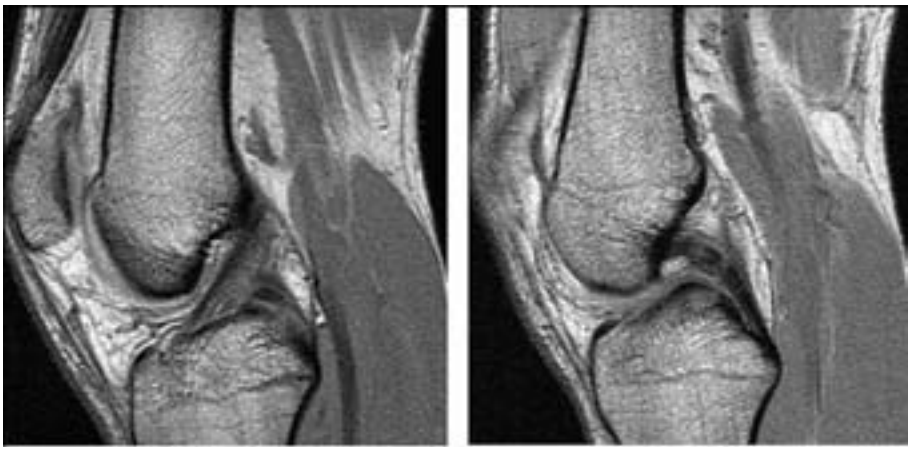

Fig. 3a. MRI of an intact ACL and PCL

Fig. 3b. MRI of an ACL rupture at the femoral insertion. It is typical that the ACL is not straight as seen in Fig. 2a, but seems to be loose.

"unhappy triad" consisting of injuries to the ACL, MCL and the medial meniscus). The collateral ligaments are best examined in 0° and 30° knee flexion. At 30° flexion pathologic laxity indicates MCL respectively LCL injuries. When varus and valgus angulation are applied with the knee at 0° flexion pathologic laxity indicates additional injuries of the medial or lateral posterior capsular injuries [2].

Always be aware that acute disruptions of the ACL are probably the most often undetected lesions in acute knee injuries!

Radiological Diagnosis

Native ap and lateral X-Rays are standard to detect bony injuries (osseous ligament avulsions, e.g. Segond fragments, etc.). MRI scans are indicated if concomitant injuries are suspected (ligament injuries, meniscal injuries, etc.). It may also help to diagnose an ACL injury if clinical diagnosis is difficult. However, ACL injuries are sometimes difficult to detect on MRI scans and the diagnosis depends on the experience of the radiologist (Fig. 3a and 3b).

Treatment

The treatment goal for all ACL injuries is restoration of functional stability and full motion while minimizing morbidity. Most patients who tear the ACL have high expectations and desire a rapid return to their preinjury state.

Conservative:

Nearly all of us know somebody who has good knee function, despite long-standing diagnosis of injury to the ACL. This leads some surgeons to the conclusion that there is no need to treat ACL injuries surgically. However, there is a tendency of patients with chronic knee instability to develop further injuries, especially of the medial meniscus as well as of the cartilage. Most surgeons would agree with the observation that anterior cruciate ligament ruptures are "the beginning of the end of the knee" [4]. With increasing instability, the shear forces across the top of the tibia increase, the meniscal cartilages tear, and the articular cartilage erodes. This erosion is the degenerative arthritis felt as grinding and pain, particularly when stair climbing, running or jumping are involved.

Operative

During the past three decades, as rotatory instabilities have become better understood, increased efforts have been made to repair, augment, or reconstruct the ACL. Primary repair did not work out well. This has led to a number of methods to augment or reinforce the primary repair, either by autogenous materials or by synthetic bands. The purpose of synthetic augmentation devices was to enhance the initial graft strength, to allow for immediate proper intraoperative tensioning of the graft and to provide for more secure fixation of the graft. Kennedy, dissatisfied with available autogenous and prosthetic procedures for anterior cruciate ligament re-

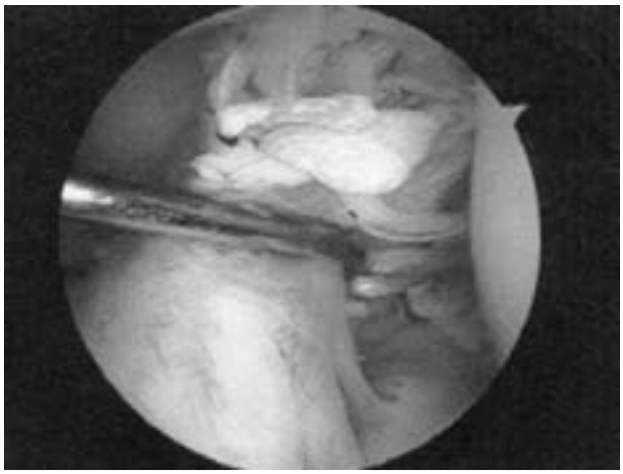

Fig. 4. ACL rupture at the typical location of the femoral insertion

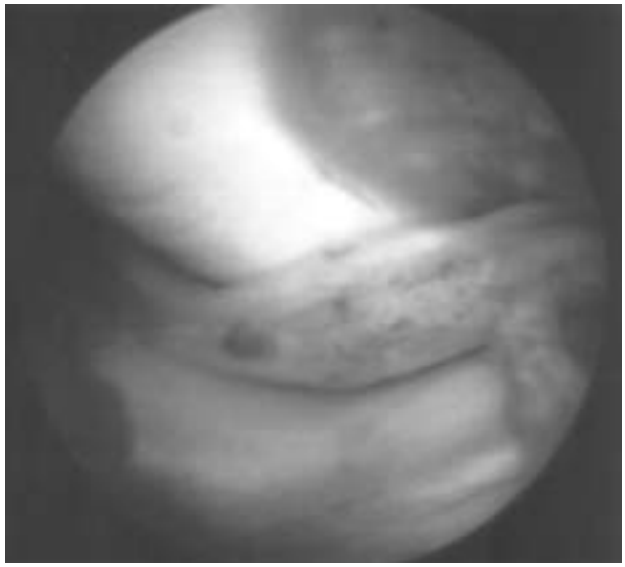

Fig. 5. Additional bucket-handle tear of the medial meniscus in combination with an ACL injury.

construction, developed the Ligament Augmentation Device (LAD). The results were quite good at some units, but did not work that well in most of the others. Not even the latest and improved version of synthetic augmentation bands (LARS) resulted in acceptable results, because of the tenous blood supply and the unpredictable healing of the ACL. I see the only indication for synthetic bands as prosthetic replacement in professional athletes, who sustain an injury to the ACL and need to be back within 10–14 days. These patients require a proper explanation that the chance of ligamentous healing is not very high for the ACL and that they might require a proper reconstruction (BTB or STG) at the end of the season. Another indication is for athletes who have had several operations before, and in whom you will not find autogenous material for ligament repair (another option is cadaver ligaments).

A special situation is the avulsion injury of the ACL where the tibial attachment of the ligament has been avulsed with a piece of bone from its tibial insertion. In these cases, an arthroscopy is suggested to clear the joint of blood clots, reduce the fragment and fix it with either screws or sutures.

All operations, whether an open or arthroscopic suture or reconstruction technique are performed, start with an arthroscopy of the knee to evaluate the localization and extent of the ACL rupture (Fig. 4), as well as further injuries (Fig. 5).

Fig. 6. After incision in the medial line, above the patellar tendon, a bone plug is removed from the tip of the patella using a small chisel. It is important to use the oscillating saw first to avoid fracturing the patella during this manoeuvre.

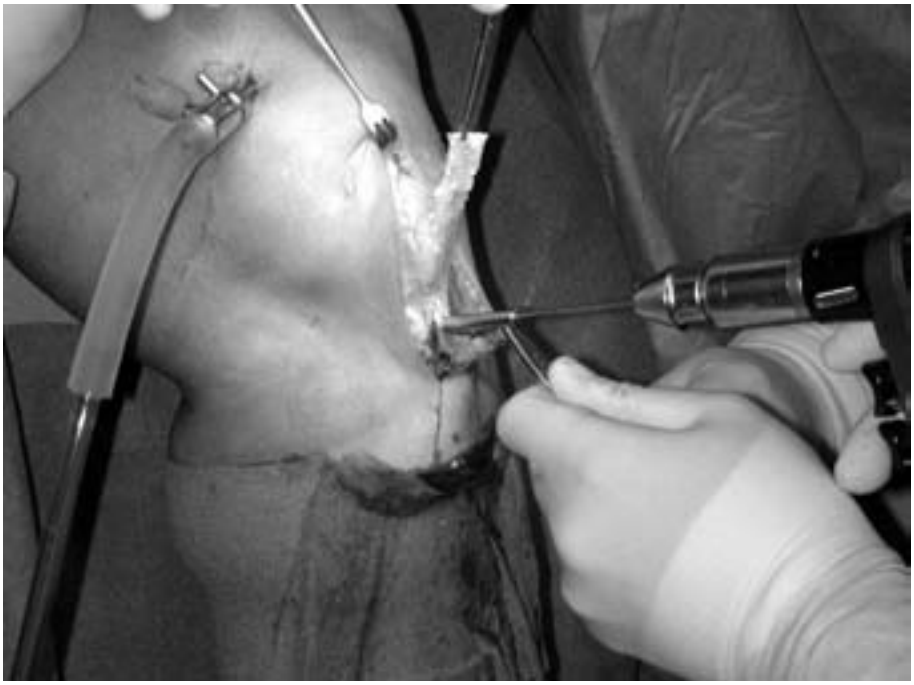

Fig. 7. Drilling the tibial bone plug. The patellar one has already been harvested.

Reconstruction

There are two grafts that are commonly used to replace a torn anterior cruciate ligament: the central-third patellar tendon graft (BTB) and the hamstring (semitendinosus/gracilis) tendon graft.

a) Patella Tendon Graft (BTB)

The patella tendon graft consists of a bone plug removed from the patella (Fig. 6), the tendon attached to this bone plug and another bone plug removed from the tibial insertion (= bone-tendon-bone graft, BTB). An oscillating saw is used, before the bone plugs are mobilised with a small chisel. It is advisable to make the drills in the bone plugs (for the sutures required to pull the BTB graft into the bone tunnels) before the plugs are harvested (Fig. 7). The bone plugs should not be too large, to avoid both fractures of the patella and anterior knee pain.

The size of the bone plugs is then measured. The bone plugs will need some modelling,and not exceed a diameter of 8–9 mm to avoid damage especially of the femoral tunnel.

The next step is the tibial tunnel, which is drilled from medial to the tibial tuberosity up to the tibial attachment of the ACL that has already been resected. The former attachment of the ACL is quite obvious, the guide wire should enter the articular joint in the middle of the insertion, about 5–8 mm in front of the posterior cruciate (Fig. 8). There are different guides helping the surgeon to find the optimal position for the tibial canal, most of them with an angulation of 50–60 degrees. If the bone plugs are of different size, choose the tibial canal as the bigger one.

It is mandatory to drill the femoral canal as exactly as the tibial one (Fig. 9). The exact location is about 5 mm from the posterior rim of the femoral notch, at an 11 o'clock position for the right knee, and a 1 o'clock position for the left knee. Correct tunnel placement is the most important step in the whole operation. Anterior tun-

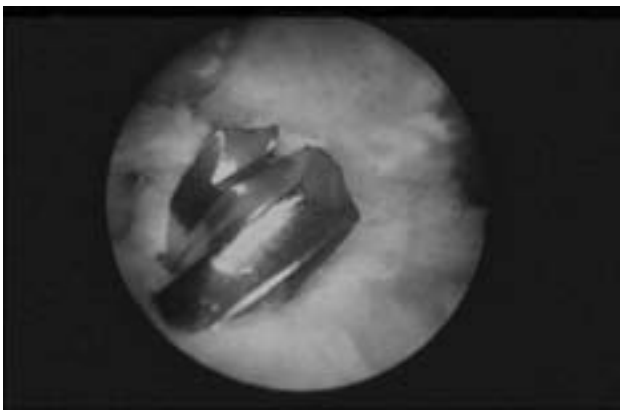

Fig. 8. It is important to watch the drill entering the articular joint to avoid injuries to the cartilage and soft tissues inside the joint.

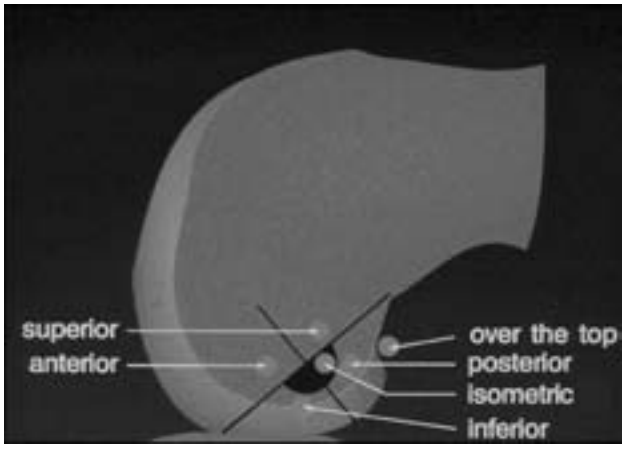

Fig. 9. It is important to drill the femoral tunnel exactly at the isometric point to avoid a limitation of motion.

Fig. 10. If using fluoroscopy to check the femoral position of your guide wire, note that the placement should be as posterior as possible, at the end of the Blumensaat line. You still have to check the position to be exactly at the 1 or 11 o'clock position, as you cannot check this by the lateral view of the image intensifier.

nel placement has been shown to cause graft impingement, leading to a loss of full extension – and possibly graft failure. Posterior tunnel placement will cause loss of full flexion. It is advisable to use guides to create the tibial and femoral tunnel – and if you are just at the beginning of learning the procedure, it is a good idea to

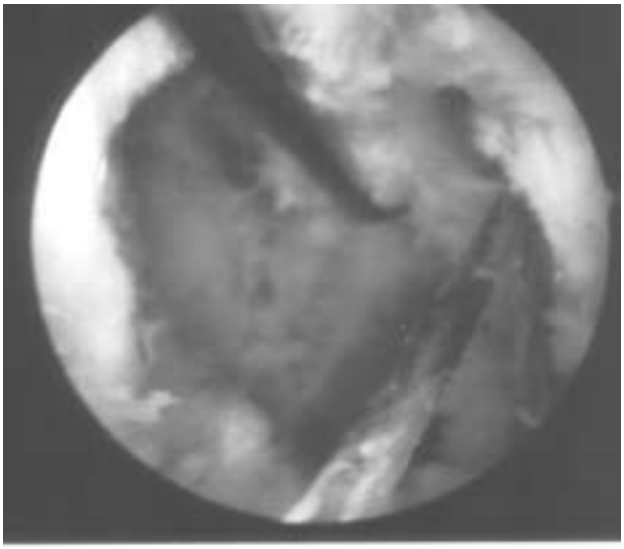

Fig. 11. Fig. 10 shows the femoral tunnel on the right side of the picture with sutures that are used for pulling in the graft. On the upper side of the picture we see a hook that shows the close relation of the posterior rim of the femoral notch to the femoral tunnel. The interference screws can break through the small bone bridge if the tunnel is too close to the posterior rim.

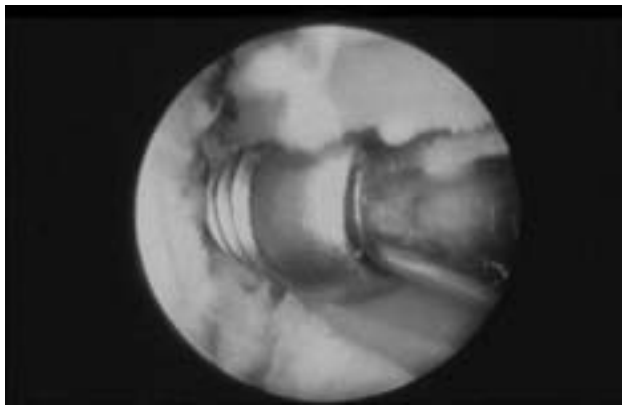

Fig. 12. The femoral interference screw is inserted with a protection sleeve that prevents the BTB graft from being injured when getting in the screw. The absence of the protection sleeve usually leads to destruction or discission of the BTB graft, compromising the whole operation.

check the position of the femoral K-wire with fluoroscopy (Fig. 10).

Make sure the width of the notch from the lateral border of the PCL to the lateral femoral condyle is at least 10 mm, when using a 10 mm BTB to accommodate the new ligament. A notchplasty needs to be performed if the ACL graft is larger than the native ACL.

Sutures are passed through the tunnels then, to pull in the graft (Fig. 11). Interference screws are used for fixation (Fig. 12). The graft will undergo fibrotic degeneration and will develop into a new ligament eventually (Fig.13).

b) Hamstring (Semitendinosus and Gracilis) Tendon graft (STG)

Gracilis and semitendinosus are harvested by an oblique or straight incision just above the hamstrings. The bursa of the Pes anserinus is opened. The tendons are found inside the wall of the bursa. I find it helpful to go in with a curved vessel clamp to mobilise and strip the

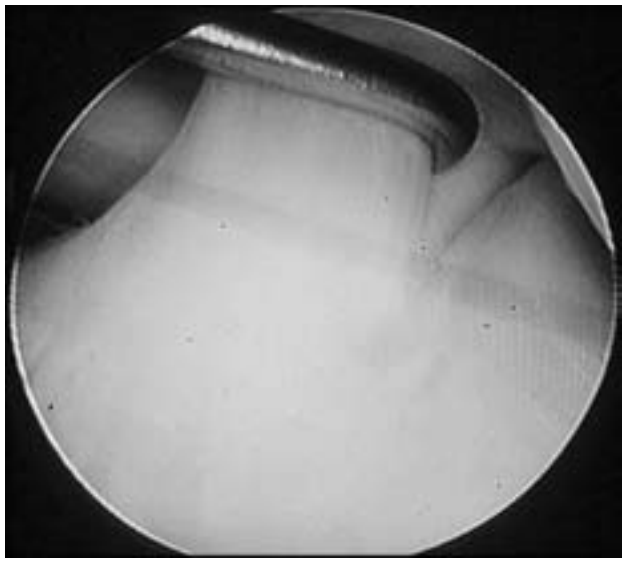

Fig. 13. BTB graft about five years after ACL reconstruction

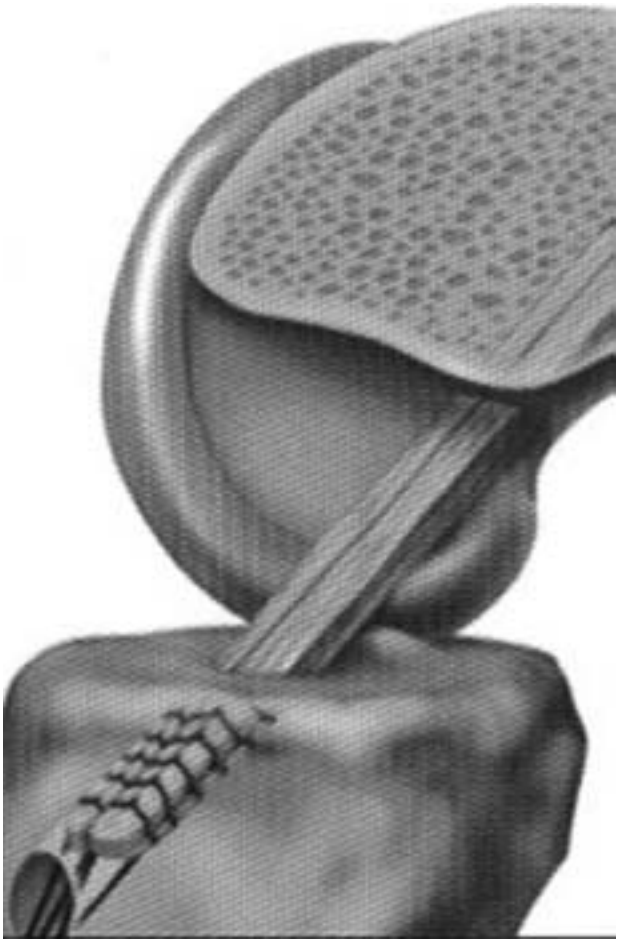

Fig. 14. The STG graft is inserted in the same way as the BTB graft

gracilis tendon first, then comes the semitendinosus tendon. The preparation of these tendons, especially of the semitendinosus one, has to be very carefully performed, trying to cut all the supplying vinculas of the tendons with scissors before trying to strip the tendon. Being careless will end up with you stripping only a short piece of the tendon, destroying the rest – and giving you a useless graft. However, with the required attention graft harvesting is easy.

I prefer a quadrupled STG graft, whose strength is greater than that of the original ACL. It is mandatory to put this graft under tension with a preload of 8 kg, to avoid elongation in the postoperative course. The STG graft should be under tension for at least 10–15 minutes. This gives you time to resect the torn ACL, have a look through the knee, searching for additional injuries and to drill the tibial and femoral tunnel in the same way as described above. The diameter of the tunnel should be as small as possible, allowing the graft just to be pulled in (measure the diameter of the graft before placing it under tension at the work-station). The graft is then pulled in (Fig. 14) and fixed either by interference screws, cross pins or endo-buttons. It is mandatory for the ingrowth of the STG graft to be in close contact with the bone walls. Widening of the femoral tunnel might occur if bone healing is delayed.

BTB versus STG

Considerable debate continues as to whether one or the other graft is preferable. Noyes and coworkers [5] stated that the patella tendon graft has a mean strength of 163–175 % of that of the normal ACL. The strength of this graft, as well as the strong immediate fixation of the bone plugs in the bony tunnels, with early bony healing, has been largely responsible for its popularity as an intraarticular ACL replacement during the past decade. Many authors, relying on the same source of information, stated that the BTB must be stronger – and therefore better than the STG.

Howell [6], on the contrary, showed that the gracilis and semitendinosus tendons when used in combination and double looped have an initial load-to-failure strength greater not only than the native ACL but also than a 10 mm patellar tendon autograft. Newer fixation techniques appear to be as strong as those used with patella tendon reconstruction. Tendon healing in the bone tunnels, however, will be slower than the bone-to-bone healing with patella tendon grafts, creating concern about subjecting the patients to an accelerated rehabilitation programme. However, initial pain after STG harvest is less compared to BTB harvesting, as hamstring tendon grafts neither need bone plugs (with corresponding bone defects) nor disruption of the extensor mechanism, theoretically decreasing or eliminating the morbidity associated with BTB harvest.

There have been four randomized clinical trials within the last few years finding no difference between the two graft types in terms of functional outcome. BTB grafts were associated with increased morbidity, increased anterior knee pain and pain on kneeling as well as with increased extension deficits [7–10]. One study looked explicitly at incidence and severity of pain on kneeling [10] and found a rate of nearly 70 % of pain on kneeling in the patellar tendon group, which was the most significant difference between the two groups. There is another problem with increased rates of possible patella fractures and ruptures of the rest of the patella tendon, although these complications do not occur too often. The advantage of the BTB is the fast ingrowth of the bone blocks in the bony tunnels, which allows faster rehabilitation and a faster return to competitive sports. The principal disadvantage of hamstring tendon grafts was increased anterior knee laxity, although it did not appear to be associated with any functional deficit. Some authors also found an increased incidence and severity of radiographic widening of the femoral tunnel in association with hamstring grafts. The clinical significance of this phenomenon remains unclear, as it did not correlate with graft laxity and functional outcome [10].

The decision which graft to use depends on the needs of the patients and is based on a serious discussion with the same. Patellar tendon grafts are preferable in patients who are active in competing sports and in those with loose knees. These patients need to consent that they are aware of an increased rate of anterior knee pain as well as pain at kneeling. Hamstring tendon grafts are preferable in all the other patients, which are the majority.

Fig. 15. The probing hook demonstrates the elongation of this insufficient ACL

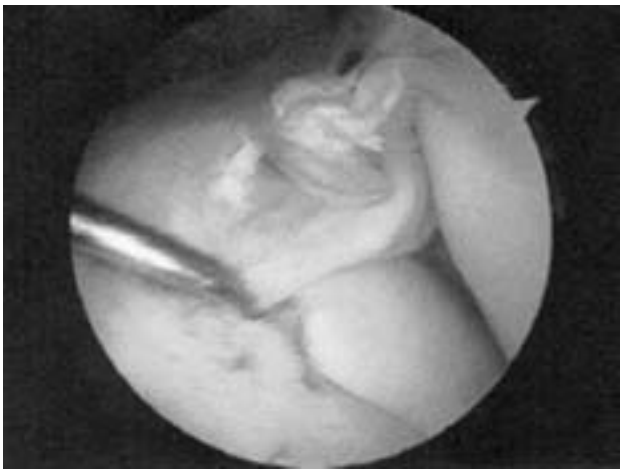

Fig. 16. This ACL seemed to be completely intact. However, after opening the synovial sleeve, ruptured parts of the ligament appear.

Arthrofibrosis and time of operation

Arthrofibrosis is a potential complication of acute ACL reconstruction [11, 12, 13], with loss of motion due to an excessive fibrotic response in the repair process. Clinical symptoms are pain, inflammation and restricted range of motion. The main reason for the occurrence of arthrofibrosis is an inflammatory reaction during the healing process of the knee. It is therefore forbidden to perform an ACL reconstruction during the vulnerable time, which is 10–42 days after the initial trauma. Some studies suggest that an ACL reconstruction should take place with 48 hours. If this is not possible, the patient has to wait for at least six weeks for ACL reconstruction, during which time he undergoes an extensive programme of rehabilitation. Some authors even suggest that an ACL should never be operated on in the acute situation. They are convinced that waiting to perform surgery until the patient has regained full range of motion, including hyperextension, not only minimizes the potential for postoperative stiffness, but allows a faster return of strength postoperatively, thus allowing an earlier return to sports [14]. I personally suggest having an arthroscopic look into the knee within the first ten days. If no signs of synovitis are obvious, I proceed with ligament repair, as early repair shortens the rehabilitation process significantly, and is therefore of advantage for the patient. However, the patient needs to know that with the slightest suspicion of synovitis, ACL reconstruction must be postponed for a minimum of six weeks. In cases of synovitis, I administer oral antiphlogistics for at least 10 days before I start the second operation six to eight weeks after the initial trauma.

ACL Elongation

There is a certain rate of incomplete rupture of the ACL and of ruptures, but without injury to the synovial sleeve of the ACL (Fig. 15). Some of these knees will become instable with time as the ACL will degenerate slowly; some, however, will heal showing a certain degree of laxity (Fig. 16). In the case of an elongated ACL a shrinking procedure with Arthrocare or electro-coagulation can be tried (especially in patients who do not want to undergo ACL reconstruction), coagulating the elongated ACL z-wise from proximal to distal. The results are not very convincing, with a success rate of less than 50 % in my experience, but it represents at least an attempt to avoid a significantly larger operation and pain for the patient.

ACL injuries in children

These injuries were long considered to be an ailment not to be treated, because of the fear of touching the growth plates, producing growth arrest and consecutive deformity. However, children and adolescents are participating in increasing numbers in competitive and recreational sports. Stanitski and coworkers [15] found that sports injuries were the cause of 70 % of acute hemarthroses in children. Tears of the ACL accounted for 63 % of these injuries. Aichroth and coworkers [16] observed a group of children treated conservatively, who developed progressive instability of the knee and deterioration in function. Few of these children were able to maintain their sporting activities. The authors therefore concluded that ACL deficiency of the ACL was not as benign as previously thought and decided therefore to be more aggressive and operate ACL injuries. More and more authors describe this problem with the young and active patient. Children do not generally accept refraining from sports and have a high incidence of consecutive injuries: meniscal tears, chondral lesions, ligament lesions [17].

Most surgeons in the past avoided drilling through the physes and used non-anatomical positioning for the grafts, often without drill holes to avoid injuries to the growth plates [16]. However, evidence from experimental animals suggests that more than 7 % of the physis has to be damaged to produce growth arrest [17]. An appropriate tunnel of 7 to 9 mm involves much less than 7 % of the physis.

The results of ACL reconstruction with hamstring tendons in children are quite good, problems with the open physis are rare and are usually surgical pitfalls [16, 18]. Suture techniques give insufficient results [18], other techniques (cross pins above the femoral physis, and screws below the tibial physis) are to be preferred.

Rehabilitation

The main idea of rehabilitation is to achieve early healing and good function without problems with range of motion because of capsular and ligament shrinking due to immobilisation. This is why braces should be avoided in the postoperative course if possible. There is no indication for a brace in the first weeks after ligament repair. The only indication is an intraoperative complication that requires more cautious mobilisation postoperatively than usual.

During the first ten to fourteen days after the operation cool packs should be applied to reduce swelling as well as continuous passive motion (CPM). The patient is taught to perform isometric exercises for the quadriceps at least three times a day, and to try lifting his legs several times a day while being at rest.

I suggest using crutches for at least fourteen days – and longer, until the gait cycle returns to normal. It is better for the patient to walk nicely with crutches than to limp without crutches. Limping is hard to get rid of – this is why we put great emphasis on gait cycle exercises and have the patient in for physiotherapy at least three times a week. But in future, most patients will not have a chance to receive such treatment due to cuts in social spending. I therefore suggest using additional private physiotherapy as often as possible. The patients need to be aware that postoperative physiotherapy accounts for 50 % of the treatment success.

Two weeks after the operation different treatment proceeds for the patients with BTB and STG. Whereas patients with BTB grafts will start with proprioceptive exercises and in-door cycling on ergometers two weeks after the operation, patients with STG grafts keep on with isometric exercises and gait-cycle training. BTB patients will start with jogging four to six weeks after the operation, will start team training about eight weeks after the operation, and will be back about twelve to fourteen weeks after operation. STG patients must be slowed down, although they feel usually better and have less pain compared to the BTB patients. However, bony ingrowth takes longer into the tendons than it takes for the bone plugs to heal. This simple fact makes it paramount that STG patients start cycling six weeks after operation, start jogging 12 weeks after operation, and go back into normal sports about six months after the anterior cruciate ligament reconstruction.

Conclusion

Ruptures of the ACL should be treated in people involved in sports as they require a stable knee. STG grafts seem to have an advantage compared to BTG grafts as far as postoperative pain and complications are concerned. However, competitive athletes will require a BTB, as this graft allows an earlier come-back compared to the STG graft.

References

1. Torg JS, Conrad W, Kalen V (1976) Clinical diagnosis of anterior cruciate ligament instability of the athlete. Am J Sports Med 4: 84–93
2. Feagin JA (2000) Physical examination of the knee. In: “Principles and Practice of Orthopaedic Sports Medicine”, Lippincott Williams & Wilkins, Philadephia, pp 613–622
3. Strobel MJ (1998) Manual of arthroscopic surgery. Berlin New York Tokio, pp 367–570
4. Miller RH (1998) Knee injuries. In: “Campell’s – Operative Orthopaedics”. St. Louis London Tokio, pp 1113–1299
5. Noyes FR, Butler DL, Paulos LE, Grood ES (1983) Intra-articular cruciate reconstruction. In: Perspectives on graft strength, vascularization, and immediate motion after replacement. Clin-Orthop 172: 71–77
6. Howell SM (1993) Arthroscopically assisted technique for preventing roof impingement of an anterior cruciate ligament graft illustrated by the use of an autogenous double-looped semitendinosus and gracilis graft. Opin Tech Sports Med 1: 58–65
7. Anderson AF, Snyder RB, Lipscomp AB (2001) Anterior cruciate ligament reconstruction. A prospective randomized study of three surgical methods. Am J Sports Med 29: 272–279
8. Aune AK, Holm I, Risberg MA et al (2001) Four-strand hamstring tendon autograft compared with patellar tendon-bone autograft for anterior cruciate ligament reconstruction: A randomized study with two-year follow-up. Am J Sports Med 29: 722–728
9. Erikson K, Anderberg P, Hamberg P (2001) A comparison of quadruple semitendinosus and patellar tendon grafts in reconstruction of the anterior cruciate ligament. J Bone Joint Surg 83B: 348–354
10. Feller JA, Webster KE (2003) A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. Am J Sports Med 31: 564–573
11. Berbig R, Rillmann P (2000) Operationszeitpunkt bei der vorderen Kreuzbandruptur. Unfallchirurg 103: 726–730
12. Shelbourne KD, Wilckens JH, Mollabashy A, DeCarlo M (1991) Arthrofibrosis in acute anterior cruciate ligament reconstruction. The effect of timing of reconstruction and rehabilitation. Am J Sports Med 19: 332–336
13. Shelbourne KD, Patel DV, Martini DJ (1996) Classification and management of arthrofibrosis of the knee after anterior cruciate ligament reconstruction. Am J Sports Med 24: 857–862
14. Shelbourne KD, Foulk DA (2000) Treatment of anterior cruciate ligament injuries. In Principles and Practice of Orthopaedic Sports Medicine, Lippincott Williams & Wilkins, pp 743–761
15. Stanitski CL, Harvell JC, Fu F (1993) Observations on acute knee hemarthrosis in children and adolescents. J Pedaitr Orthop 13: 506–510
16. Aichroth PM, Patel DV, Zorrilla P (2002) The natural history and treatment of rupture of the anterior cruciate ligament in children and adolescents: A prospective review. J Bone Joint Surg 84-B: 38–41
17. Millet PJ, Willis AW, Warren RF (2002) Associated injuries in pediatric and adolescent anterior cruciate ligament tears: does a delay in treatment increase the risk of meniscal tear? Arthroscopy 18: 955–959

18. Mäkelä EA, Vanionpää S, Vihtonen K et al (1988) The effect of trauma to the lower femoral epiphyseal plate: an experimental study in rabbits. J Bone Joint Surg 70-B: 187–191

19. Attmanspacher W, Dittrich V, Stedtfeld HW (2003) Behandlungsergebnisse nach operativer Versorgung kindlicher Kreuzbandverletzungen. Unfallchirurg 106: 136–143