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Does Anterior Cruciate Ligament Reconstruction prevent or initiate Knee Osteoarthritis? -A critical review

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ABSTRACT

Anterior Cruciate Ligament (ACL) injuries are common in the knee and are often caused by sports injuries. These injuries are common among the young population of the society and are significant causes of morbidity and functional impairment. Arthroscopic ACL Reconstruction (ACLR) is considered as a gold standard in the management of ACL injuries. ACLR has been shown to restore the joint stability, and improve the functional outcome. Nevertheless, the role of ACLR in the prevention of development and progression of osteoarthritis (OA) of the knee has remained controversial. While some authors are of the view that ACLR has a protective effect in the prevention of OA of the knee, others share a contrary view that ACLR potentiates the progression of OA in these operated cases. This research paper aims to review the effects of ACLR in the prevention, development, and progression of OA, alongside other factors that may modulate these effects on patients.

1. Introduction

Anterior Cruciate Ligament (ACL) injuries are common injuries to the knee and the incidence of ACL injuries is increasing due to greater involvement of the younger population in the sports activities.[1] These injuries are common among the young population of the society and are significant cause of morbidity and functional impairment. It is estimated that about 40% of all knee injuries are the ACL injuries.[2] The majority of complete ACL tear are now being treated surgically. However, in some cases with partial ACL tears, patients with low demand, etc. can be treated conservatively.[3] Arthroscopic ACL Reconstruction (ACLR) is considered as a gold standard for the management of ACL injuries.[4] It has been shown to restore the joint stability, and improve functional outcome. Nevertheless, the role of ACLR in the prevention, development, and progression of osteoarthritis (OA) of the knee has remained at best controversial. While some authors are of the view that ACLR has a protective effect in the prevention of OA of the knee, others are of the opinion that ACLR potentiates the progression of OA in these operated cases. This research paper aims to review the effects of ACLR in the prevention, development, and progression of OA, alongside other factors that may modulate these effects on patients.

1.1. Association of ACLR and knee OA

Arthroscopic ACLR, using autograft or allograft is the mainstay in the treatment of ACL injuries.[5–7] Opinions differ in the surgical techniques,[8] but the basic principles which include tunnel placement and graft fixation are universally applicable. The favorite choice of autograft includes patellar tendon, semitendinosus, and gracilis grafts. No autograft variety is found to have an advantage over the other in the protection against the development of OA, whether it is a hamstring or patellar tendon graft that is used.[9] The allografts available for ACLR are a patellar tendon, hamstring tendon, Achilles tendon graft, posterior tibialis tendon as well as the anterior tibialis tendon grafts. Tensions is usually maintained on the graft while bio-screws is used to fix the reconstructed ligament onto the femoral and tibial tunnels in case of bone-patellar tendon-bone (BPTB). The ACLR is widely used in the treatment of ACL injuries because of its proven benefits, like restoration of angular and rotational stability of the joint, restoration of the joint kinematics, improvement of the functional capacity of the patient, and improvement of the patient's well-being.[10–13] However, there is no consensus yet on the role of ACLR in the prevention of OA in the patients that had ACL injuries (Table 1).

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Table 1
Proposed effects of ACLR and Knee OA.

S/N	AUTHORS	YEAR	REFERENCE NUMBER	PROPOSED EFFECT
1	Paschos NK	2017	5	Deleterious
2	Leiter JRS et al.	2013	14	Deleterious
3	Neuman et al.	2008	15	Deleterious
4	Brambilla et al.	2015	16	Deleterious
5	Luc B et al.	2014	23	Deleterious
6	Struewer J et al.	2011	17	Beneficial
7	Lin SH	2017	22	Beneficial
8	Roemer FW et al.	2014	10	None
9	Lohmander LS et al.	2004	20	None
10	Feller J	2004	21	None
11	Magnussen RA	2013	26	None
12	Oiestad BE et al.	2010	28	None

In a study of 74 patients who had ACL injuries over a 12-year follow-up, Leiter et al. discovered that there was radiographic OA in 19% of the reconstructed knees as compared to 4% in the non-reconstructed knees.[14] They, therefore, concluded that individuals who had ACLR had a higher chance of developing OA than the people who did not have repairs.

In a study of 94 patients who had ACLR and were monitored for 15 years, Neuman et al. found that there was a relatively lower prevalence of patella-femoral OA in patients who had non-operative treatment compared to the patients that had an ACLR.[15] Patients treated conservatively had a prevalence of 3% as compared to the ACLR group where prevalence was 26.6%. They, therefore, concluded that ACLR might not be able to prevent the development of OA in ACL injured patients. Several factors (Table 2) have been proposed to increase the risk of development of OA.[16–18] Some of these factors like obesity are intrinsic to the patients while some predate the onset of the injury.

In a 13 year follow-up of 773 patients who had isolated ACL rupture and subsequently had ACLR, it was shown that 20% of the subjects had OA during the period under review.[19] Another study also showed that 6% of 221 subjects that ACLR had OA after being followed up for 12 years while the prevalence was 2.5% in the contralateral non-injured knees.[20] In a similar study of 249 patients who had single bundle ACLR following ACL injury that was monitored over seven-year period showed that the prevalence of radiographic OA in comparison with the contralateral knee was 39%.[21]

Whereas the works above showed that ACLR was to a reasonable extent associated with increased prevalence of OA, but some other works proved to the contrary. Roemer et al. (2014) showed that the prevalence of radiographic tibiofemoral and patella-femoral OA were 12% and 19% respectively in a study of 20 patients that had ACL injuries who were followed up for five years irrespective of the option of treatment used. In a similar study, it was found out that there was no significant difference in the prevalence of OA between the people who had ACLR and those that were treated non-operatively amongst 103 female soccer players who were monitored over a 12 year period.[22] Feller reported that there is no difference in the radiographic outcome between patients treated operatively and those that had conservative management among 238 male soccer players who followed up for 14 years after sustaining ACL injuries.[23] He concluded that ACLR did not protect against the development of OA.

The timing of surgery is also an essential factor that influences the development and progression of OA in ACL injured patients. In a review of 11,921 patients, Lin Sheng-Hsiung et al. pointed out that ACLR can only have a protective effect against the development of OA if the repair is done within one month of injury.[24] According to them, reconstruction done after one month of injuries does not protect against the development of OA. Hence, early arthroscopic ACLR reduces the chances of development and progression of OA in patients with ACL injuries.

1.2. Pathogenesis of ACL injury and knee OA

Osteoarthritis of the knee may be a late complication of ACL injury.[25] Individuals who had ACLR are at higher risk of developing OA than the general population. The exact pathogenic mechanisms through which ACL injuries cause OA are not known. However, some theories that attempt to explain the relationship between ACL injuries and the development of OA have been proposed (Table 3).

Initial impact at the time of the injury is believed to cause injury to the articular cartilage.[26] It is the forerunner of chronic degeneration of the cartilage and subsequently leads to OA. Moreover, there is a defect in the neuromuscular function following ACL injury that causes instability of the knee. In the injured knee, the synoviocytes and chondrocytes are stimulated to produce inflammatory mediators like interleukins 1, 6 and 8 as well as tumor necrosis factor (TNF). These chemical substances are believed to cause degradation of proteoglycans, collagen destruction, and chondrocytes necrosis. The resultant effect of these is the destruction of articular cartilage and subsequent development of OA. Steroids may have a role in the inhibition of these injurious cytokines which may again be tested at large scale. Similarly, the role of biological treatment like platelet-rich plasma (PRP) and stem cells have not been researched extensively. Hence their relevance remains at best experimental.

Changes in the axial loading of the injured are also responsible in the development and progression of OA. It is because an ACL injury causes joint instability which increases shear stress on the menisci and articulating surfaces of the knee and invariably leads to chronic degeneration and development of OA.

Meniscal and cartilage injuries have been implicated in the

Table 2
Factors responsible for increased risk of OA after ACLR.

INHERENT	
1	Concomitant or secondary meniscal tear
2	Concomitant or secondary articular cartilage injury
3	High Body Mass Index (BMI)
4	Older age of the patient at the time of ACLR
5	Metabolic response of the joint to operative trauma
SURGICAL	
1	Operative trauma to the cartilage
2	Menisectomy
3	Post-operative haemarthrosis
4	Post-operative ankylosis
5	Abnormal joint mechanisms following surgery
6	Prolonged inflammation post-operatively

Table 3
Pathogenesis of ACL injury and Knee OA.

Pathogenesis of ACL injury and Knee OA	
1	Concomitant articular cartilage injury
2	A defect in neuromuscular function
3	Production of inflammatory mediators
4	Changes in the axial loading of the knee
5	Concomitant meniscal injury

development and progression of OA in ACL injured knees.[27–30] In a particular study, the prevalence of OA in isolated ACL injury was 13% compared to 48% where there was associated meniscal injuries. Menisectomy either done before ACLR or done concurrently increases the likelihood of developing OA. Menisci help in the maintenance of the anteroposterior stability of the knee joint.[31] Menisectomy reduces the contact area and increases the shear stress on the knee. It also reduces the load-bearing capacity of the joint thereby causing derangements of the structural integrity of the joint. Therefore, ACL injuries in combination with meniscal injuries lead to increased joint instability, distortion of the joint kinematics, as well as causing differential axial loading of the joint. Moreover, a combination of meniscal injury and cartilage increase the chances of developing OA of the knee in ACL injured patients. It is because articular cartilage damage is one of the early events in the development of Knee OA. These entire factors will lead to development and progression of OA in ACL injured patients. Besides, meniscal repair is also found to increase the prevalence of OA. Nevertheless, the intact meniscus is better than absent meniscus. Meniscal repair is preferable to menisectomy with regards to reduction of OA in ACL injured patients undergoing ACLR.

Surgical techniques can also influence the development of OA in ACL injured patients. Although the choice of grafts and tunneling techniques may not play any role in the development of OA, recreating normal biomechanics remains a challenge. A too tight or too lax ligament, abnormal placement of the tunnels, and an iatrogenic injury to the ligament may potentially increase the chances of OA. Surgical outcome improves with experience, and the use of technology will be of much help in reducing the prevalence of OA. Choice of reconstruction method and rehabilitation can better be utilized to improve outcome and therefore reduce the prevalence of OA in ACL injured patients.

The timing of the surgery is also crucial in determining the development of OA. The prolongation of interval time between onset of injury and surgical intervention can lead to increased joint instability. It is because there will be progressive continuous disruption of the intra-articular structures if the repair is not done early enough especially if there are concomitant osteochondral injuries. The chances of development of OA in an ACL injured knee is said to increase at the rate of 0.6% per month of delay. Hence, it is advisable that if repair contemplated, it should be done within one month of injury. Increased length of follow-up also increases the risk of OA. In a study of 249 patients who underwent ACLR following ACL injuries, Li et al. showed that 64.8% of the individuals who had prior menisectomy had OA while 84.2% of the patients that had concurrent menisectomy developed OA. In the same study, only 34.6% of the patients that did not have menisectomy developed OA.

2. Conclusion

Anterior cruciate ligament (ACL) injuries are common in sportsperson especially in the young segment of the population. These injuries often lead to loss of person-hours and reduced functional capacity of the affected individuals. Arthroscopic ACL reconstruction (ACLR) is considered the gold standard of treatment because it gives good functional restoration and improved patients' satisfaction. Contrary to popular belief, an ACLR has been shown not to protect against the development and progression of osteoarthritis (OA) of the affected knee. Development and progression of OA of the affected knee are potentiated in the presence of meniscal or chondral injuries or when surgery of the meniscus is carried out. Hence, we recommend that the patient who had ACL injury should be thoroughly evaluated to rule out associated osteochondral and meniscal injuries. These patients should not only be counseled on the standard of treatment of arthroscopic ACLR but should also be informed that an ACLR may not protect their injured knee against the development of OA. The surgery may even lead to an early onset of OA, especially if the surgery is not done early or if there is presence of meniscal and osteochondral injuries.

Conflicts of interest

The authors declare that there is no conflict of interest.

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