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# Assessment of articular cartilage damage in weight bearing region during acute and chronic anterior cruciate ligament reconstruction

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## Introduction

Knee injuries are a common occurrence particularly among young active individuals usually secondary to sports injuries. Injuries to the Anterior Cruciate Ligament (ACL) are most common accounting for 40% to 50% of all ligamentous knee injuries.(1) These tears occur whenever there is maximum strain on the ligament with the knee in near full extension with a valgus force applied.(2,3)

The sequelae of ACL tears are repeated knee instability which can be functionally disabling. It results in further injuries to the chondral surface and meniscus. Patients with an ACL deficient knee can develop early degenerative changes.(4) The cause for the degenerative changes is heterogeneous, with widely varying ages, level of activity before injury and previous history of knee injury or surgery in patients which may already have significant degenerative changes within the knee.

ACL reconstruction and aggressive rehabilitation can help in delaying the progression of degenerative changes by indirectly limiting further cartilage damage and meniscal tears. The timing of surgical reconstruction after injury is of considerable importance.

This study was undertaken to assess whether a delayed reconstruction of ACL leads to increased articular cartilage damage in the weight bearing region when compared to early ACL reconstruction. We also assessed the location, depth of the articular cartilage damage, and meniscal injuries.

## Materials and Method

A hospital based cross sectional study was conducted with one hundred and three patients presenting with ACL tears between September 2014 and August 2016.

Patients presenting with primary knee injury having an ACL injury with or without meniscal injury which was confirmed clinically and radiologically were included in the study. We have excluded the patients with multi-ligamentous injury, contralateral knee injuries, radiological evidence of longstanding osteoarthritis in ipsilateral knee, previous surgery in ipsilateral knee and patient's age more than 50 years from the study.

The proforma included demographic data of the patients, time and mode of injury. The number of instability episodes was grouped as less than five, five to fifteen episodes, and more than fifteen episodes. This was done as most of the patients were not able to provide a definite number of episodes. The affected knee was examined for the swelling, abrasions, ecchymosis and ligamentous injury were also assessed by special tests. Range of motion was noted and contralateral knee was examined for any signs of injury. Appropriate radiographs were taken with two projections; Antero Posterior (AP) and lateral views. ACL and meniscal injuries were confirmed by Magnetic Resource Imaging (MRI).

The patients were divided into 3 groups as acute (less than 3 months), subacute (3-6months), and chronic cases (more than 6 months) based on the duration of injury to surgery.

Diagnostic knee arthroscopy was performed. Meniscal and chondral injuries were assessed. Meniscal injuries were classified as medial or lateral meniscal injuries. Articular cartilage loss over the femoral condyles and tibial condyles were assessed using the probe. Outerbridge classification was used to grade the cartilage loss (Fig. 1).(5) International knee documentation committee (IKDC) knee form was used to enter the data.(6)

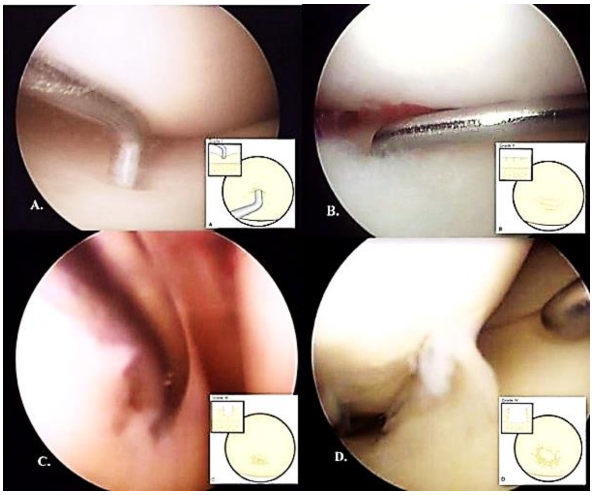


**Fig. 1**

Fig. 1: Outerbridge classification of articular cartilage damage. (A) Grade 1 is swelling or softening of an intact cartilage surface. (B) Grade 2 is represented by fissuring and fibrillation over a small area (<1.5 cm). (C)

Grade 3 includes the same pathologic changes over a larger area (>1.5 cm). (D) Grade 4 changes represent erosion to subchondral bone.

The femoral and tibial surfaces were divided into anterior (A), central (C) and posterior (P) regions. These were further subdivided as medial, central and lateral regions. Zones were classified as anterior medial(am), anterior lateral(al), anterior central(ac), posterior central(pc), posterior medial(pm), posterior lateral(pl), central medial(cm), central lateral(cl) and central central(cc) as shown in Fig. 2.

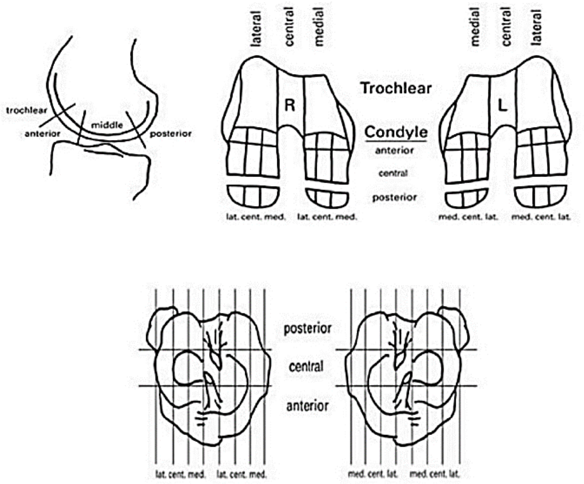


**Fig. 2**

Fig. 2: Schematic diagram showing the classification of zones in condyles

All the patients participated in the study gave their written informed consent. Ethics committee approval was taken for the study from regional ethical review board.

**Statistical Analysis:** Data was grouped as categorical and continuous data. Variables with quantitative data (continuous data) such as number of buckling episodes, age, and duration of injury to surgery were analyzed. Mean and standard deviation values were calculated for quantitative data. Grading of articular cartilage damage was considered as qualitative data (categorical) and was expressed in the terms of percentage. The grading of articular cartilage damage was considered in each medial and lateral condyle of both femoral and tibial surfaces. Then the proportions were compared using Chi-square test of significance. This was done by comparing grading of each articular cartilage damage (medial femoral, lateral femoral, medial tibial and lateral tibial) with duration of injury to surgery. The P value of less than 0.05 was accepted as indicating statistical significance. Initially, all the data was entered in Microsoft Excel 2013 and later it was analyzed using Statistical Package for the Social Sciences (SPSS) software version 21(IBM Corp. Armonk, New York).

## Results

103 patients were included in our study. Among them, there were 92 males and 11 females. The mean average age of patients was 30.28. The mean duration of injury to surgery was 33.5 weeks.

### Articular Cartilage Damage and Duration of Injury

**Medial Femoral Condyle:** There was 9.1% medial femoral condyle cartilage damage in acute, 43.7% in subacute and 84.2% in chronic group. Most of the articular cartilage damage was seen in the central central (cc) zone (Table 1). There was a statistically significant relationship between medial femoral condyle cartilage damage and duration of injury to surgery(P value <0.001).

**Table 1: Medial Femoral Condyle changes with duration of injury to surgery**

| | | Femoral Medial Condyle | | | | | Total | χ2 value | 'p' value |
|---|---|---|---|---|---|---|---|---|---|
| | | Grade 0 | Grade 1 cc | Grade 1 cm | Grade 3 cm | Grade 4 cc | | | |
| < 3 months | n | 30 | 3 | 0 | 0 | 0 | 33 | 42.916 | <0.001 |
| | % | 90.9 | 9.1 | 0 | 0 | 0 | | | |
| 3 – 6 months | n | 18 | 13 | 0 | 0 | 1 | 32 | | |
| | % | 56.2 | 40.6 | 0 | 0 | 3.1 | | | |
| > 6 months | n | 6 | 26 | 3 | 1 | 2 | 38 | | |
| | % | 15.8 | 68.4 | 7.9 | 2.6 | 5.3 | | | |

cc, Central central; cm, central medial.

**Lateral Femoral Condyle:** There was 15.2% lateral femoral condyle cartilage damage in acute, 21.9% in subacute and 52.6% in chronic group. All lesions seen were grade 1cc(central central) (Table 2). There was a statistically significant relationship between lateral femoral condyle cartilage damage and duration of injury to surgery(P value = 0.001).

**Table 2: Lateral Femoral Condyle changes with duration of injury to surgery**

| | | Femoral Lateral Condyle | | Total | $\chi^2$ value | 'p' value |
|---|---|---|---|---|---|---|
| | | Grade 0 | Grade 1 cc | | | |
| < 3 months | n | 28 | 5 | 33 | 13.417 | 0.001 |
| | % | 84.8 | 15.2 | | | |
| 3 – 6 months | n | 25 | 7 | 32 | | |
| | % | 78.1 | 21.9 | | | |
| > 6 months | n | 18 | 20 | 38 | | |
| | % | 47.4 | 52.6 | | | |

cc, Central central.

**Medial Tibial Condyle:** There was 12.1% medial tibial condyle cartilage damage in acute, 40.5% in subacute, and 68.4% in chronic group. Most of the articular cartilage damage was seen in the central central (cc) zone compared to central medial (cm) zone (Table 3). The relationship between medial tibial condyle cartilage damage and duration of injury was statistically significant to surgery(P value < 0.001).

**Table 3: Medial Tibial Condyle changes with duration of injury to surgery**

| | | TibialMedial Condyle | | | | | | Total | $\chi^2$ value | 'p' value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Grade 0 | Grade 1 cc | Grade 1 cm | Grade 1cm | Grade 2cc | Grade 3cm | | | |
| < 3 months | n | 29 | 3 | 0 | 0 | 1 | 0 | 33 | 33.128 | <0.001 |
| | % | 87.9 | 9.1 | 0 | 0 | 3.0 | 0 | | | |
| 3– 6 months | n | 19 | 10 | 2 | 0 | 0 | 1 | 32 | | |
| | % | 59.4 | 31.2 | 6.2 | 0 | 0 | 3.1 | | | |
| >6 months | n | 12 | 23 | 0 | 1 | 0 | 2 | 38 | | |
| | % | 31.6 | 60.5 | 0 | 2.6 | 0 | 5.3 | | | |

cc, Central central; cm, central medial.

**Lateral Tibial Condyle:** There was 45.4% lateral tibial condyle cartilage damage in acute, 28.1% in subacute and 60.5% in chronic group. P value was 0.110 and the relationship between lateral tibial condyle cartilage damage and duration of injury to surgery was not statistically significant. Although the value was not statistically significant, there was increased tibial condyle cartilage damage in the chronic group (Table 4).

**Table 4: Lateral Tibial Condyle changes with duration of injury to surgery**

| | | Tibial Lateral Condyle | | | | | Total | $\chi^2$ Value | 'P' Value |
|---|---|---|---|---|---|---|---|---|---|
| | | Grade 0 | Grade 1 cc | Grade 1 cm | Grade 2 cm | Grade 3 cm | | | |
| < 3 months | n | 18 | 14 | 0 | 1 | 0 | 33 | 13.043 | 0.110 |
| | % | 54.5 | 42.4 | 0 | 3 | 0 | | | |
| 3 – 6 months | n | 23 | 7 | 1 | 0 | 1 | 32 | | |
| | % | 71.9 | 21.9 | 3.1 | 0 | 3.1 | | | |
| > 6 months | n | 15 | 19 | 3 | 0 | 1 | 38 | | |
| | % | 39.5 | 50.0 | 7.9 | 0.0 | 2.6 | | | |

cc, Central central; cm, central medial.

In our study, among 103 patients, six patients had grade 3 and three patients had grade 4 cartilage damage. They were all treated with subchondral drilling and debridement during ACL reconstruction.

**Buckling and Articular Cartilage Damage:** The number of episodes of buckling with respect to femoral and tibial articular cartilage damage was considered. The incidence of cartilage damage was more with increase in the number of buckling episodes (Table 5).

**Table 5: Relationship between buckling and articular cartilage damage**

| S. No. | Number of Buckling episodes | Femoral Medial Condyle | Femoral Lateral Condyle | Tibial Medial Condyle | Tibial Lateral Condyle | Total |
|---|---|---|---|---|---|---|
| 1 | Less than 5 | 2 | 1 | 2 | 3 | 8 |
| 2 | 5 To 15 | 14 | 11 | 13 | 15 | 53 |
| 3 | More than 15 | 33 | 20 | 28 | 29 | 110 |

**Meniscal Injury:** There were 13 meniscal injuries in the acute group, 16 in the sub-acute group and 23 in the chronic group. In the acute group, we found the incidence of lateral meniscus injury of 61.5% compared to 38.5% medial meniscal injury. In the subacute group the incidence of medial meniscus injury was 56.8% compared to 43.2% lateral meniscus injury. In the chronic group, there was 78.3% of medial meniscus tear in our study (Fig. 3).

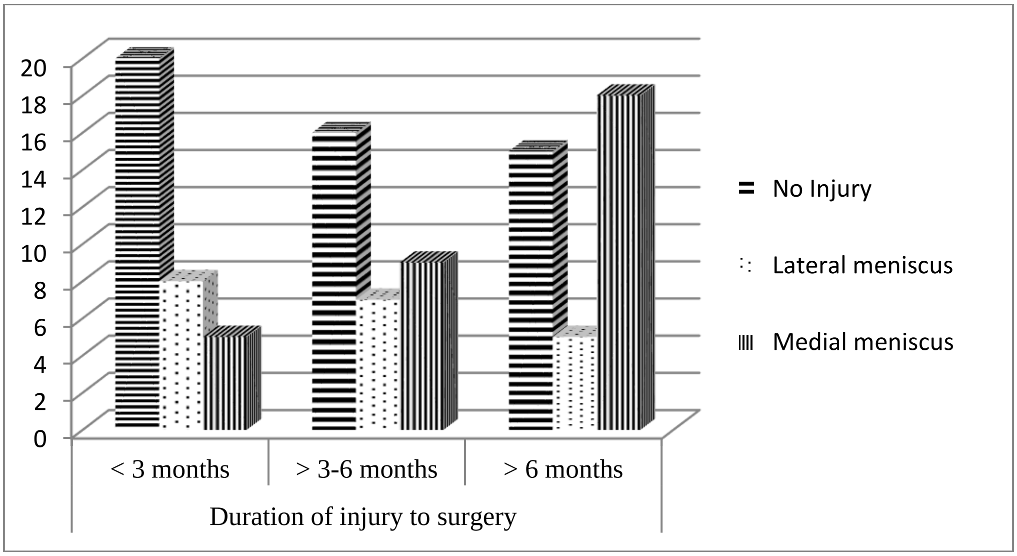


**Fig. 3: Relationship between Meniscal Injury and Duration of Injury to surgery**

## Discussion

Repeated instabilities in young individuals with ACL injury is disabling and it can impair their daily activities. ACL injuries are common following sports injuries and motor vehicle accidents. In our study, motor vehicle accidents contributed to most of the cases of ACL injury.

Keays et al(7) suggested the development of osteoarthritis is more likely seen with a longer interval between injury and surgery. Marks and Donaldson(8) also found a linear relationship between chondral damage and the time from injury after ACL rupture. The abnormal stress over the chondral surfaces secondary to change in tibio femoral biomechanics and the frequent pivoting episodes cause further injuries to the chondral surface and the menisci in an ACL deficient knee.

Some studies have found that even in patients who have been operated by ACL reconstruction in the acute period continue to have early degenerative changes compared to their uninjured knee. This was probably a sequelae of the initial trauma to the cartilage or the release of biological mediators at the time of injury causing irreparable damage to the cartilage.(9,10,11) Knee osteoarthritis following the articular cartilage damage in ACL torn patients was also explained by increased levels of chondro-destructive cytokines and decreased levels of chondro-protective cytokines.(12)

The purpose of our study was to determine whether there is a relationship between duration of injury and particular zone of damage to articular cartilage. The location and the depth of articular cartilage damage were assessed.

ACL-injured knees have been evaluated for cartilage degeneration by using T1r mapping; there was greater cartilage degeneration in ACL-injured patients which was seen in the middle region of the femoral condyle that contacted the tibia while the degree of flexion was small.(12)

Studies have found that medial meniscal tears and chondral damage increases with age and with time from initial injury in patients with ACL deficient knees. Chondral lesions (>60%) were found in the medial compartment of knee(particularly medial femoral condyle). A strong positive correlation was found between injuries to medial meniscus and cartilage damage over medial femoral condyle.(13,14,15)

In our study, there was significant cartilage damage over the weight bearing region(central central zone) of medial femoral and medial tibial condyle.

Maffuli et al(16,17) found that in acute ACL tear, the lateral subluxation of the tibial articular surface collides with the lateral femoral condyle leading to acute lateral tibial condyle lesion and it was partially opposed by lateral meniscus. The energy is directly transferred to the subchondral bone which causes acute lateral tibial condyle lesion. The initial shear stresses were absorbed by articular cartilage and meniscus and as the stresses progressed it failed to absorb it at a later stage, thereby causing both meniscal tears and osteochondral lesions.

In our study, lateral tibial condylar articular damage was more in the acute group compared to other condyles and there was increased medial tibial condyle damage in the chronic group.

There was increased articular cartilage damage with increase in number of episodes in our study. Buckling causes repetitive micro trauma and thereby leading to more articular cartilage damage.

Meniscal injuries occur in 41% to 77% of acute ACL-deficient knees and 73% to 98% of chronic ACL-deficient knees.[18,19,20] Keene et al[1] found increased medial meniscus tear in chronic ACL tears. Some studies showed that the lateral meniscus is commonly torn in acute ACL tears and the medial meniscus torn in chronic ACL tears.[21,22,23] Cipolla et al[13] demonstrated lateral meniscal involvement in 51% and medial meniscal injury in 31% of the patients in the acute stage (less than two weeks from injury). Lateral involvement was 48% in the chronic cases, but medial meniscal involvement rose to 70% in their study.

Chhadia et al[24] has explained that the medial meniscus may be susceptible in ACL-torn knees that undergo recurrent instability as it is a secondary stabilizer to anterior translation. The explanation for a more chronic medial meniscus and acute lateral meniscus tears could be because of a greater translation of the lateral meniscus in a knee with absent ACL compared with the medial meniscus.[25]

We found that the lateral meniscus injury (61.5%) was more common in the acute group whereas in the chronic group, there was increased incidence of medial meniscus tear (78.3%).

There were some limitations in our study. Firstly, being a cross sectional study, no follow up was done to correlate the increased cartilage damage found in the central central (cc) zone(weight bearing area) to increased arthritic changes. Secondly, it was done in our Indian population, in which most of ACL injuries were caused by motor vehicle accidents than sports injuries which causes a difficulty in comparing the cartilage loss with the athletic population.

## Conclusion

Increase in time to surgery causing a delayed ACL reconstruction leads to higher incidence of chondral and meniscal damage. Repeated buckling episodes due to knee instability cause cartilage damage in patients with chronic ACL injuries. Increased significant cartilage damage was noted over the weight bearing region of the medial femoral and medial tibial condyles for chronic ACL tears. Increased lateral meniscus injury was seen in acute ACL tears when compared to increased medial meniscal injury in chronic ACL torn patients. Thus, we suggest an early reconstruction to prevent the osteochondral injuries to the central central (cc) zone for avoiding early degeneration of the knee joint.

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