

Original Research Article

Timing of anterior cruciate ligament reconstruction and its effect on associated chondral damage and meniscal injury: a prospective observational study

Saroj Kumar Patra¹, Nikhil Unnava^{1*}, Bishnu Prasad Patro², Sarthak Mohanty³

¹Department of Trauma and Emergency (Orthopedics), ²Department of Orthopaedics, All India Institute of Medical Sciences, Bhubaneswar, Orissa, India

³Department of Orthopedics, IMS and SUM Hospital, Bhubaneswar, Orissa, India

Received: 24 April 2023

Revised: 01 June 2023

Accepted: 03 June 2023

*Correspondence:

Dr. Nikhil Unnava,

E-mail: nikhilunnava@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Following an anterior cruciate ligament (ACL) tear, associated injuries in the knee involving menisci and articular cartilage increase with time. This study was performed to assess the distribution of secondary injuries after an ACL tear with time and identify a suitable timing for the reconstruction surgery.

Methods: 74 patients with an ACL tear were divided into three groups based on time since injury- less than six months, six months to one year, and greater than one year. The odds of finding each lesion in every group were calculated and tested for statistical significance. Receiver operating characteristic curves (ROC) were drawn to predict individual lesions with time since injury. The diagnostic performance and statistical significance of these tests were identified.

Results: The odds of finding all lesions were greater than one after a year of ACL tear but only chondral damage was statistically significant ($p=0.025$). Poor diagnostic accuracy was observed for medial meniscal injury even after three years of an ACL tear. Chondral injury showed a good area under the curve (0.817) which predicted chondral damage with a sensitivity of 62% at a cut-off of three years after the ACL injury.

Conclusions: After three years of ACL tear, meniscal injuries could not be accurately predicted. However, a significant rise in chondral injuries could be seen and predicted accurately with good sensitivity. There could be a role of MRI or arthroscopy to assess the extent of injury of articular cartilage in patients who do not undergo ACL reconstruction after this time.

Keywords: Anterior cruciate ligament injury, Cartilage damage, Lateral meniscus, Medial meniscus, Sports injury

INTRODUCTION

Anterior Cruciate ligament (ACL) injuries are one of the most common sports-related injuries in Orthopedic surgery.^{1,2} There is literature that suggests the increased incidence of medial meniscus injuries with increasing time to reconstruction surgery.³⁻⁶ Early surgery, however, before attaining a good knee range of motion and quadriceps strength is associated with arthrofibrosis and poor results.^{7,8} Due to the close proximity, the lateral meniscus is a common structure injured with an acute ACL

tear.^{3,9,10} Anterior cruciate ligament tears cause a change in the normal biomechanics of the knee thereby predisposing it to other injuries. The medial meniscus is known to serve as a restraint to anterior tibial translation. With an ACL deficiency, there is evidently increased stress on the meniscus which leads to chronic injury or tear.^{11,12} Altered biomechanics is also responsible for cartilaginous damage over time with chondral lesions leading to osteoarthritic changes.¹³⁻¹⁵ Since these associated injuries are time-based, our study was done to find the periods at which each type of injury is common and how patients present at

different time points. Secondly, there is no consensus regarding the ideal time for surgery. We attempted to identify the risk of having a secondary lesion with time and perform an analysis to predict a suitable timing of the surgical intervention.

METHODS

The approval for this study was given by the Institutional Review Board/ Ethical Committee at the All India Institute of Medical Sciences (AIIMS), Bhubaneswar vide T/IM-NF/T&EM/18/67 dated 31st May 2019. It was a prospective study performed at a single center- All India Institute of Medical Sciences (AIIMS), Bhubaneswar, India, with all cases operated by two senior surgeons. It was conducted from October 2019 to September 2021. A total of 74 participants were enrolled after obtaining an informed consent.

Inclusion criteria included those patients with a history of injury to their knee, who were diagnosed with an ACL tear by the authors after clinical and radiological examination. Those patients requiring a reconstruction surgery were enrolled. Participants of ages 20-60 were included.

The time since injury was noted for all subjects and divided into three groups- less than six months, six months to one year and more than one year. Stress was given to a major twisting injury of knee, associated with hemarthrosis, popping sound etc. for calculation of time since injury. Subjects having previous knee surgeries, absence of a history of trauma and stiff knees were excluded. Injuries not of menisco-chondral character like posterior cruciate ligament (PCL) injury, posterolateral corner (PLC) injuries etc. were also not part of the study. A standard diagnostic arthroscopy was performed at the beginning of surgery and the following observations were noted. Associated meniscal tears- both lateral and medial if present were classified based on location. A note was made on the presence and extent of chondral damage associated. All patients underwent a double bundle ACL reconstruction. Hamstring autograft (semitendinosus and gracilis) was the graft of choice. The graft was placed into the joint using a trans-tibial tunnel and a suspensory method of fixation using endobutton was used to hold it in place. All patient details regarding demographic data, time since injury, associated lesions as seen on MRI and arthroscopy etc. were tabulated.

Statistical analyses were performed to identify the mean and standard deviations of these demographic data. Medial, lateral meniscal tears and chondral injuries were separated and the distribution of participants with these injuries were further subclassified based on time since injury i.e., less than six months, six months to one year and greater than one year.

Regression analysis was performed to obtain an odds ratio. Each lesion i.e., medial, lateral meniscus and chondral damage was assessed separately. In addition, any

secondary lesion after the ACL tear was also assessed. With each of these being the dependent variable, the odds of finding a lesion in the different time intervals was calculated. A significance value was calculated for the same. For example, the odds of finding a medial meniscal lesion in the >12 months interval was 1.58 with a p value of 0.4. Prediction of the different lesions with time was done by drawing receiver operating characteristic curves (ROC). A cutoff value was determined separately for each lesion and area under the ROC curve was calculated. This provided the diagnostic accuracy of the prediction. In addition, sensitivity and specificity value were obtained and tests were performed to check for statistical significance.

RESULTS

There was a total of 80 patients enrolled in the study. Six patients did not give consent for further participation, so a total of 74 patients were included. There were 69 males and five female participants. The mean age of the population was 31.82±2.02. All patients showed a positive Lachman positive test and anterior drawer test. The pivot shift test was positive in 40 subjects. The time since injury was less than six months in 25 subjects (33.7%), six months to one year in 12 (16.2%) and more than one year in 37 subjects (50%) (Table 1). The mean time since injury was 79.8919±24.087 weeks. However, in patients with a secondary lesion, the mean time to surgery was 113.70±138.61 weeks. The total number of patients with any associated injuries along with ACL tear were 37 (50%). 20.3% (15) of the participants had lateral meniscal injury, 32.4% (24) of the participants had medial meniscal injury and 21.6% (16) of the participants had an associated chondral damage.

Table 1: Distribution of lesions in different time intervals.

Parameters	Time to surgery (months)			p value
	<6 (n=25) (%)	6-12 (n=12) (%)	>12 (n=37) (%)	
LM damage	4 (16.0)	1 (8.3)	10 (27.0)	0.303
MM damage	7 (28.0)	3 (25.0)	14 (37.8)	0.601
Chondral damage	2 (8.0)	1 (8.3)	13 (35.1)	0.019
Any secondary lesion	10 (40.0)	4 (33.3)	23 (62.2)	0.104

Table 2 Association between time to surgery (weeks) and parameter.

Parameters	Time to surgery (weeks)	P value
LM damage	148.67±192.40	0.035
MM damage	117.33±159.07	0.173
Chondral damage	181.75±183.99	<0.001
Any secondary lesion	113.70±138.61	0.012

The mean time to surgery with patients having lateral meniscal injury was 148.67±192.40, in patients with medial meniscal injury was 117.33±159.07 and those with chondral damage was 181.75±183.99. It was seen that with an increase in time to surgery, there was a positive association of all variables. There was a significant

positive association with the variables- lateral meniscus injury, chondral injury and any secondary lesion (Table 2). Both lateral and medial meniscal injuries showed an increasing trend in the first six months of ACL injury, followed by a dip in incidence during 6-12 months and a second spike after 12 months.

Table 3: Prediction analyses results of different lesions.

	Cut off value (weeks)	Area under the curve	Sensitivity	Specificity	Diagnostic accuracy
Any secondary lesion	≥111 (0.012)	0.671 (0.544 - 0.798)	43.2% (27-61)	91.9% (78-98)	67.6% (56-78)
Medial meniscus	≥156 (0.173)	0.599 (0.443 - 0.755)	33.3% (16-55)	94.0% (83-99)	74.3% (63-84)
Lateral meniscus	≥111 (0.035)	0.678 (0.511 - 0.844)	60.0% (32-84)	83.1% (71-92)	78.4% (67-87)
Chondral injury	≥156 (<0.001)	0.817 (0.677 - 0.957)	62.5% (35-85)	98.3% (91-100)	90.5% (81-96)

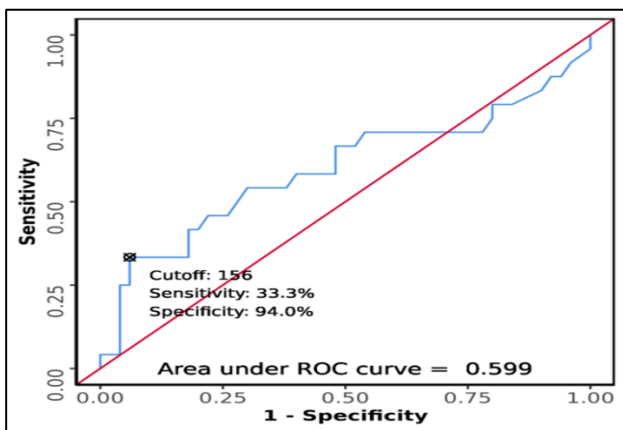


Figure 1: Receiver operating characteristic (ROC) curve analyses showing diagnostic performance of time to surgery (weeks) in predicting medial meniscus injury.

The area under the ROC curve (AUROC) for time to surgery (weeks) predicting medial meniscal damage was 0.599 (95% CI: 0.443-0.755), thus demonstrating poor diagnostic performance. It was not statistically significant (p=0.173). At a cut-off ≥156 weeks, it predicted medial meniscal damage with a sensitivity of 33%, and a specificity of 94%. The cut off and the diagnostic parameters reported were not reliable as the test was not statistically significant (Figure 1 and Table 3). The curve

values for predicting lateral meniscal injuries were poor in diagnostic value.

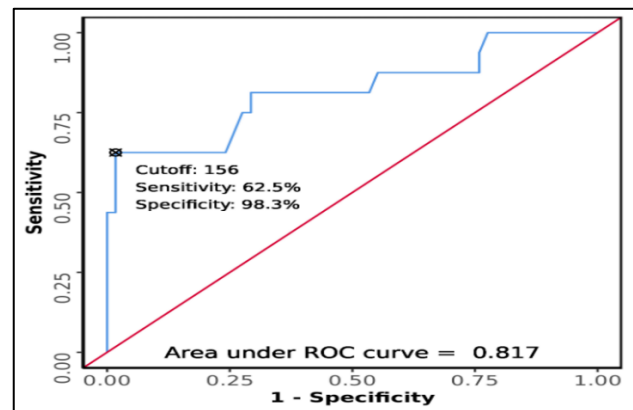


Figure 2: Receiver operating characteristic (ROC) curve analysis showing diagnostic performance of time to surgery (weeks) in predicting chondral damage.

The area under the ROC curve for time to surgery(weeks) predicting chondral damage was 0.817(95% CI: 0.677-0.957), thus predicting good diagnostic performance. It was statistically significant (p<0.001). At a cut off value of >156 weeks it predicted chondral damage with the sensitivity of 62% and specificity of 98% (Figure 2 and Table 3).

Table 4: Regression Analyses for variables with time since injury- showing their odds ratio and p values.

	Medial meniscus		Lateral meniscus		Chondral injury	
	Odds ratio	P value	Odds ratio	P value	Odds ratio	P value
Less than 6 months	1.01	0.078	1.01	0.037	1.02	<0.001
6 months to one year	0.86	0.848	0.48	0.53	1.05	0.972
More than one year	1.57	0.423	1.94	0.313	6.23	0.025

Table 5: Basic demographics of the study population.

	<6 months	6-12 months	>12 months
Mean age	27.9	32.4	35.1
Sex distribution	21 male, 1 female	29 Male, 3 females	19 male, 1 female
BMI	28.4	27.5	27

DISCUSSION

The timing of ACL surgery is important as it may affect clinical outcomes of patients.^{7,14,16} There is a debate regarding the ideal timing of surgery in literature, but it can be stated that the decision of timing depends on a multitude of factors. While early operative interventions show a high incidence of arthrofibrosis, an excessive delay may lead to quadriceps wasting in the absence of physiotherapy and secondary associated lesions in the long term. There is little evidence regarding the time elapsed from the ACL tear to the secondary lesions.

It is famously said that the fate of the ACL deficient knee is decided at the time of the initial insult itself despite the differences of treatment chosen.¹⁷⁻¹⁹ However the importance of ACL reconstruction surgery in the prevention and delay of osteoarthritis of the knee has been shown in multiple studies.^{20,21} Early surgery may prevent the development of secondary lesions in the knee such as meniscal tears and cartilaginous injuries.

Our study contains only five female participants thus a conclusion based on sex of the individual cannot be made.

An initial rise of both meniscal injuries in first six months of ACL tear could be explained by the associated insult during the time of the ACL injury itself. The accompanying pain, reduced mobility and performance is the probable cause for patients considering surgery. Razi et al¹⁴ showed that the risks of meniscal injury after ACL tears was as early as three months and therefore suggesting an early surgery. A dip in the 6-12 months period of the number of participants in our study could be explained by the attempt to cope with the injury as the pain is insignificant and mobility improves along with a good knee range of motion. It is to be noted that this population constitutes the major chunk of undiagnosed disease in the community. Screening of this category can help in early identification of the pathology and prevent worsening of associated injuries. The final category of more than 12 months shows a second rise of participants who presented for surgery. As time progresses, instability is the predominant problem which could be troublesome not only during vigorous activities but also during simple walking on level ground. Multiple pointers show an increased trend of associated secondary injuries after an ACL tear with passage of time.

Regression analysis for any secondary lesion with time in our study showed an odds ratio of 2.46. This not only

means more difficult surgeries due to the need to repair more structures of the knee but also an increase in cost to the patient. This is in concordance with Hur et al who showed that early ACL reconstruction performed helps save the meniscus without many complications.²² There is also a chance of higher hospital stay and an increase in frequency of visits to physiotherapy clinics. This overall increase in morbidity is a burden to the healthcare system. Mather et al showed the increased cost effectiveness of early ACL reconstruction from a health system perspective.²³

Another finding in our study in the relatively lower number of medial meniscal injuries in the 6-12 months period. Meniscal tears after an ACL injury are known to be prevalent, but it could be that the pathology would tend to occur later than 12 months of injury.^{3,5,6} To prove this and identify a time span for predicting Medial meniscal injury, a ROC curve was drawn. The cut off value was found to be 156 weeks (three years). However even at this time point, the sensitivity of predicting a medial meniscal lesion was 33%. The cut off value and parameters were thus poor diagnostic predictors of injury. While the odds of meniscal injury increase with time to as high as seven times after the three years of injury, the chance of predicting it with a high sensitivity remains a problem. Thus, an exact time period after ACL injury at which medial meniscus injuries could be predicted, could not be obtained in our study.

An important outcome of our study came in the results of chondral damage after ACL injury. In the first year of injury, the odds of chondral damage are relatively low (up to 1.05), but after 12 months it increased to 6.23, which was a statistically significant (p=0.025) (Table 4). In the ROC, the cutoff value obtained was three years (156 weeks). At the three-year mark, the area under the curve becomes 0.817 and achieves a statistical significance of <0.001. It predicts the chondral damage with a sensitivity of 62% which demonstrates good diagnostic performance due to statistical significance.

While copers of ACL injury adapt to activities of daily living well as time passes, the above facts show that meniscal injuries are difficult to predict after injury. Campos et al showed in a case series that the risk of meniscal injury became greater with a delay in surgery of 6 months and after one year, the risk of cartilage injury was significantly higher.²⁴ There could be an importance of clinical examinations at specific intervals. To screen for the same. Positive clinical signs like joint line tenderness, positive McMurray’s test etc. will then be an indication for a fresh MRI scan and further intervention. At the three-

year interval chondral changes begin to appear more commonly. This shows a relevance of an MRI scan or diagnostic arthroscopy after three years of ACL injury in patients who do not undergo reconstruction surgery to look for developing cartilaginous lesions in the knee. These lesions if found, have to be tackled according to the size, grade and extent.²⁵

An important confounder in our study is that the time since injury is taken based on patient history. Patients presenting late may not have all the relevant documents or radiological scans from previous visits, or they may never have consulted with an orthopedic surgeon before. Thus, in some cases it is hard to predict if the injury in question has occurred at the time of the initial trauma or if it has developed because of the ACL injury. Secondly, no comments could be made on the differences in nature of injuries in opposite sexes

CONCLUSION

The results in our study are consistent with literature in terms of the increased odds of associated injuries with time after an ACL tear. However, we were able to spot a specific pattern or dip in the six months to one year period. Lateral and medial meniscal injuries could not be accurately predicted even after three years of surgery. The importance of the increasing rates of chondral injury after three years could be studied and the nature of these lesions could be identified. A larger study with similar aims can also help with corroborating the results of our study. Patients may choose to avoid a surgery due to various reasons like fear, poor counselling, or financial constraints.

Recommendations

We recommend that such patients and the patients who can cope with the injury get an elective follow up which includes a screening for cartilaginous injury at an interval of three years after injury. This may be in the form of an MRI or arthroscopy so that an intervention, if required may be offered to patients to prevent further injuries.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee All India Institute of Medical Sciences (AIIMS), Bhubaneswar vide T/IM-NF/T&EM/18/67 dated 31st May 2019

REFERENCES

- Moses B, Orchard J, Orchard J. Systematic review: annual incidence of ACL injury and surgery in various populations. *Res Sports Med.* 2012;20(3-4):157-79.
- Montalvo AM, Schneider DK, Webster KE, Yut L, Galloway MT, Heidt RS, et al. Anterior cruciate ligament injury risk in sport: a systematic review and meta-analysis of injury incidence by sex and sport classification. *J Athlet Train.* 2019;54(5):472-82.
- Bellarbarba C, Bush-Joseph CA, Bach BR. Patterns of meniscal injury in the anterior cruciate-deficient knee: a review of the literature. *Am J Orthop.* 1997;26(1):18-23.
- Hagino T, Ochiai S, Senga S, Yamashita T, Wako M, Ando T, et al. Meniscal tears associated with anterior cruciate ligament injury. *Arch Orthop Trauma Surg.* 2015;135(12):1701-6.
- Hagmeijer MH, Hevesi M, Desai VS, Sanders TL, Camp CL, Hewett TE, et al. Secondary meniscal tears in patients with anterior cruciate ligament injury: relationship among operative management, osteoarthritis, and arthroplasty at 18-year mean follow-up. *Am J Sports Med.* 2019;47(7):1583-90.
- Venkataraman S, Ethiraj P, Shanthappa AH, Vellingiri K. Association of meniscus injuries in patients with anterior cruciate ligament injuries. *Cureus.* 2022;14(6).
- Shelbourne KD, Wilckens JH, Mollabashy A, DeCarlo M. Arthrofibrosis in acute anterior cruciate ligament reconstruction. The effect of timing of reconstruction and rehabilitation. *Am J Sports Med.* 1991;19(4):332-6.
- Mayr HO, Weig TG, Plitz W. Arthrofibrosis following ACL reconstruction--reasons and outcome. *Arch Orthop Trauma Surg.* 2004;124(8):518-22.
- Cipolla M, Scala A, Gianni E, Puddu G. Different patterns of meniscal tears in acute anterior cruciate ligament (ACL) ruptures and in chronic ACL-deficient knees. *Knee Surg Sports traumatol Arthrosc.* 1995;3(3):130-4.
- Feucht MJ, Bigdon S, Bode G, Salzmänn GM, Dovi-Akue D, Südkamp NP, et al. Associated tears of the lateral meniscus in anterior cruciate ligament injuries: risk factors for different tear patterns. *J Orthop Surg Res.* 2015;10(1):34.
- Kawamura S, Lotito K, Rodeo SA. Biomechanics and healing response of the meniscus. *Operat Tech Sports Med.* 2003;11(2):68-76.
- Nesbitt RJ, Herfat ST, Boguszewski DV, Engel AJ, Galloway MT, Shearn JT. Primary and secondary restraints of human and ovine knees for simulated in vivo gait kinematics. *J Biomech.* 2014;47(9):2022-7.
- Gupta P, Swaroop S, Arya R. Evaluation of associated meniscal and chondral injuries in patients undergoing arthroscopic anterior cruciate ligament reconstruction. *JASSM.* 2021;2(1):34-40.
- Razi M, Salehi S, Dadgostar H, Cherati AS, Moghaddam AB, Tabatabaiaand SM, et al. Timing of anterior cruciate ligament reconstruction and incidence of meniscal and chondral injury within the knee. *Int J Prev Med.* 2013;4(1):S98-103.
- Pike AN, Patzkowski JC, Bottoni CR. Meniscal and chondral pathology associated with anterior cruciate ligament injuries. *J Am Acad Orthop Surg.* 2019;27(3):75-84.

16. Anstey DE, Heyworth BE, Price MD, Gill TJ. Effect of timing of ACL reconstruction in surgery and development of meniscal and chondral lesions. *Phys Sportsmed*. 2012;40(1):36-40.
17. Nebelung W, Wuschech H. Thirty-five years of follow-up of anterior cruciate ligament-deficient knees in high-level athletes. *Arthroscopy J Arthrosc Rel Surg*. 2005;21(6):696-702.
18. Fithian DC, Paxton EW, Stone ML, Luetzow WF, Csintalan RP, Phelan D, et al. Prospective trial of a treatment algorithm for the management of the anterior cruciate ligament-injured knee. *Am J Sports Med*. 2005;33(3):335-46.
19. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part I. *Am J Sports Med*. 2005;33(10):1579-602.
20. Meunier A, Odensten M, Good L. Long-term results after primary repair or non-surgical treatment of anterior cruciate ligament rupture: a randomized study with a 15-year follow-up. *Scand J Med Sci Sports*. 2007;17(3):230-7.
21. Ichiba A, Kishimoto I. Effects of articular cartilage and meniscus injuries at the time of surgery on osteoarthritic changes after anterior cruciate ligament reconstruction in patients under 40 years old. *Arch Orthop Trauma Surg*. 2009;129(3):409-15.
22. Hur CI, Song EK, Kim SK, Lee SH, Seon JK. Early anterior cruciate ligament reconstruction can save meniscus without any complications. *Indian J Orthop*. 2017;51(2):168-73.
23. Mather RC, Hettrich CM, Dunn WR, Cole BJ, Bach BR, Huston LJ, et al. Cost-effectiveness analysis of early reconstruction versus rehabilitation and delayed reconstruction for anterior cruciate ligament tears. *Am J Sports Med*. 2014;42(7):1583-91.
24. de Campos GC, Nery W, Teixeira PEP, Araujo PH, Alves W de M. Association between meniscal and chondral lesions and timing of anterior cruciate ligament reconstruction. *Orthop J Sports Med*. 2016;4(10):2325967116669309.

Cite this article as: Patra SK, Unnava N, Patro BP, Mohanty S. Timing of anterior cruciate ligament reconstruction and its effect on associated chondral damage and meniscal injury: a prospective observational study. *Int J Res Orthop* 2023;9:770-5.