

# Anterior Cruciate Ligament Rupture and Osteoarthritis Progression

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**Abstract:** Anterior Cruciate Ligament (ACL) rupture is a common sporting injury that frequently affects young, athletic patients. Apart from the functional problems of instability, patients with ACL deficient knees also develop osteoarthritis. Although this is frequently cited as an indication for ACL reconstruction, the relationship between ACL rupture, reconstruction and the instigation and progression of articular cartilage degenerative change is controversial.

The purpose of this paper is to review the published literature with regards ACL rupture and the multifactorial causes for osteoarthritis progression, and whether or not this is slowed or stopped by ACL reconstruction.

There is no evidence in the published literature to support the view that ACL reconstruction prevents osteoarthritis, although it may prevent further meniscal damage. It must be recognised that this conclusion is based on the current literature which has substantial methodological limitations.

**Keywords:** Anterior cruciate ligament, anterior cruciate ligament reconstruction, cartilage damage, knee surgery, meniscus, osteoarthritis.

## INTRODUCTION

The anterior cruciate ligament (ACL) is an important stabiliser of the knee, functioning as the primary constraint preventing anterior translation of the tibia on the femur, and also stabilising the knee against rotational and valgus stresses [1]. Rupture of the ACL, unfortunately, is a common sports injury, with a reported incidence of 0.38 per 100,000 individuals [2]. It frequently affects young, active people with long working futures and sporting ambitions. Functional problems in the ACL deficient knee arise from instability, particularly in activities requiring pivoting and side stepping. This can cause levels of disability ranging from limitation of sporting activity to restricting activities of daily living. Recurrent knee injuries secondary to instability can result in intraarticular damage, in particular meniscal tears and subsequent osteoarthritis (OA).

The majority of patients with ACL deficient knees are able to walk normally and perform straight line activities. Studies in nonoperatively managed patients who remain active [3], however, have indicated that up to 44% of patients will develop significant functional disability affecting their ability to perform activities of daily living. Many studies have shown that ACL deficient knees will

deteriorate radiologically and functionally over time due to advancing osteoarthritis [3, 4].

As a result the ACL is the most commonly injured ligament undergoing surgical intervention, aiming to return the patient to his or her preinjury level of activity and preventing osteoarthritis. In the United States alone around 175,000 ACL reconstructions were performed in the year 2000 [5], costing around \$2 billion. Meta analyses of the published literature [6, 7] have shown that between 67 and 76 % patients of patients undergoing ACL reconstruction are able to return to preinjury levels of activity, with up to 80% of patients having normal or near normal functional International Knee Documentation Committee (IKDC) scores.

What is still a matter of controversy, however, is the ability of ACL reconstruction to prevent or delay the onset of degenerative change within the knee. Fig. (1) is an example of ACL reconstruction not preventing the development of advanced osteoarthritis from developing in a young patient. The purpose of this paper is to review the concepts surrounding the pathogenesis of osteoarthritis in the ACL deficient knee and whether early or late reconstruction can delay or prevent degenerative change.

## OSTEOARTHRITIS AFTER ACL RUPTURE

The relationship between osteoarthritis and ACL rupture is one of the main reasons cited for advocating ACL reconstruction in the young, active patient but is difficult to

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the absence of a functioning ACL, the static and dynamic loading of forces across the knee is altered, increasing the forces applied to the articular cartilage [30], which can both initiate and perpetuate osteoarthritis progression. The loss of anterior-posterior translational stability and rotational stability results in a spatial shift in areas of tibiofemoral contact. This change in the load bearing area and contact mechanics, particularly in rotational malalignment, has been associated with an increased in degenerative change [31, 32]. This is likely to be perpetuated by the loss of the ACL's proprioceptive function.

**Fig. (2).** Coronal T2 weighted MRI image of a knee with a chronic ACL tear with a deficient medial meniscus and medial compartment osteoarthritis.

Apart from the altered contact mechanics of the articular cartilage, continued instability also increases the likelihood of further injury to the knee, injuring other structures, including the menisci [27], which in turn would accelerate degenerative change.

#### ACL RECONSTRUCTION AND OA PROGRESSION

In order to determine if reconstruction of the ACL can prevent or delay progression of OA, we should look at studies comparing patients with ACL deficient and ACL reconstructed knees. Unfortunately, when reviewing the literature it must be noted that long-term studies on knee injuries are very heterogeneous in methodology, in particular with regards outcome measures, type of graft, timing of surgery and rehabilitative regimes. There is also great variability and poor reporting of variables that might be expected to influence outcome, such as age, patient sex, activity levels, and other patient-associated factors. The limited size, short follow up and design flaws within many studies prevent definitive conclusions from being made and make pooling of data or meta analysis difficult.

Early studies including that by Dale Daniel and colleagues indicated a higher incidence of radiographic OA in patients with ACL reconstructed knees compared to those

treated non-operatively, at mean follow-up of 64 months [33]. Although the ACL reconstruction techniques described at the time are largely no longer used, a more recent study from the same institution showed a similarly greater incidence of radiographic arthrosis in patients treated operatively with BPTB allograft compared to those managed conservatively [34]. However, in the same study, Tegner scores (grading activity level) were significantly higher in the patients treated with early reconstruction (within 3 months of the ACL injury). The main criticism of this study is the lack of randomisation, with ACL reconstruction being performed in the more severely injured knees.

Another study reviewed outcomes in Swedish soccer players who had sustained a ruptured ACL and were followed up at 7 [35], 12 [36] and 14 years post injury. Reconstruction was performed in 60% of the players studied. At each time point, there was no significant difference seen between surgically and conservatively managed players in terms of radiographic evidence of osteoarthritis, presence of symptoms, and level of sporting activity.

Similarly, another study observed 79 professional Norwegian handball players, at a mean follow-up of 7 years post ACL rupture [37]. Greater antero-posterior laxity was demonstrated in the conservatively treated subjects compared to those treated surgically. This did not, however, correlate with functional recovery as the authors found that a higher percentage of patients returned to the same level of sport activity when treated conservatively. There was no difference in the prevalence of radiologically abnormal or severe arthritic change between the two groups.

Fink and colleagues reported their findings in 2001 demonstrating no significant difference in radiographic narrowing of the joint space in patients treated with reconstruction compared to those treated conservatively at mean follow-up of 11 years (48% vs 50% respectively) [38]. In this study all the reconstructions were performed using a bone-patella tendon-bone graft. The study was somewhat weakened by the fact that the decision to proceed with operative or non-operative treatment was made by the patients, introducing significant bias. The authors also demonstrated a correlation between participation in pivoting sports and development of early osteoarthritic changes in those treated non-operatively.

A retrospective study from 2008 compared the outcomes of treatment of isolated ACL ruptures with bone-patella tendon-bone graft reconstruction with that of conservative management, demonstrating a significantly higher prevalence of radiographic joint space narrowing in the ACL reconstructed group (45% vs 24%), at average follow-up of 11.1 years [39].

One recent paper has, however, shown reduced rates of osteoarthritis after ACL reconstruction. A recent retrospective, non-randomised study with 17-20 year follow up showed a significantly lower rate of severe osteoarthritis after reconstruction when compared to a conservatively managed control group (16.5% vs 56%). Although over 50% of reconstructed patients did have mild degenerative changes, in the conservatively managed patient group there were no normal knees [40].

The continued progression of osteoarthritis after ACL reconstruction is perhaps not surprising given the multifactorial causes for degenerative change. Although the continually improving methods for ACL reconstruction restore stability and much of the normal mechanics of the knee, the reconstructed knee is not a normal knee. Altered mechanics in the reconstructed knee can be expected to produce abnormal loading patterns across the joint, significantly increasing the risk of OA [10].

Multiple studies have also investigated potential risk factors for the development of osteoarthritis after ACL reconstruction. One such study identified Female sex, Body Mass Index (BMI), time from injury to surgery, medial and patellofemoral compartment chondrosis, prior medial or lateral meniscectomy, concurrent medial meniscectomy, and length of follow-up as risk factors for developing radiographic evidence of degenerative change, with medial meniscectomy followed by pre-existing chondral damage the strongest predictors [41]. Similarly, a prospective cohort study by Keays and colleagues found five factors to be predictive of tibiofemoral osteoarthritis. These were meniscectomy, chondral damage, the use of patella tendon as a graft, weak quadriceps and poor quadriceps to hamstring strength ratios. Of these meniscectomy, followed by chondral damage, was again the strongest predictor of degenerative change [41].

When looking specifically at the effect of meniscal and chondral damage on the results of ACL reconstruction, a retrospective study found that patients with no evidence of meniscal or chondral damage at ACL reconstruction had good outcomes, with 97% having normal or near normal radiographic appearances, with a mean follow up of over 7 years [42]. Conversely, abnormal or severely abnormal radiographs were seen in 9%, 23% and 25% of patients who had undergone a lateral, medial or bilateral meniscectomy respectively.

In addition, post operative range of movement in the knee has been shown to be another risk factor for progression of osteoarthritis. In a recent paper by Shelbourne, patients were retroactively reviewed at a mean of 10 years post reconstruction. In these patients the rehabilitation regime aimed to regain a full range of motion as early as possible. Patients who regained a full range of movement had a significantly lower incidence of osteoarthritis when compared to patients who had restrictions in flexion or extension (39% vs 53%) [43].

#### **TIMING OF ACL RECONSTRUCTION**

When considering the impact of ACL reconstruction on osteoarthritis, it is difficult to compare or pool the results of multiple studies due to the great variability in surgical technique, graft choice, rehabilitation regimes and timing of surgery. The timing of surgery, and whether this may have an impact on subsequent development of arthritis, is an area of controversy.

Some studies comparing ACL reconstruction for acute ruptures with reconstruction after a period of chronic instability do show improved subjective and objective results [44-46]. This includes a reduced rate of osteoarthritis on

x-rays [47]. A study by Jarvela in 1999 [48] assessed knee radiographs after early (mean 6 days) or late (mean 3.7 years) ACL reconstruction, with the late reconstruction group having a significantly higher incidence of medial compartment degenerative changes, although no difference was seen in the patellofemoral joint or lateral compartment. Other studies, however [42, 49], have shown no significant difference.

Multiple papers have noted that the need for meniscectomy at ACL reconstruction increases with delayed surgery, arguing that there is a greater incidence of meniscal injury in functionally unstable knees, which in turn may lead to subsequent tibiofemoral osteoarthritis [25, 26, 47, 50, 51]. One multicentre study quotes the relative risk of meniscal injury at 5 years being almost 6 times that of the first year post injury [51]. Furthermore, some studies have produced results suggestive that ACL reconstruction would have a protective effect, preventing further meniscal damage [27, 34, 48], and therefore make the argument that early ACL reconstruction can reduce the development of subsequent meniscal pathology and osteoarthritis.

A meta analysis of the published literature, however, did not support this hypothesis, finding no significant difference in the incidence of meniscal pathology or osteoarthritis after early or late ACL reconstruction [49]. This paper, did, however accept that this finding was underpowered due to small sample sizes. There was also considerable variability in what was felt to be an early of late reconstruction. Clearly more research is required, as the current evidence base is hindered by methodological limitations.

#### **CONCLUSION**

ACL rupture is a common sporting injury frequently affecting young patients. Although reconstruction of the ACL can improve the functional outcome, particularly in patients with a high functional demand, there is currently little data supporting the concept that ACL reconstruction prevents or delays degeneration of the knee joint.

Patients with ACL ruptures with concomitant meniscal, and to a lesser extent, chondral damage are at greater risk of developing osteoarthritis, whether or not the ACL has been reconstructed. It has been shown that ACL reconstruction prevents further meniscal damage, and the argument has been put forward that this could reduce further chondral injury. There is, however, limited evidence to support this.

Choice of treatment remains very much patient guided in many institutions and is often dependent on the level of sports participation. It is difficult to make meaningful comparisons between outcome studies due to the heterogeneity of methodology, which includes, severity of initial injury, surgical technique, graft choice, timing of surgery and rehabilitation. Pooling data and meta analyses is therefore difficult due to the weaknesses of the published studies. Randomised, controlled trials could provide a definitive answer but, to be sufficiently powered, would require recruitment of a large number of young patients who would be willing to be treated conservatively.

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## CONFLICT OF INTEREST

Neither of the authors have a conflict of interest to declare in relation to the production of this manuscript.

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