Original Article

Atlas of complications in anterior Cruciate Ligament Reconstruction

Stergios G. Papastergiou¹, Nikolaos E. Koukoulis², Theophilos D. Dimitriadis², Efstathios I. Kalivas¹, Athanasios V. Papavasileiou³, Evangelos C. Ziogas³

¹"Agios Pavlos" General Hospital, Thessaloniki, Greece; ²"Saint Luke's" Hospital, Thessaloniki, Greece; ³"Interbalkan Medical Center", Thessaloniki, Greece

Abstract

Objectives: The aim of this study was to investigate the incidence of anterior cruciate ligament reconstruction complications. **Methods:** One thousand nine hundred and seventy two (1972) anterior cruciate ligament reconstructions, performed in a single Orthopaedic Department the last 27 years, were studied and followed for up to two years postoperatively. In 1244 cases (one thousand two hundred and forty four) hamstrings autograft was used for the reconstruction and in the rest 728 (seven hundred and twenty eight) cases bone patella tendon bone autograft was used for the reconstruction. **Results:** In total, 467, 23.68% complications were found in our patient population. 431, 21.85% complications occurred intraoperatively and 36, 1.82% complications occurred postoperatively. **Conclusions:** The variety and frequency of complications in anterior cruciate ligament reconstruction underline the importance of accurate surgical technique and close postoperative follow-up.

Keywords: Anterior cruciate ligament, Complications, Reconstruction, Intraoperative, Postoperative

Introduction

The incidence of anterior cruciate ligament (ACL) injury is rising, mainly due to the growing number of recreational and professional athletes. ACL insufficiency leads to knee instability and the optimal treatment is ACL reconstruction. More than 100000 ACL reconstructions are performed annually in the United States¹. Despite improvements in surgical technique and instrumentation of ACL reconstruction, complications do occur. We strongly believe that the incidence of complications is underreported in the literature because of the difficulties to recognize and record them. Awareness of the prevention and treatment of complications is mandatory in order to obtain the best clinical outcome after ACL reconstruction. In this article, we present the experience of a single Orthopaedic Department the last 27 years.

Material and Methods

We retrospectively reviewed the data of files of 1972 patients with ACL rupture, which were treated with ACL reconstruction in our Department over the last 27 years. ACL reconstruction complications were divided in two main categories: intraoperative complications and postoperative

complications. All complications occurred during the operation and up to 2 (two) years postoperatively were recorded and included in this study.

The term "preoperative complications" has been used by other authors² in ACL reconstruction, but in our opinion is not accurate. Preoperative planning is very important in the final outcome of ACL reconstruction, but wrong decisions are not complications. As a result, preoperative planning is not discussed in this article.

In our perspective, graft failure is a bad clinical outcome and not a complication. Consequently, graft failure will not be reported as a complication in this study.

The authors have no conflict of interest.

Corresponding author: Nikolaos E. Koukoulis, 2 Ach Samothraki Street, Ntepo, 54248, Thessaloniki, Greece

E-mail: nkoukoulis@yahoo.gr

Edited by: Christos K. Yiannakopoulos

Accepted 7 November 2018

Results

In total, four hundred and sixty seven (467, 23,68%) complications were encountered. Four hundred and thirty one (431, 21,85%) occurred intraoperatively and thirty six (36, 1,82%) postoperatively.

Intraoperative Complications

Complications during graft harvesting

Complication: Short hamstring tendons due to early transection (Figure 1).

Incidence: 7/1244 (0.56%)

Clinical significance: Small graft both in length and diameter that could lead to graft failure.

Prevention: The stripper should not be used to cut expansions: it is blocked in the junction and is more likely to section the tendon rather than the expansion, resulting in a short graft.

Treatment: Harvest a new graft from ipsilateral leg (patella tendon or quadriceps tendon) to replace or augment the initial graft.

The use of an allograft is an option, if the allograft is available and the patient informed.

Complication: Graft dropped accidentally on the floor (Figure 2).

Incidence: 1/1972 (0,05%)

Clinical significance: Contaminated graft and risk of infection.

Prevention: Secure the graft at all times with sutures and clamps.

Treatment: Harvest a new graft from ipsilateral leg patella tendon or quadriceps tendon) to replace or restore the initial graft. The use of an allograft is an option if the allograft is available and the patient informed. The most successful sterilization protocols used chlorhexidine or mechanical agitation with a polymyxin B-bacitracin solution to achieve sterility in 100% of their respective experimental graft tissues³.

Complication: Patella fracture (Figure 3).

Incidence: 5/728 (0,68%)

Clinical significance: Slower rehabilitation program.

Prevention: Bevel the patella bone cuts. Use sharp osteotomes specially design for beveled bone cuts.

Treatment: Patella fixation is required.

Periosteal sutures, cerclage wire or screw may be used to fix the patella. Use of functional cast with knee locked in extension for 6 weeks may be needed.

Complication: Infrapatellar branch of the Saphenous nerve injury (Figure 4).

Incidence: 342/1972

Clinical significance: Disturbed sensitivity in the area of the

Figure 1. Hamstring tendons.

Figure 2. Graft dropped accidentally on the floor.

Figure 3. ORIF of Patella fracture.

Figure 4. Infrapatellar branch of the Saphenous nerve.

Figure 5. Postoperative hematoma.

infrapatellar branch of the saphenous nerve distribution.

Prevention: The horizontal skin incision presents lower rate of nerve injury (14,9%) compared to the vertical skin incision (39,7%) and the difference is statistically important⁴.

Treatment: No treatment can be applied. Improvement in sensitivity could be obtained several months postoperatively depending on the type of nerve injury (compression injury vs neurotmesis).

Complication: Excessive removal of muscle tissue in hamstrings graft harvesting (Figure 5).

Incidence: 4/1244 (0,32%)

Clinical significance: Hematoma formation.

Prevention: When harvesting the hamstrings use a stripper that allows the surgeon to transect the tendon at desired length. Avoid advancing the stripper beyond the musculotendinous junction thus increasing the muscle injury and bleeding. Compressive stockings.

Treatment: Compressive stockings.

Complications during tunnel placement

Complication: Posterior wall blow-out during femoral tunnel drilling (Figure 6).

Incidence: 2/1972 (0,1%)

Clinical significance: Insecure femoral fixation and risk of graft failure.

Prevention: Anatomic guide wire placement and careful drilling. If any doubts for placing the guide wire far too posteriorly, drill for 2-3 mm, withdraw the drill and evaluate the stump created on the femoral condyle and if the posterior wall is impaired.

Treatment: Drill a new anatomic femoral tunnel.

Try to change the angle of drilling. Even if the entrance of the old and new tunnels is united and partially common, the new anatomic tunnel follows different orientation and is separated from the old one. Use double fixation with suspensory fixation and interference screw if possible.

Complication: Non anatomical tunnel placement of femoral and tibial tunnels (Figure 7).

Figure 6. Posterior wall blow-out.

Figure 7. Non anatomical and anatomic femoral tunnel.

Incidence: 3/1972 (0,15%)

Clinical significance: Knee range of motion deficit. Risk of graft failure.

Prevention: Anatomic guide wire placement for both femoral and tibial tunnels. Aim for the center of the ACL footprint.

Treatment: Drill new, anatomic tunnel.

If the initial tunnel does not interfere with the new, anatomic one, you can leave it alone.

If the old initial tunnel interfere with the new, anatomic one, you can use a larger screw, a second screw or bone graft

depending on the mismatch of the graft and the united, enlarged tunnel.

Complication: Medial femoral condyle osteochondral lesion during femoral tunnel drilling using the anteromedial portal technique (Figure 8).

Incidence: 3/1972 (0,15%)

Clinical significance: Knee pain and effusion.

Prevention: Careful drilling. When drilling the femoral tunnel, advance the drill into the joint manually and with direct vision of the drill.

Treatment: Remove any chondral debris and leave stable healthy cartilage. If the size of the lesion is small ($<1 \text{ cm}^2$) leave it alone. In larger lesions think of microfractures.

Complication: Inadvertent femoral cortex drilling with the large drill in suspensory femoral fixation (button) (Figure 9).

Incidence: 1/1244 (0,16%)

Clinical significance: Insecure femoral fixation and graft failure.

Prevention: Careful drilling.

Treatment: Use an extension button to increase the length of the button.

Use an interference screw for additional fixation.

Complications during graft passage

Complication: Graft too thick compared to tunnel diameter.

Incidence: 24/1972 (1,2%)

Clinical significance: The graft cannot enter the tibial tunnel and the guide sutures may break when pulling the graft.

Prevention: Careful graft sizing and drill diameter control.

Treatment: Remove any soft tissue or debris that may interfere between the entrance of the tibial tunnel and the graft.

If the graft is still thicker than the tunnel, increase the tunnel diameter accordingly using dilators (preferably) or drill.

Complication: Graft too thin compared to tunnel diameter

Incidence: 2/1972 (0,1%)

Clinical significance: Insecure graft fixation and risk of graft failure.

Prevention: Careful graft sizing and drill diameter control.

Treatment: If interference screw is the choice of fixation, use a thicker screw according to the tunnel – graft mismatch. Use of second suspensory fixation is helpful (button, staple etc). If extra-cortical fixation has been selected for fixation, change to interference screw or add an interference screw as a second fixation method.

Complications during graft fixation

Complication: Inaccurate cross-pin positioning (Figure 10).

Incidence: 11/483 (2,2%)

Clinical significance: Inadequate graft fixation and risk of graft failure

Figure 8. Direct vision of the drill during intraarticular advancement.

Figure 9. Extension button.

Figure 10. Inaccurate cross-pin positioning.

Prevention: Verification of correct cross-pin tunnel should be made with direct vision and/or with the test of two guide wires, that are inserted through the cross-pin and femoral tunnels and meet at the point of fixation, resulting in the metal-to-metal feeling⁵.

Treatment: Revise the cross-pin position or use another fixation method (interference screw or extracortical fixation).

Figure 11. Femoral screw breakage.

Figure 12. Tibial interference screw malpositioned.

Complication: Screw breakage (Figure 11).

Incidence: Femoral tunnel: 5/ 728 (0,68%) - Tibial tunnel: 15/1972 (0,76%)

Clinical significance: Inadequate graft fixation and risk of graft failure

Prevention: Tap the tunnel. In case you feel unexpected resistance when advancing the screw, consider using a smaller in diameter screw.

Treatment: Remove all the fragments of the broken screw. Check the graft. Tap the tunnel again and use a smaller screw if needed.

Figure 13. Late button "flip".

Complication: Screw outside the femoral or tibial tunnel (Figure 12).

Incidence: 2/1972 (0,1%)

Clinical significance: Inadequate graft fixation and risk of graft failure

Prevention: Use cannulated screws for graft fixation. Insert the guide wire inside the tunnel and check the guide wire position arthroscopically.

Treatment: If you detect the problem intraoperatively, relocate the screw.

If you detect the problem postoperatively, use a functional cast and follow a less aggressive rehabilitation program.

Figure 14. Early button "flip".

Complication: Late button "flip" (Figure 13).

Incidence: 3/1244 (0,24%)

Clinical significance: Soft tissue interposition between the button and the lateral femoral cortex results in insecure graft fixation and risk of graft failure

Prevention: Measure the femoral tunnel and mark the graft with a pen accordingly. Pull the graft slowly and always with direct vision of the progression of advancement. "Flip" the button as soon as the marks indicate that the button is out of the femoral tunnel. Graft tensioning with knee cycling helps the button to arrest on to the lateral femoral cortex.

Treatment: Apply a functional cast and follow a less aggressive rehabilitation program.

Complication: Early button "flip" (Figure 14).

Incidence: 1/1244 (0,08%)

Clinical significance: The button is mal-positioned inside the femoral tunnel resulting in insecure graft fixation and risk of graft failure

Prevention: Measure the femoral tunnel and mark the graft

Figure 15. Prominent tibial screw.

Figure 16. Cross-pin fragment and chondral injury.

with a pen accordingly. Pull the graft slowly and always with direct vision of the progression of advancement. “Flip” the button as soon as the marks indicate that the button is out of the femoral tunnel and not earlier. Graft tensioning with knee cycling confirms that the button has exit the femoral tunnel since the graft is not pulled back.

Treatment: Apply a functional cast and follow a less aggressive rehabilitation program.

Postoperative Complications

Complications related to ACL reconstruction

Complication: Prominent tibial screw (Figure 15).

Incidence: 4/1972 (0,2%)

Clinical significance: Pain with kneeling.

Prevention: Place the tibial screw all the way into the tunnel and avoid using bulky sutures and knots over the tunnel.

Treatment: Screw removal after the graft has healed.

Complication: Implant breakage or migration after graft healing (Figure 16).

Incidence: 3/1972 (0,15%)

Clinical significance: Knee chondral injury.

Prevention: High level of suspicious when facing chondral injury symptoms after an asymptomatic period postoperatively⁶.

Treatment: Arthroscopic removal of the implant and chondral injury treatment.

Complication: Cyclops lesion – loss of extension (Figure 17).

Incidence: 6/1972 (0,3%)

Clinical significance: Knee extension deficit

Prevention: Ask for full extension exercises immediately after surgery.

Treatment: Follow an aggressive rehabilitation program and in case of failure remove the Cyclops lesion arthroscopically.

Figure 17. Cyclops lesion.

Figure 18. Arthrofibrosis.

Complications non-related to ACL reconstruction

Complication: Arthrofibrosis (Figure 18).

Incidence: 9/1972 (0,45%)

Clinical significance: Knee flexion deficit.

Prevention: Aggressive rehabilitation program

Treatment: Aggressive rehabilitation program. In case of failure, arthroscopic release of the adhesions is needed.

Complication: Infection (Figure 19).

Incidence: 9/1972 (0,45%)

Clinical significance: Knee arthritis.

Prevention: Intravenous, peri-operative antibiotic prophylaxis has been proposed as the prevention measure against infection. Pre-soaking of the ACL grafts with topical vancomycin was found to further minimize the risk of infection⁷.

Treatment: Cultures, serial arthroscopic lavage, synovectomy and appropriate intravenous antibiotics are the gold standard treatment.

In reluctant cases, graft removal and two stages revision ACLR is needed along with antibiotics.

Figure 19. Infection.

Complication: DVT – Pulmonary embolism (Figure 20).

Incidence: 1/1972 (0,05%)

Clinical significance: It is a life threatening complication. Early symptoms are calf swelling and pain, shortness of breath, acute thoracic pain, dizziness, fainting.

Prevention: Anticoagulation therapy for 30 days, compression stockings.

Treatment: The patient should be referred immediately to a Hematologist for anticoagulation therapy.

Figure 20. DVT – Pulmonary embolism.

Complication: Complex regional pain syndrome type I (Figure 21).

Incidence: 4/1972 (0,20%)

Clinical significance: Potential symptoms are Continuing pain, hyperesthesia, temperature asymmetry, skin color changes, edema, sweating changes, trophic changes, range of motion deficit and muscle weakness that eventually result in an a slow rehabilitation program.

Prevention: Avoid operating on painful knees with effusion and range of motion deficit. Prompt analgesia and physical therapy are the only measures supported in the literature⁸.

Treatment: Multidisciplinary approach is needed.

Figure 21. Complex regional pain syndrome type I.

Discussion

Anterior cruciate ligament reconstruction is considered a safe procedure, performed arthroscopically with low complication rates. To the best of our knowledge this is the first study in the literature that reviews the intraoperative and postoperative complications of a single Orthopaedic Department. As a result, no direct comparison of our results could be made with other studies.

The main limitation of this study is that the whole research is a retrospective one. Intraoperative complications were reliably studied using the operation records. On the other hand, a percentage of postoperative complications may have been missed in the follow-up period. Nevertheless, most of the postoperative complications (range of motion deficit, dysesthesia, prominent screw etc.) reported in this study could be easily identified during the first follow-up visits. As a result, we believe that our results in postoperative complications are reliable also.

Some of the intraoperative complications are more or less subjective to determine. For example, anatomic tunnel position may differ between surgeons. In this study, all anterior cruciate ligament reconstructions were performed

by the senior author or under his direct supervision. Therefore, the results of this study reflect the point of view of a single experienced surgeon and are of great value for all surgeons.

We have to underline that most of intraoperative complications related to technical errors were encountered during the learning curve period of a new technique.

The main advantage of this study is the large amount of anterior cruciate ligament reconstructions, coming from a single Orthopaedic Department. The data presented in this study are indicative of the complications anticipated during and after an anterior cruciate ligament reconstruction. Surgeons should be aware of these complications and ready to prevent, recognize and treat them.

References

1. Lyman S, Koulouvaris P, Sherman S, Do H, Mandl LA, Marx RG. Epidemiology of anterior cruciate ligament reconstruction. *J Bone Joint Surg Am* 2009; 91:2321-8.
2. Azar FM, Arthur ST. Complications of anterior cruciate ligament reconstruction. *Techniques in Knee Surgery* 2004; 3(4):238-250.
3. Khan M, Rothrauff BB, Merali F, Musahl V, Peterson D, Ayeni OR. Management of the contaminated anterior cruciate ligament graft. *Arthroscopy* 2014; 30(2):236-44.
4. Papastergiou SG, Voulgaropoulos H, Mikalef P, Ziogas E, Pappis G, Giannakopoulos I. Injuries to the infrapatellar branch(es) of the saphenous nerve in anterior cruciate ligament reconstruction with four-strand hamstring tendon autograft: vertical versus horizontal incision for harvest. *Knee Surg Sports Traumatol Arthrosc* 2006; 14(8):789-93.
5. Papastergiou SG, Koukoulis NE, Dimitriadis T, Pappis G, Parisi CA. RigidFix Femoral Fixation: A Test for Detecting Inaccurate Cross Pin Positioning. *Arthroscopy* 2007; 23(11):1247.e1-3.
6. Papastergiou SG, Koukoulis NE, Ziogas E, Dimitriadis T, Voulgaropoulos H. Broken bioabsorbable femoral cross-pin as a cause of a chondral lesion after anterior cruciate ligament reconstruction. *BMJ Case Rep.* 2009; 2009: bcr09.2008.0883.
7. Phegan M, Grayson JE, Vertullo CJ. No infections in 1300 anterior cruciate ligament reconstructions with vancomycin pre-soaking of hamstring grafts. *Knee Surg Sports Traumatol Arthrosc* 2016; 24(9):2729-35.
8. Reuben SS. Preventing the Development of Complex Regional Pain Syndrome after Surgery. *Anesthesiology* 2004; 101:1215-24.