

## Original Research Article

# Femoropatellar alterations in knees with chronic anterior cruciate ligament injuries: a radiographic analysis

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**Received:** 01 November 2023

**Revised:** 06 December 2023

**Accepted:** 11 December 2023

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## ABSTRACT

**Background:** The objective of this study was to correlate the occurrence of patellofemoral malalignment in a chronic anterior cruciate ligament (ACL) deficient knee using common radiological parameters.

**Methods:** A case-control study was conducted on 35 adult patients with previously diagnosed unilateral chronic ACL injury. The injured knee was considered as the case, while the contralateral normal knee served as the control. Radiological parameters including the Caton-Deschamps patellar height index, Merchant patellar congruence angle, and Laurin lateral patellar tilt angle were measured on X-rays obtained from both normal and ACL injured knees. A comparative analysis was performed between the two groups.

**Results:** The Caton-Deschamps patellar height index had a mean value of  $0.95 \pm 0.05$  in the ACL-deficient knee. The Merchant patellar congruence angle showed mean values of  $12.66 \pm 0.84$  degrees in the ACL injured knee, while the Laurin lateral patellar tilt angle was  $8.06 \pm 1.41$  degrees in knees with ACL failure. These results indicate lower patellar height, greater lateral displacement of the patella, and increased lateral patellar tilt in knees with chronic ACL tears, thereby affecting the patellofemoral joint.

**Conclusions:** Chronic ACL tears are associated with patellofemoral malalignment, characterized by decreased patellar height, increased lateral displacement of the patella, and greater lateral patellar tilt, thus impacting the patellofemoral joint.

**Keywords:** ACL, Patellofemoral malalignment, Sports injury, Knee

## INTRODUCTION

The anterior cruciate ligament (ACL) is a crucial ligament responsible for stabilizing the knee joint. In recent years, there has been a notable increase in the incidence of ACL injuries, primarily due to the growing participation in sports activities.<sup>1</sup> These injuries commonly occur in athletes engaged in sports that involve pivoting movements, such as gymnastics, soccer, basketball, handball, and football.

The patellofemoral joint is a diarthrodial plane joint comprising the posterior surface of the patella and the trochlear surface of the distal anterior femur. The static

alignment of the patellofemoral joint involves the relationship between the patella and the femoral sulcus, as well as the shape of these structures. On the other hand, dynamic alignment refers to the movement of the patella during tibiofemoral motion, known as patellar tracking.<sup>2</sup>

### *Impact of ACL injury*

ACL injury significantly affects the tibiofemoral kinematics, leading to an increased incidence of meniscal tears and articular cartilage loss.<sup>3-6</sup> Gait analysis studies have demonstrated that knees with ACL injuries exhibit altered rotational movements (greater internal rotation and lesser external rotation) and increased medial translation

of the tibia over the femur during the stance and swing phases of gait, compared to normal knees. This imbalance in tibiofemoral kinematics resulting from ACL injury poses a risk for secondary injuries to the patellofemoral joint.<sup>6-8</sup>

**Consequences of ACL deficiency**

Knees lacking the ACL often develop patellofemoral cartilage degeneration and experience concomitant quadriceps atrophy and weakness.<sup>9</sup> Furthermore, anterior knee pain remains one of the main complaints among these patients. However, literature is scarce regarding patellofemoral alterations in ACL-deficient knees, particularly in the Indian population where activities involving squatting and ground-level movements are commonplace. Therefore, the objective of this study is to compare three femoropatellar radiographic parameters and assess their malalignment in chronic ACL-deficient knees. A better understanding of these phenomena may contribute to the improvement of treatments and rehabilitation protocols for patients with ACL injuries.

**METHODS**

A case-control study was conducted in the department of orthopaedics, Safdarjung Hospital, New Delhi from October 2018 to March 2020. The study included 35 patients diagnosed with unilateral complete ACL deficiency. Ethical committee approval was taken from the institutional ethical committee (IEC/Vmmc/Sjh/Thesis/October/2018-228). The patient selection process was based on predefined inclusion and exclusion criteria.

**Inclusion criteria**

Patients aged 18 to 65 years, both genders. Individuals diagnosed with unilateral complete anterior cruciate ligament deficiency based on magnetic resonance imaging (MRI) findings. Additionally, eligible participants are identified through positive results in clinical assessments, including the Lachman test, anterior drawer test, and pivot shift test. The study specifically includes patients with a duration of injury greater than 3 months, aiming to explore and analyze cases with a more chronic aspect of anterior cruciate ligament deficiency.

**Exclusion criteria**

Patients presenting with additional ligament injuries in the same knee, as well as those with bilateral ligament injuries. Pre-existing knee disorders, such as knee deformities, hyperlaxity syndrome, and knee osteoarthritis. Additionally, individuals with associated fractures or other injuries in the ipsilateral extremity were not included in the study.

Digital radiography was performed on both knees, including absolute lateral view radiographs with 30° of knee flexion and axial radiographs of the patella at a 30°

downward inclination. The Caton-Deschamps patellar height index, Merchant patellar congruence angle, and Laurin lateral patellar tilt angle were measured on the obtained radiographs for both knees (Figures 1-3). It is worth noting that patients with meniscus injuries were allowed in the study. This decision was made because isolated ACL injuries without any damage to the meniscus are rare, and accurately quantifying the extent of meniscus damage without proper arthroscopic examination is challenging. The obtained results were analysed using appropriate statistical tests. Demographic information such as age, sex, and the limb involved was analysed individually. Before participation, all enrolled patients provided written informed consent.

In a study conducted by Vasconcelos et al in 2015, the mean values of Merchant's patellar congruence angle and lateral inclination of the patella were observed as -2.57±5.86 and 11.25±4.54, respectively, in normal knees, and 2.08±6.16 and 6.70±4.86, respectively, in knees with ACL injuries.<sup>9</sup> Using these values as a reference, a minimum sample size of 22 patients was determined with 95% power of the study and a 5% level of significance. To account for potential errors, a total sample size of 30 patients was selected.

**RESULTS**

The mean age of the patients in this study was 28.97±8.8 (mean±SD) years with extremes of 18 and 55 years. Maximum proportions of patients (54.29%) were in the age group of 21-30 years (Table 1).

**Table 1: Distribution of age (years) of study subjects.**

Age (years)	Frequency	Percentage
18-20	4	11.43
21-30	19	54.29
31-40	8	22.86
>40	4	11.43

The study showed a preponderance of the male population with 30 males; and 05 females in the total study group. In our study, the right side is predominant with 27 cases (77.14%) out of 35 cases. We had the maximum number of cases due to non-sporting activity (20 cases, 57.14%) e.g. twisting of the knee while walking, 13 cases due to sporting activity e.g. football, running, while 2 patients were in the non-activity group (Table 2).

**Table 2: Showing different mode of injury in patients in our study.**

Mode of injury	No. of patient	Percentage
Sporting activity	13	37.14
Non sporting activity	20	57.14
Non activity	2	5.71

Caton–Deschamps Patellar height index had a mean value of  $0.95 \pm 0.05$  in the abnormal knee whereas its mean value in a normal knee is  $1.01 \pm 0.05$  (Table 3 and Figure 4). Therefore, the patellar height is lower in ACL-injured knees.

Merchant’s angle of patellar congruence had mean values of  $12.66 \pm 0.84$  degrees in the ACL injured knee and  $5.69 \pm 1.3$  degrees in the contralateral normal knee indicating the greater lateral displacement of the patella in ACL injured knees.

**Table 3: Comparison of Caton–Deschamps patellar height index (ratio) between normal and abnormal knee in total study subjects.**

Caton–Deschamps patellar height index (ratio)	Abnormal knee (n=35)	Normal knee (n=35)	Total	P value	Test performed
Mean±standard deviation	$0.95 \pm 0.05$	$1.01 \pm 0.05$	$0.98 \pm 0.06$	<0.0001	Paired t test; t value=7.225
Median (IQR)	0.95 (0.92-0.98)	1 (0.98-1.03)	0.98 (0.94-1.018)		

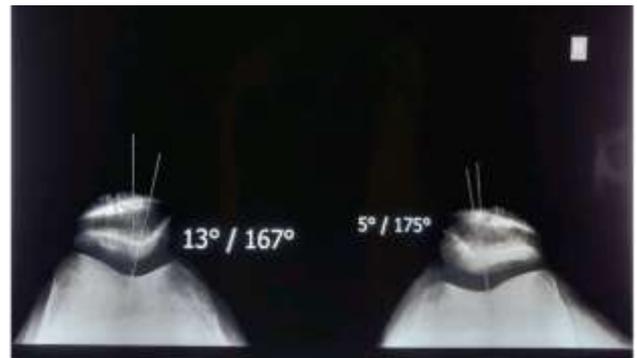
**Table 4: Comparison of Merchant’s Patellar congruence angle (degrees) between normal and abnormal knee in total study subjects.**

Merchant’s patellar congruence angle (degrees)	Abnormal knee (n=35)	Normal knee (n=35)	Total	P value	Test performed
Mean±standard deviation	$12.66 \pm 0.84$	$5.69 \pm 1.3$	$9.17 \pm 3.68$	<0.0001	Wilcoxon signed ranks test; z value=5.197
Median(IQR)	13 (12-13)	6 (5-6.5)	9.5 (6-13)		
Range	11-14	3-8	3-14		

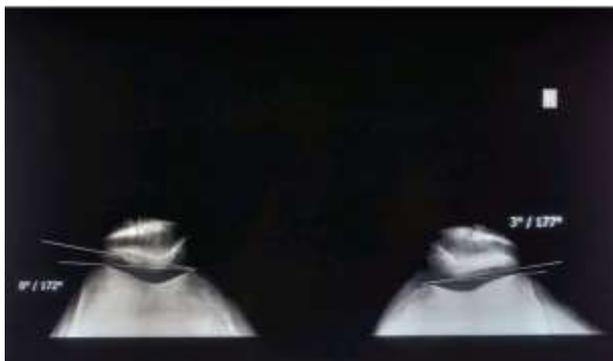


**Figure 1: Caton Deschamps patellar height index and the parameter values.**

indicating that the patella shifted more laterally in the ACL-injured knees (Figure 5).

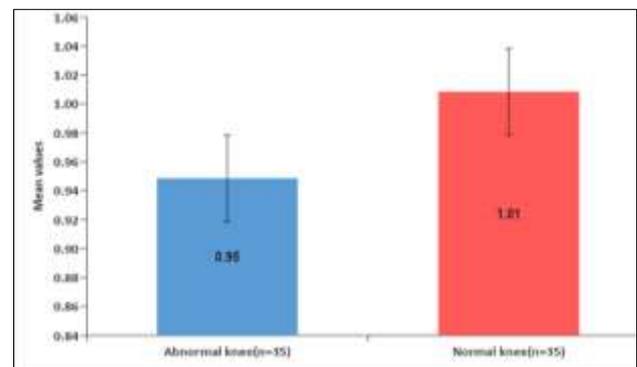


**Figure 3: Merchant’s angle of patellar congruence and its calculation in the reference case, left (ACL deficient) knee=13 degrees, right (normal) knee=5 degrees.**

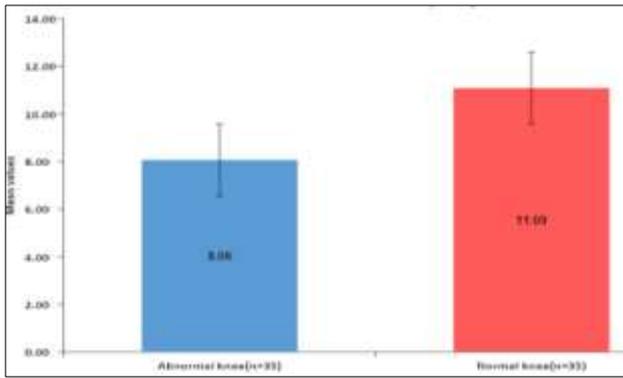


**Figure 2: Laurin’s lateral inclination angle of the patella and its calculation in the reference case left (ACL deficient) knee=8 degrees, right (normal) knee=3 degrees.**

Laurin’s angle of lateral inclination of the patella had mean values were  $8.06 \pm 1.41$  degrees in the ACL-injured knee and  $11.09 \pm 1.5$  degrees in the contralateral normal knee



**Figure 4: Comparison of Caton–Deschamps patellar height index (ratio) between normal and abnormal knee in total study subjects (parametric variables).**



**Figure 5: Comparison of lateral inclination of the patella (degrees) between normal and abnormal knee in total study subjects (parametric variables).**

## DISCUSSION

A kinematic coupling exists between the patellofemoral and tibiofemoral articulations, linked through the patellar tendon. The occurrence of an ACL injury has led to notable changes in both sagittal and coronal plane angles, along with an increase in external twists. This shift in the orientation of the patellar tendon can be attributed to the fact that the patellofemoral joint (PFJ) operates in association with the tibiofemoral joint complex. Changes occur in the tibiofemoral joint during different phases of walking as a result of ACL injuries, which inevitably impact the functioning of the femoropatellar joint.<sup>10</sup>

Our study aimed to identify potential femoropatellar alterations in knees with chronic ACL injuries that occurred at least 3 months prior. We utilized the unaffected contralateral knee of each patient as a control for comparison. By analyzing commonly used radiographic parameters in clinical practice, we aimed to shed light on these alterations and their significance. Our findings revealed a significant difference in the Caton–Deschamps patellar height index between ACL-injured knees (mean:  $0.95 \pm 0.05$ ) and normal knees (mean:  $1.01 \pm 0.05$ ) ( $p < 0.0001$ ). Subgroup analysis of male subjects and those with associated meniscus injuries also demonstrated significant differences.<sup>11</sup> Furthermore, we observed a decreased lateral inclination angle of the patella in ACL-injured knees (mean:  $8.06 \pm 1.41$  degrees) compared to contralateral normal knees (mean:  $11.09 \pm 1.5$  degrees) ( $p < 0.0001$ ). The Merchant's patellar congruence angle also showed a significant correlation, with ACL-injured knees exhibiting higher values (mean:  $12.66 \pm 0.84$  degrees) compared to normal knees (mean:  $5.69 \pm 1.3$  degrees) ( $p < 0.0001$ ). The reversibility of femoropatellar alterations following ACL reconstruction remains inconclusive. While some studies suggest a return to normal values post-reconstruction, others indicate persistent alterations.<sup>11,12</sup> Further research is necessary to clarify these findings. Moreover, slight changes in patella orientation relative to the femoral trochlea can have significant implications for femoropatellar biomechanics. The increased patellar displacement and lateral inclination observed in knees

with ACL failure are believed to be associated with anterior knee pain and femoropatellar arthrosis.<sup>13,14</sup>

## Limitations

The limitations of our study are a small sample size, a single-center study, lack of a control group, potential selection bias, and lack of longitudinal data. The study focused on the radiographic analysis of patellofemoral alterations but did not assess the clinical symptoms experienced by the patients, such as pain, instability, or functional limitations. Including subjective measures of symptoms would have provided a more comprehensive understanding of the impact of femoropatellar alterations.

## CONCLUSION

Femoropatellar alterations in knees with ACL injuries, as well as those undergoing ACL reconstruction, are often overlooked in clinical practice. Incorporating a comprehensive radiological examination with a detailed analysis of femoropatellar radiographic parameters can facilitate early detection of these alterations and inform appropriate therapeutic approaches. Further investigation is needed to better understand the impact of ACL reconstruction on femoropatellar mechanics and long-term outcomes.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the institutional ethics committee*

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**Cite this article as:** Arora ES, Sharma BP, Das N, Mohindra M, Shaina S. Femoropatellar alterations in knees with chronic anterior cruciate ligament injuries: a radiographic analysis. *Int J Res Orthop* 2024;10:123-7.