

## Anterior Cruciate Ligament Reconstruction and Radiographic Progression to Knee Osteoarthritis

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### ABSTRACT

The aim of this study was to evaluate the radiological progression to knee osteoarthritis (OA), including compare the results of semitendinous and gracilis (STG) and bone-patellar tendon-bone (BPTB) grafts. This is a retrospective study that assessed patients submitted to anterior cruciate ligament (ACL) reconstruction with more than 8 years follow-up, between 2005 and 2011. *Tegner activity scale*, *Knee Injury and Osteoarthritis Outcome Score* (KOOS), and *Visual Analogue Scale* (VAS) were used to evaluate patient perceptions of symptoms and function. The degree and location of OA were evaluated according to *Kellgren and Laurence* classification. Progression to radiographic Knee OA was assessed according to *Felson et al.* and symptomatic patients were identified. We evaluate 38 patients with history of ACL reconstruction, with a mean follow-up time of 9.86 years. 22 (57.9%) patients were submitted to STG and 16 (42.1%) to bone-patellar tendon-bone grafts. Radiographic

OA was present in 20 (52.6%) patients, with 17 (44.7%) symptomatic at final follow-up. OA of the medial compartment was the most frequent, with 26 (68.4%) patients. A significant difference was found in progression to radiographic OA in BPTB and STG groups: 12/16 (75%) and 8/22 (36.4%) respectively; as well as in symptomatic OA, 11/17 (64.7%) and 6/17 (35.3%) respectively. Similarly, the results of function and satisfaction levels were superior in STG group (KOOS 86.05, Tegner 5, VAS 8.1) than in BPTB group (KOOS 64.38, Tegner 4, VAS 6.3).

This study shows that ACL reconstruction did not protect the knee from secondary OA at 8 years of follow-up. The study also showed that graft type can affect the risk of radiographic and symptomatic progression to OA.

**Key words:** ACL reconstruction; Knee osteoarthritis; Radiographic osteoarthritis

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### INTRODUCTION

ACL tear is a devastating injury with potential both short and long term complications.

It's reconstruction is one of the most common orthopaedic procedures, with an incidence that can reach 60 per 100 000 and sport activities athletes more affected<sup>[1,2]</sup>.

Short-term knee functional impairment is successfully addressed with ACL reconstruction and rehabilitation. The goal of ACL reconstruction is to restore joint stability, with secondary benefits with restoration of normal joint kinematics, decrease stress on the menisci and chondral surfaces<sup>[3]</sup>. However, the development of OA still prevalent<sup>[4]</sup>, and the long-term consequences of ACL injury and the role of ACL reconstruction towards fully restoring knee biomechanics and potentially preventing cartilage degeneration post-traumatically is surrounded with controversy<sup>[5,6]</sup>.

Reconstructed knees appears to lead to more cases of OA compared to healthy non injured knees, according to the majority of the authors<sup>[4,7]</sup>. However, the cause of OA is multifactorial, and long-term outcomes after an ACL injury can be largely influenced by the presence of associated injuries, such as meniscus and cartilage injuries, as well as a high body mass index (BMI)<sup>[8,9,10]</sup>.

The BPTB graft has also been mentioned has a possible risk factor for worse outcomes regarding of patella infera and to cause patellofemoral problems, namely kneeling, compared with hamstring tendon graft<sup>[11,12]</sup>.

On the other hand, the role of several factors are unclear: age at surgery, mean time between ACL tear to surgery and time from surgery and the development of OA.

The aim of this study was to evaluate the radiological outcome and progression of knee OA, including to compare the results of hamstrings and patellar tendon grafts. Similarly, the authors pretend to evaluate the effects of length of time after surgery and preoperative time from injury to surgery.

Therefore the authors attempt to answer whether ACL injury leads to OA and whether ACL reconstruction can prevent it.

## MATERIALS AND METHODS

This is a retrospective study that assessed patients submitted to ACL reconstruction with STG or BPTB grafts, with more than 8 years follow-up, between 2005 and 2011.

All patients had a traumatic ACL injury with instability and were previously healthy in both knees, with no radiological signs of OA.

Patients who had prior ACL surgery, history of a cartilage procedure or who had concomitant knee ligament injury were excluded from the study. Similarly, were excluded patients who underwent a major knee surgery during the follow-up period.

Surgical method, graft type and source, associated menisci or articular cartilage injury, and associated surgical procedures were obtained from a review of patients records.

The ACL reconstruction procedure was performed with the patient in the supine position. The injured knee was examined under anesthesia to confirm the diagnosis. A padded tourniquet was placed high on the operative thigh. Routine diagnostic arthroscopy was done to verify ACL rupture and to address associated meniscal or chondral injuries.

In bone-tendon-bone reconstruction technique, an 8 cm longitudinal incision was made with the knee flexed to 90°, from the inferior pole of the patella to approximately 2 cm distal to the tibial tubercle, along the medial aspect of the patellar tendon. Dissection was carried through the subcutaneous tissue to the patellar paratendon, that was then incised longitudinally along the mid-portion of the patellar tendon. A 10 mm, middle-third patellar tendon autograft, with 25-mm bone plugs at either end was obtained. The bone fragments were roundly edged, and sizing tubes used to confirm appropriately size.

Soft tissues were cleaned including ACL remnants, to identify the resident ridge and the posterior articular cartilage of the lateral condyle of the femur. An inside-out technique was performed with the knee in maximal hyperflexion and a guide pin was placed through the medial portal into the medial aspect of the lateral femoral condyle at the ACL footprint, and driven out the lateral aspect of the leg through the skin. This was over reamed to a predetermined distance depending on the chosen graft fixation technique.

The tibial drill guide was placed through the anteromedial portal, at the ACL tibial footprint in line with the medial tibial spine. The

external portion of the guide was positioned at anteromedial tibia (midway between the anterior tibial tuberosity and the medial tibial joint line), generally calibrated in a 45° angle, and tibial tunnel was drilled.

A passing suture was used to pass the graft trough bone tunnels, a femoral interference screw was advanced, appropriate tension to the sutures on tibial plug was applied before tibial interference screw was advanced.

In the ACL hamstring reconstruction technique, gracilis and semitendinous tendons were prepared and looped to create a quadrupled graft. An inside-out femoral tunnel drilling technique was performed with a cortical suspension device. The guidewire was advanced through the femoral cortex and overdrilled to 4.5-mm. The tibial and femoral tunnels were created similarly to the method used for the patellar tendon graft, the size of the drill bit was selected according to the graft size.

The tunnels were reamed to the corresponding diameter of the larger end of the quadrupled graft, with a femoral depth that allow the desired graft-to-tunnel interface, typically around 25 mm. An ethibond suture loop was placed through both tunnels to pull femoral fixation device through the tibial tunnel, joint space and femoral tunnel, exiting the cortex. Finally the tibial cortex was tapped and an interference screw was used for tibial fixation.

All subjects underwent an immediate rehabilitation program protocol after the first day of the surgery, articular range of motion 0°-90° for the first 3 weeks, and then 0-120° as tolerated. A brace was used, locked at full extension only for weight bearing initially.

*Tegner activity scale* was used to measure the type and level of leisure time, walking, and sporting activities and *KOOS* was used to evaluate patient perceptions of symptoms and function. A *VAS* was used to access knee pain.

Standard radiographic assessment was performed in both knees, through anteroposterior (AP) view in standing position, lateral (30 degrees of knee flexion) and patellar axial views. On the other hand, the degree and location of OA according to *Kellgren and Lawrence* classification were assessed preoperatively by AP and lateral radiographs, and at the final follow-up.

All radiographs were evaluated by a senior knee surgeon and were classified according to the *Kellgren and Lawrence* (K-L) grading scale. Progression to radiographic knee OA was assessed according to *Felson et al*<sup>[13]</sup>, using *Kellgren and Lawrence* grade 2 (significant osteophytes and/or cartilage reduction up to 50%), as the cut-off for the presence of osteoarthritis. We used changes from K-L0 or K-L1 to K-L  $\geq 2$  from the total follow-up as new onset of OA.

To identify symptomatic OA, we used a previously published definition according to the *KOOS* combined with radiological results. A patient with a *KOOS* below a threshold on any parameter has a symptomatic knee: 86.1 for pain, 85.7 for symptoms, 86.8 for function and daily living, 85.0 for function, sports and recreational activities, 87.5 for quality of life. Symptomatic OA was defined based on this subgroup of patients with radiological OA<sup>[14]</sup>.

Clinical evaluation included knee range of motion with a goniometer, and instability, with anterior drawer and Lachman tests at final follow-up. Similarly, time to return to activities of daily living, to work and to sports were recorded.

## RESULTS

### Sample Characteristics

One hundred twenty-three patients had been treated with ACL reconstruction between 2005 and 2011, and only 38 subjects (31%)

consented to participate at the follow-up revision, with a mean follow-up time of 9.86 years (SD 1.28).

The mean age at time of injury was 28.7 (SD 8.29) with 34 males (89.5%) and 4 females (10.5%). 23 (60.5%) patients had a right knee injury, and 15 (39.5%) a left knee. 35 (92.1%) patients had been submitted to surgery more than 6 months after injury.

22 (57.9%) patients were submitted to an ACL-reconstruction with hamstrings graft and 16 (42.1%) with patellar tendon.

Only three patients were submitted to surgery in the first 6 months after injury. Therefore, we couldn't analyze the variable time to surgery.

### Prevalence of OA

Radiographic OA was present in 20 (52.6%) patients, with 17 (44.7%) symptomatic at final follow-up.

Of those patients with radiographic progression to OA, medial compartment involvement was the most frequent, with 14 (70.0%) patients, followed by anterior compartment [3 (15.0%)], lateral compartment [1 (5.0%)] and tricompartmental OA [2 (10.0%)].

When we analyze separately the group of patients based on graft types, we found a statistical significant difference between the two groups, with 12/16 (75%) and 8/22 (36.4%) of radiographic OA criteria in OTO and STG group respectively ( $p = 0.019$ ).

Of those patients with symptomatic OA, 6/17 (35.3%) and 11/17 (64.7%) belongs to STG and OTO group respectively, with a statistical significant difference ( $p = 0.011$ ).

### Function and satisfaction scores

Table 1 resumes functional and satisfaction results. The mean *KOOS* was 76.92 (SD 22.37), with 64.38 (SD 23.11) for OTO group and 86.05 (SD 17.13) for STG group.

The mean *Tegner* score was 6.08 (SD 1.38) and 4.71 (SD 1.71) before injury and at final follow-up, respectively. For BPTB group the values varied from a mean of 5.88 (SD 1.09) before and 4.25 (SD 1.57) after surgery at final follow-up, and for STG varied from 6.23 (SD 1.57) to 5.04 (SD 1.76).

Mean VAS was 7.34 (SD 2.13) at final follow-up, with 8.10 (SD 1.63) for STG and 6.31 (SD 2.36) for BPTB groups.

We do not have data for associated lesions, namely meniscal ruptures, or osteochondral lesions due to information loss in clinical records.

## DISCUSSION

Our study shows that ACL reconstruction did not protect knee from secondary OA at 8 years follow-up. This findings are supported by the literature<sup>[4,15]</sup>, the incidence of OA post-ACL reconstruction are very high, it can reach 47% at 7 years follow-up, and 80% at 15 years<sup>[10,16,17,18]</sup>.

It also showed that graft type can affect the risk of radiographic and symptomatic progression to OA. BPTB graft can be related to a worse functional and satisfaction outcomes compared to STG. Sajovic *et al.*, as well as other papers, found a higher prevalence of OA in BPTB reconstructions and a significantly more frequent positive pivot-shift test in this group<sup>[11,12,16,19]</sup>. For this reason, we gradually lost surgical experience with BPTB graft procedure, which could be an important factor in the worse outcome of this patients.

The majority of patients had OA progression at final follow-up, being the medial compartment the most frequently affected. This findings were presented in other studies, namely Barenus B *et al*<sup>[11,20]</sup>.

No conclusions could be taken regard the effect of time between

**Table 1** Functional and satisfaction results.

Variables	Mean $\pm$ SD
Total KOOS	76.92 $\pm$ 22.37
KOOS other symptoms	76.26 $\pm$ 22.35
KOOS pain	78.89 $\pm$ 22.21
KOOS activities of daily living	83.47 $\pm$ 19.69
KOOS sports and recreation	62.94 $\pm$ 32.38
KOOS knee related quality of life	57.41 $\pm$ 35.35
Tegner before injury	6.08 $\pm$ 1.38 (3-9)
Tegner final follow-up	4.71 $\pm$ 1.71 (2-9)
VAS	7.34 $\pm$ 2.13 (2-10)

injury and ACL reconstruction on the prevalence of OA, due to the small group of patients (only 3), that had been submitted to surgery lesser than 6 months after injury. However, results from the literature establish an increasing frequency of meniscus injuries with increasing time between injury and surgery and the effect of meniscus resection on OA<sup>[21]</sup>. There is also data in literature suggesting an increased risk of OA among patients with longer times between injury and reconstruction<sup>[22]</sup>.

The reason for the variation between studies in the prevalence of OA after ACL reconstruction appears to be multifactorial, as are different treatment regimens, different times to follow-up, different study populations, different OA grading systems and other factors such as bone mass index and age.

Currently, there is a broad consensus in the literature about increased prevalence of knee osteoarthritis after an ACL reconstruction over the time, including level I studies and meta-analysis<sup>[23,24]</sup>.

Despite the limitations associated with the surgical management, it is considered the "gold standard" of care in young active adults that desire to return to pre-injury activity. The non-operative management are associated with poor functional outcome with an increased risk of secondary ACL and meniscus surgery<sup>[25,26]</sup>.

An important limitation of this study was the lack of information regard associated lesions, namely meniscal ruptures and osteochondral lesions at the time of surgery. This did not allow to evaluate their role as risk factors to radiologic and clinical knee OA progression. On the other hand, we have a limited number of patients that agreed to participate in the study, which can interfere with the results.

## CONCLUSION

ACL reconstruction did not protect knee from secondary radiographic and clinical OA at 8 years follow-up, being the medial compartment the most frequently affected. In our experience, BPTB graft can be related to a worse functional and satisfaction outcomes compared to STG. Despite the limitations associated with the surgical management, it is the "gold standard" of care in young active adults that desire to return to pre-injury activity.

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