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ACL Injuries In Young Athletes: The Culprit And The Time Lost! A Prospective Correlation Analysis of Anterior Cruciate Ligament Injuries with Meniscal and Chondral Lesions

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Abstract

Background: Anterior cruciate ligament (ACL) injuries impair quality of life of an athlete with the possibility of osteoarthritis if left untreated. The aims of the study were to analyse the pattern of chondral and meniscal injuries and the temporal association of severity of these injuries with delay in ACL reconstruction.

Material and Methods: In this prospective study, patients who underwent knee arthroscopy from Jan 2015 to Dec 2018 for clinico-radiologically diagnosed ACL tear were included in the study. Mode of injury, time from injury (TFI) to ACL reconstruction and intraoperative findings of chondral lesions, meniscal tears and other intra-articular injuries was recorded. The association between the index injury and whether there was any significant correlation between TFI, severity of chondral and meniscal lesions and mode of injury were analysed.

Results:429 male and 15 female athletes were included in the study with a mean age of 28.98±7.08 years,53.6% of patients in the 26–35 years age group. Twisting during running events was the most common mode of injury in 139(31.3%) patients. Mean TFI was 55.35±23.84(14-129) weeks. There was a significant correlation between the grade of the chondral lesion and TFI ($p < 0.0001$) as all grade III and IV chondral lesions were observed with a mean TFI of 69.9±4.23 weeks. The odds of finding a medial meniscus tear associated with a complete ACL tear were statistically significant when TFI was more than 59.3 weeks.

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There was a significant correlation between the incidence of medial compartment chondral injury and medial meniscus tear at a mean TFI of 55.3 weeks(p=0.007,OR=1.90) without significant correlation between lateral compartment chondral injury and lateral meniscus tear (p=0.91, OR=1.03).There was no significant correlation between a particular mode of injury and ACL tear.

Conclusions: The delay in treatment of ACL injuries greater than 70 weeks leads to higher grade chondral lesions and complex meniscal injuries in young athletes that can be avoided with early management of an ACL deficient knee.

Keywords: Anterior cruciate ligament; chondral lesions; meniscus; injury; time from injury

Introduction

The role of the anterior cruciate ligament (ACL) is to identify the changes in direction of movement, the knee joint position, the changes in rigidity of joints, and speed and acceleration of movement (1). Injuries to ACL are serious complications affecting athletes (2); however, due to the immense diversity in its pathophysiology still, studies focused on a better understanding of this complication are being conducted (3, 4). It is well reported that ACL tears are linked to injuries of the cartilage and the meniscus. However, the natural outcome of such an injury is still controversial, to some extent with regard to the concomitant injury pattern in the athlete's knee. The rate of incidence of ACL injuries varies from 0.03% in the general population to 0.15%-3.7% in athletes (5). A 10-fold higher incidences of ACL injuries is reported among US military service members due to extensive physical exercises (6).

The functional level of an athlete after an injury to ACL is presumed to be compromised unless managed surgically and osteoarthritis as a consequence in such an injury in long term has been a contention (7) which still is speculative. The question arises, whether an ACL deficient knee will follow the same natural history in each athlete. Moreover, a bias exists in predicting the natural outcome of an ACL deficient knee, which is primarily due to the delay in arthroscopic evaluation of such injuries, which reveals meniscal or articular cartilage injuries in large majority of these injuries (8). There is a gap in understanding if any knee injury in athletes have a predictive correlation to the development of a meniscal tear or chondral injury in an ACL deficient knee which worsens with delay in the treatment of ACL tear and eventually osteoarthritis of knee that has been studied previously by various authors (9, 10). The quest for arriving at a consensus on which day after an ACL injury is an ideal time to reconstruct is still unresolved, though there is a consensus that the delay in ACL reconstruction aggravates injury to the menisci and the articular cartilage. In this study, we aim to analyse the factors which might lead to an arthroscopic evaluation of a knee injury in a young athlete and the possibility of developing concomitant intra or extra articular lesions at the initial episode or as a delay in management of the injury. The authors hypothesized that majority of injuries to athletes in are due to either running or a jumping and there is a very high probability of developing an articular cartilage lesion or a meniscal tear if the time from initial injury to the arthroscopic evaluation increases.

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Material and Methods

The present study is a prospective single centre study. The institutional ethics committee approval was taken before analysis of data pertaining to knee arthroscopy procedures conducted at tertiary care orthopaedic and sports injury centre from Jan 2015 to Dec 2018.

The study included data recording, compilation and statistical analysis of all the patients who underwent arthroscopy of knee. All those patients' data was included in the study who were taken up for knee arthroscopy following an episode of knee injury. Exclusion criteria were arthroscopy of knee for atraumatic knee disorders, polytrauma, ipsilateral lower limb injuries, concomitant proximal tibial or distal femoral fractures, bilateral knee injuries, more than 40 years or younger than 15 years of age, previous history of knee surgery, infection and paediatric musculoskeletal injuries.

Patient details like mode of injury, symptoms, clinical finding and clinical diagnosis, MRI findings, time from injury (TFI) were recorded. The findings of the arthroscopic evaluation were recorded in the format of a complete or partial ACL tear, PCL tear, tear of lateral or medial meniscus, articular cartilage lesion, tear of collateral ligaments and other significant arthroscopic findings. The articular cartilage lesion was mapped as per the geographic location in femur, tibia or patella and the lesion was classified according to the modified Outerbridge system of articular cartilage injuries of knee classification. The data analysis was carried out to ascertain the epidemiology of the cohort with respect to the mode of injury, the prominent arthroscopic findings and the correlation of the arthroscopic diagnosis with the mode of injury, the time from injury, the association and correlation between the various intra-articular lesions along with the trend of evolving injury, if any with relation to the delay in undergoing the arthroscopic surgery. For the purpose of statistical analysis, TFI was divided into time intervals. The data was not analysed with respect to the therapeutic procedure performed during the arthroscopy and the bearing of the same on the outcome of the patient function and disability.

Statistical Analysis

All statistical analyses were performed using SPSS for Windows, version 21.0 (SPSS, Chicago, Illinois). Categorical variables were summarized by frequency distribution for each categorical component (relative frequencies and percentage). Results were reported as mean±standard deviation for continuous variables and as number (%) for nominal variables.

Results

The prospective data collection recruited a total of 479 patients. However, the cohort sample size was 444 patients after application of exclusion criteria. The cohort consisted of 429 males (96.6%) and 15 females (3.4%). The mean age of the cohort was 29.69 years (15–54 years), 238 (53.6%) patients in age group of 26 to 35 years and 128 (28.8%) patients in age group of 15 to 25 years. The analysis of the mode of injury which led to the knee injury revealed the most common cause to be twisting injury during running as reported in 139 (31.3%) patients, followed by 88 (19.8%) patients who got injured while jumping across a ditch during the sports training and the least frequent cause was due to falling as reported in 65 (14.6%) patients. The less common modes of injury were reported to be due to football in

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51 (11.5%) patients followed by 28 (6.3%) patients each due to basketball, wrestling, injury sustained in road traffic accident, and injury while playing kabaddi (3.8%) **(Table 1).**

The arthroscopic findings presented in **Table 2** revealed that 400 (90.1%) patients had a tear of ACL, out of which 229 (51.6%) patients had a complete tear of ACL whereas 171 (38.5%) had a partial or single bundle tear of ACL. There was tear in lateral meniscus in 92 (20.7%) patients and 124 (27.9%) patients had tear in medial meniscus. On further analysis of meniscal tears, 47 (51%) of lateral meniscus tears were reported to be either flap or complex tears. However, the medial meniscal tears were predominantly longitudinal (bucket handle tears) in 54 (67.7%) out of 124 patients. Fourteen (3.2%) patients had a tear in posterior cruciate ligament (PCL) and 9(2%) patients had an abnormal plica.

The analysis of knee injuries presented in **Figure 1** revealed that complete ACL tear, partial ACL tear and PCL tear were reported in 229, 171, and 14 patients. Medial meniscus tear was observed in 124. In femoral, tibial and patellar chondral lesions, the maximum patients were observed to have grade II lesions.

The analysis of the time from injury (TFI) in weeks to the arthroscopic surgery was carried out in an interval-based manner of 16 weeks. The mean TFI was 55.35±23.84 weeks (8 to 130 weeks). The maximum number of patients, 109 (24.5%) were in TFI interval of 49–64 weeks followed by 98 (22.1%) patients each in TFI interval of 33 to 48 weeks and 65 to 89 weeks. There were only 22 (5.0%) patients in TFI interval of less than 16 weeks, 60 (13.5%) patients in TFI interval of 17 to 32 weeks and one (0.2%) patient who underwent arthroscopy more than 128 weeks from time of injury (**Table 4**).

The distribution of articular cartilage (chondral) injuries was assessed and mapped as per the geographic location within the femoral, tibial, and patellar articular surfaces. There were 143 (32.2%) patients with chondral lesions in femoral articular surface, 114 (79.7%) had a lesion in medial femoral condyle and 29 (20.27%) patients had a lesion in lateral femoral condyle. The distribution of chondral lesions in tibial articular surface was in 96 (21.6%) patients, 39 (40.6%) in medial tibial plateau and lateral tibial plateau chondral lesions were present in 57(59.3%) patients. There were 112 (25.2%) patients with patellar chondral lesions, 70(62.5%) lesions in medial patellar facet and 42 (37.5%) lateral patellar facet lesions. Table 4 shows the distribution of grade of chondral lesion in each compartment. On analysis of the chondral injuries, grade II lesions observed in femur, tibia and patella was 17.5%, 12.8%, and 16.2%, respectively.

The statistical analysis of the mean TFI (in weeks) as per the grades of chondral lesions in femur when subjected to ANOVA showed a statistically significant correlation ($p < 0.0001$) between the higher grade of chondral lesion with a higher TFI; patients with grade I lesions had a mean TFI of 15.65 weeks whereas grade IV lesions were found in patients with a mean TFI of 70.63 weeks. A similar pattern of chondral lesion grade in tibial plateau when correlated with TFI showed a statistically significant ($p < 0.0001$) association, grade I lesions were noted in patients with TFI of 58.35 weeks whereas 77.50 weeks was the mean TFI in patients with grade IV lesions (ANOVA 13.36). The data was subjected to analyse the correlation between the ACL tear, chondral lesion and TFI. There was significant association between grades of chondral injury of femur, tibia and patella with time from injury. As the time from injury increases there is deterioration in chondral surface and worsening of grades of chondral injury.

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ACL tear and mode of injury

There is no association between ACL tear (complete or partial) and jumping as the mode of injury. Chance of sustaining ACL tear as compared to other modes of injury is same.

ACL tear and age of subject

There is no association between ACL tear (complete or partial) and age of subjects. There is no difference in the mean age of patients who have sustained ACL tear and those who have not, in subjects with knee injury.

ACL tear and medial tibial chondral injury

There is a significant association between medial tibial chondral injury and complete ACL tear. 36% chance of medial tibial chondral injury if ACL tear present against a 53% chance of not having medial tibial chondral injury if ACL tear is present.

Complete ACL tear and medial compartment injury

There is a significant association between medial compartment injury and complete ACL tear. 41% chance of medial compartment injury if ACL tear present against a 55% chance of not having medial compartment injury if ACL tear is present.

Partial ACL tear and medial compartment injury

There is no significant association between partial ACL tear and Medial compartment injury. Though there is more chance of having a medial compartment injury against not having a medial compartment injury, if there is a partial ACL tear but it is not statistically significant.

Complete ACL tear and lateral femoral chondral injury

There is a significant association between lateral femoral chondral injury and complete ACL tear. 27% chance of lateral tibial chondral injury if ACL tear present against a 54% chance of not having lateral tibial chondral injury if ACL tear is present.

Complete ACL tear and lateral tibial chondral injury

There is a significant association between lateral tibial chondral injury and complete ACL tear. 37% chance of lateral tibial chondral injury if ACL tear present against a 54% chance of not having lateral tibial chondral injury if ACL tear is present.

Complete ACL tear and lateral compartment injury

There is a significant association between lateral compartment injury and complete ACL tear. 38% chance of lateral compartment injury if ACL tear present against a 56% chance of not having lateral compartment injury if ACL tear is present.

Partial injury and lateral tibial chondral injury

There is a significant association between lateral tibial chondral injury and Partial ACL tear. 51% chance of lateral tibial chondral injury if ACL tear present against a 37% chance of not having lateral tibial chondral injury if ACL tear is present.

Partial ACL injury and lateral compartment injury

There is a significant association between lateral compartment injury and Partial ACL tear. 49% chance of lateral compartment injury if ACL tear present against a 35% chance of not having lateral compartment injury if ACL tear is present.

Having a Partial ACL tear increases the chances of lateral tibial chondral injury and lateral compartment injury which is statistically significant (Odds Ratio more than 1).

There is a significant association between medial meniscus tear and medial femoral chondral injury and medial tibial chondral injury. Overall, if there is a medial meniscus tear then there

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is significant chance that an associated medial compartment injury is also present, most likely in medial femoral condyle or medial tibial condyle.

There is a no significant association between lateral meniscus tear and lateral compartment injury. If Partial ACL tear is present then there is a statistically significant chance of medial meniscus tear not occurring (OR is less than 1). If Complete ACL tear is present then there is a statistically significant chance of medial meniscus tear also occurring (OR is more than 1).

There is a significant association between medial meniscus tear and medial femoral chondral injury and medial tibial chondral injury. Overall, if there is a medial meniscus tear then there is significant chance that there is an associated medial compartment injury, most likely in medial femoral condyle or medial tibial condyle **(Table 5).** No significant association was observed between lateral meniscus tear and lateral compartment injury. A significant association between Partial and Complete ACL tear and medial meniscus tear was observed **(Table 6 and 7).**

Discussion

ACL injuries are life changing events for the young athletes and might cause recurrent incidences of instability and may lead to secondary injury to the menisci and the cartilage (11); increasing the risk of tears in the medial meniscus, which plays a pivotal role in load bearing and shock absorption (12).

In our study, injuries due to twisting were the most common reason for ACL among the study population. This study establishes that a higher grade of chondral lesions (grade III and IV) was observed in patients with a TFI of 69.9 ± 4.23 weeks to ACL reconstruction and also demonstrated that in TFI more than 59.3 weeks, the odds of finding a medial meniscus tear along with complete ACL tear was statistically significant. Similar to the study by Gupta et al (Gupta article), at mean TFI of 55.3 weeks, a significant correlation was observed between incidence of medial compartment chondral injury and medial meniscus tear. However, for lateral compartment chondral injury and lateral meniscus tear, no significant correlation was observed. TFI is an important predictor for grade III and grade IV chondral lesions (10).

Previous studies have reported a link between ACL tear and chondral and medial meniscal tear (13). The present study reported 27.9% medial meniscal tears. Lee et al., have reported 44% medial meniscal tears in their study on patients who had undergone ACL reconstruction due to ACL tears (n=174) (14). A few studies have reported incidences of medial meniscus tears associated with ACL tears to be around 51.9-63% (15, 16). However, a recent study by Keyhani et al have reported 44.4% incidences of meniscus tears after ACL injury. Similar to our study, Keyhani et al have also reported maximum incidence of bucket handle tears among the population with meniscus tears (17) and an increase in TFI are reported to be linked to higher incidences of medial meniscus tears (18). In the present study, a TFI of more than 59.3 weeks was found to be associated with higher risks of medial meniscus tears. Analysis of the association between medial compartment injury and medial meniscus tear in the data collected in the present study revealed that there was a significant chance of medial femoral and medial tibial condyle injury if there was a medial meniscus tear. In low flexion positions, medial femoral condyle injuries are one of the most serious complications (19).

An optimal management of ACL injuries is required which involves detailed understanding of patient's short- and long-term priorities and considerable investments from the patients (20). Previous studies have established higher rates of second ACL ruptures in athletes

younger than 25 years in comparison to older athletes (21). The present study had 28.8% patients in the age group of 15-25 years. ACL injuries often concomitantly occurs with meniscal, cartilage or other knee ligament injuries. Thereby, it is pertinent to accurately investigate substantial concomitant injuries (20,22,23) and their timely management.

The present study focusses on the associated injuries and a detailed analysis of how exactly the ACL deficient knee deteriorates with progressive delay in surgical treatment. The strength of the study is its prospective design and strict inclusion of young athletes. The limitation of the study is a single centre sample and the study cohort could have been followed up for further changes post ACL surgery.

Conclusion

ACL injuries in young athletes can cause recurrent instability leading to chondral and medial meniscus tear. The meniscal and chondral lesions associated with ACL injuries depends on multiple factors and has a complex pathogenesis. Increase in TFI has a higher risk of chondral lesions of higher grade. To avoid complications, prompt management of the meniscal and chondral lesions associated with ACL injuries should be considered during ACL reconstruction. The scope of such studies can be expanded to a further follow-up of the surgically treated knees with regard to the chondral injury outcome.

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Table 1: Patient demographics and mode of injury

Variable	**N=444**
Age, mean±SD	29.69±7.085
15-25	128 (28.8 %)
26-35	238 (53.6 %)
36-45	69 (15.5 %)
46-55	6 (1.4 %)
56-65	3 (0.7 %)
Gender	
Male	429 (3.4 %)
Female	15 (96.6 %)
Modes of injury	
Road traffic accident	28 (6.3 %)
Run	139 (31.3 %)
Ditch	88 (19.8 %)
Fall	65 (14.6 %)
Football	51 (11.5 %)
Basketball	28 (6.3 %)
Wrestling	28 (6.3 %)
Kabaddi	17 (3.8 %)

Table 2: Distribution of ligamental injuries

ACL TEAR	
Complete	229 (51.6 %)
Partial	171 (38.5 %)
Absent	44 (9.9 %)
PCL tear	
Present	14 (3.2 %)
Absent	430 (96.8 %)
MCL tear	
Present	15 (96.8 %)
Absent	429 (96.6 %)

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LCL tear	
Present	8 (1.8 %)
Absent	436 (98.2 %)
Lateral meniscus tear	
Present	92 (20.7 %)
Absent	352 (79.3 %)
Medial meniscus tear	
Present	124 (27.9 %)
Absent	320 (72.1 %)
Plica	
Present	9 (2.0 %)
Absent	435 (98.0 %)

Table 3: Distribution of the patients based on TFI to arthroscopic surgery

Time from injury (weeks)	N= 443
LESS THAN 16	22 (5.0 %)
17 - 32	60 (13.5 %)
33 - 48	98 (22.1 %)
49 - 64	109 (24.5 %)
65 - 80	98 (22.1 %)
81 - 96	36 (8.1 %)
97 - 112	15 (3.4 %)
113 - 128	4 (0.9 %)
More than 129	1 (0.2 %)

Table 4: Distribution of chondral injuries

Chondral lesion femur	
No	301 (67.8 %)
I	5 (1.1 %)
II	78 (17.6 %)
III	44 (9.9 %)
IV	16 (3.6 %)
Chondral lesion tibia	
No	348 (78.4 %)
I	17 (3.8 %)
II	57 (12.8 %)
III	18 (4.1 %)
IV	4 (4.1 %)
Chondral lesion patella	
No	332 (74.8 %)
I	29 (6.5 %)

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II	72 (16.2 %)
III	8 (1.8 %)
IV	3 (0.7 %)

Table 5: Association of medial compartment injury with medial meniscus tear

Medial meniscus tear	**Medial femoral chondral lesion**		**Medial tibial chondral lesion**		**Medial patellar chondral lesion**		**Medial compartment injury**	
	Present	**Absent**	**Present**	**Absent**	**Present**	**Absent**	**Present**	**Absent**
Present	40	84	17	107	25	99	42	82
Absent	70	250	22	298	42	278	68	252
Association	**X^2 = 5.17, df = 1, p = 0.023**		**X^2 = 5.21, df = 1, p = 0.022**		X^2 = 3.45, df = 1, p = 0.063		**X^2 = 7.64, df = 1, p = 0.007**	

Table 6: Association of partial ACL injury with medial meniscus tear

Partial ACL tear	Medial meniscus tear		Chi square test
	Present	Absent	
Present	38	133	**X^2 = 4.50, df = 1, p = 0.034**
Absent	86	187	

Table 7: Association of complete ACL injury with medial meniscus tear

Complete ACL tear	Medial meniscus tear		Chi square test
	Present	Absent	
Present	75	154	**X^2 = 5.47, df = 1, p = 0.019**
Absent	49	166	

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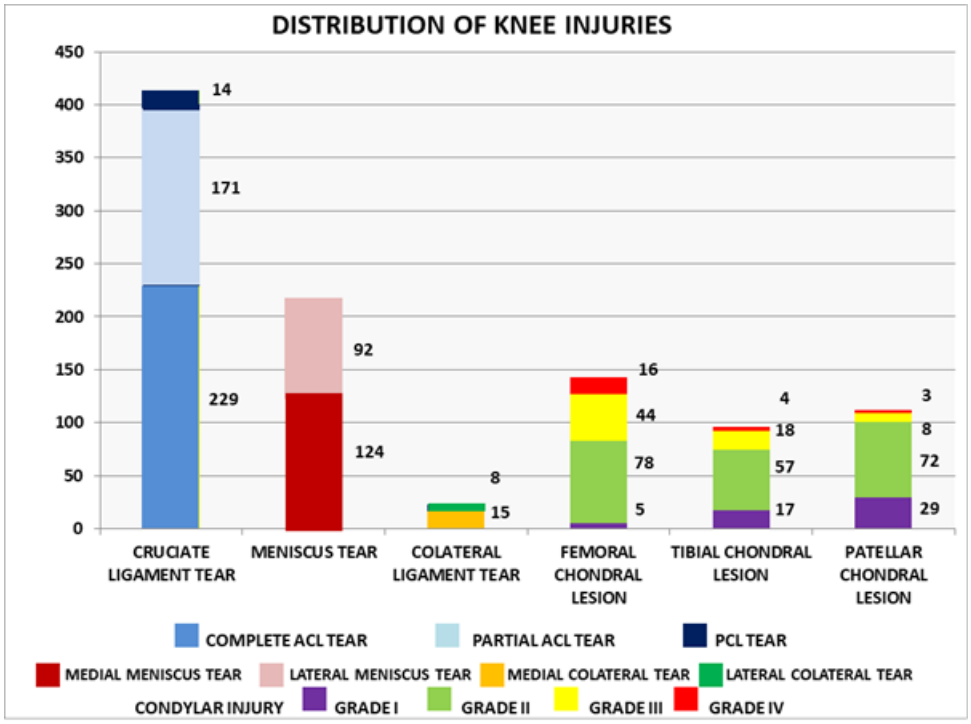

Figure 1: Distribution of knee injuries

Declaration of Interest: None

Author Contributions

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