The Deep Lateral Femoral Notch Sign: an Indirect Sign of a Torn Anterior Cruciate Ligament

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ABSTRACT

Background

The presence of a deep lateral notch has been described as an indirect sign of a tear of anterior cruciate ligament (ACL) on conventional radiographs. The aim of this study is to identify notches of the Lateral femoral condyle (LFC) in patients with tears of anterior cruciate ligament in plain X-ray so as to evaluate lateral femoral notch sign as an indirect sign of anterior cruciate ligament deficiency.

Objective

To assess deep lateral femoral notch sign in X-ray as an indirect sign of anterior cruciate ligament tear.

Method

Quantitative cross-sectional study was conducted among the patients with anterior cruciate ligament injuries scheduled for anterior cruciate ligament reconstruction at Department of Orthopedics at Dhulikhel Hospital and had anterior cruciate ligament injuries diagnosed by clinical and MRI and had undergone arthroscopic anterior cruciate ligament reconstruction. The lateral radiograph of knee was evaluated and measurements were carried out with depth and length of the impression on the anterior cruciate ligament and were measured in millimeters (mm). A depth of more than two millimeters was considered as positive lateral femoral notch sign.

Result

Ninety-five patients (92.2%) diagnosed as anterior cruciate ligament tear showed lateral femoral notch sign and among them 23% of patient had positive deep lateral femoral notch sign.

Conclusion

This study suggests that a simple lateral knee radiograph is helpful to identify the anterior cruciate ligament injury in traumatic knee injury patients among the twenty three percentage of the cases.

KEY WORDS

Anterior cruciate ligament injury, Lateral femoral notch sign, Positive lateral femoral notch sign, Sports injury

INTRODUCTION

The condylopatellar sulcus of the lateral femoral condyle (LFC) is a shallow groove separating the patellar and tibial articular surfaces of the femur. It is located lateral to the most anterior aspect of the intercondylar notch.[1] The most frequent type of ligament injury is an anterior cruciate ligament (ACL) injury.[2] In recent years, there has been a growing trend to be involved in sports activities and injury of ACL cause significant morbidity, and may be increasing in incidence as participation in high-risk sports increases.[3]

ACL injury is among the most commonly studied injuries in orthopedics.[3,4] Due to heavy social and economic burden brought by the ACL injury, it is very important to identify and prevent ACL injury.[5] If misdiagnosed and/ or left untreated, an ACL tear may lead to chronic disability.[6,7] A sulcus deeper than 1.5 mm is a reliable indirect sign of a torn ACL.[8]

In more than one-quarter of patients, plain radiographs may help to establish the diagnosis of an ACL tear.[9] The presence of a lateral femoral notch (LFN) sign in the lateral X-ray is a highly specific sign for torn ACL.[10] If this sign proves to be the reliable indicator, it could potentially aid in the diagnosis of ACL tears, particularly in the settings of Nepal where advanced imaging techniques like MRI may not available.

Hence, by conducting this cross-sectional study it identify the ACL injury and will help to improve the diagnostic accuracy, facilitate timely management and also enhance the patient outcomes.

METHODS

The study was approved from the IRC (272/2021) of KUSMS and was conducted in the Department of Orthopedics and Trauma, at Dhulikhel Hospital, Kathmandu University Hospital from Jan 2022 to March 2023. The study was conducted among the patients diagnosed with ACL tear. A convenience sample of patients meeting the inclusion criteria was recruited. Those skeletally matured patients (age more than 16 years) presented to OPD / Emergency (ER) of Dhulikhel Hospital (DH) with features suggestive of knee instability (clinical and MRI) and diagnosed of having ACL tear and were planned for ACL reconstruction were included in the study. Whereas patient having knee instability due to PCL deficiency or multi-ligaments deficiencies, acute/chronic knee infection, inflammatory, metabolic or degenerative knee conditions (rheumatoid arthritis, gouty arthritis, osteoarthritis), prior ACL reconstruction were excluded from the study.

The sample size was calculated at 95% confidence interval with 5% allowable error, and 10% non-response rate with the prevalence of deep lateral femoral notch sign as 52% in ACL tear cases based on the findings of previous study conducted by Dimitrious et al.[11] The minimum sample size was 96. The study Performa was developed based on the extensive literature review and was further validated by subject experts. The data was entered in Microsoft Excel 2013 and Statistical analysis was done by using SPSS V 21. Descriptive statistic like frequency, mean, median and standard deviation was calculated.

Procedure

All the consecutive cases of people with knee instability with ACL tear were selected as study participants. Informed written consent was obtained from each study participant explaining the purpose of study, its procedure, risks and benefits and the assurance of confidentiality of the study results. After a detailed history and clinical examination of knee, relevant information was collected and recorded. The pre-operative knee X-ray of index knee was collected. The true lateral radiograph of knee was evaluated and measurement of LFNS was carried out with depth and length of the impression on the LFC and it was measured in millimeters (mm) with the deepest impression of the notch sign by using the tangent method according to Warren et al.[12] The measurement was performed with the help of software Digimizer image analysis version 6 (2005-2022) MedCalc Software Ltd. (Fig. 1 and Fig. 2) The photograph of lateral view X-ray of knee was uploaded to software, then to measure the length of the lateral femoral notch sign, a line tangential to the LFC was drawn between the two points of the notch that were furthest apart. For depth measurements, a line tangential to the LFC was drawn. This tangent served as a reference line to determine the depth of the sulcus, which was measured perpendicular to the tangent line.[13] According to Duke G. Pao, 2.0 mm was selected as the cut-off for a pathognomonic lateral femoral notch sign.[14]

Figure 1. Measurement procedure of lateral femoral notch

RESULTS

This study included total of 103 patients fulfilling the inclusion criteria. The mean age of the patients were 35.7 ± 12 years with the range of 17 years to 68 years. The majority of the patients were from the age group of 20 to 40 years (n=61, 59.2%). There were 60 male and 43 female patients

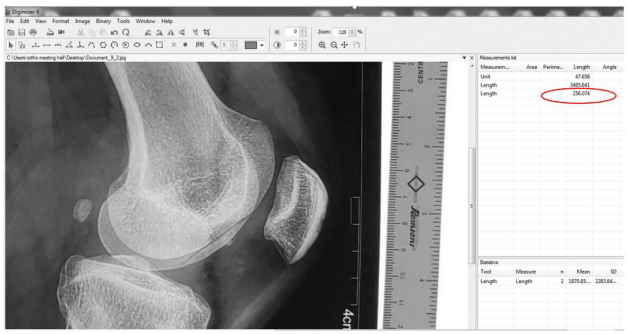

Figure 2. Depth measurement of Femoral Notch

with the male female ratio of 3:2. The findings showed that most of the patients (n=26, 25.2%) with ACL injury were students followed by farmers (n=23, 22.3%) and service holders (n=13, 12.6%).

Table 1. Socio-Demographic Characteristics of Patients

Characteristics	Number (n=103)	Percent (%)
Age in years		
< 20 years	3	2.9%
20-40 years	61	59.2%
40-60 years	37	35.9%
> 60 years	2	1.9%
Mean ±SD= 35.7 ±12 (Range 17-68 years)		
Gender		
Male	60	58.2%
Female	43	41.7%
Profession of patients		
Student	26	25.2%
Farmer	23	22.3%
Service	13	12.6%
Heavy worker (weight lifter, labor)	6	5.8%
Army/Police/Force personnel	3	2.9%
Homemaker	18	17.5%
Business	12	11.7%
Others	2	1.9%
Total	**103**	**100%**

Knee Involvement

ACL injury was common in both the knees with slight increase incidence in left knee i.e. 51.5%.

Prevalence of Lateral Femoral Notch sign

The deep lateral notch sign greater than two mm was considered as positive notch sign in ACL injured patients.

Majority of the patients (n=95, 92.2%) with ACL tear showed the Lateral Femoral Notch sign in lateral knee radiographs. So, prevalence of lateral femoral notch sign identified is 92% in this study.

Table 2. Distribution of patients based on lateral femoral notch sign

Depth of ACL notch sign	Number of cases (n=103)	Percentage
Absent of lateral femoral notch sign	8	7.76%
< 0.5 mm	27	26.21%
0.5 - 1 mm	19	18.44%
1 mm - 1.5 mm	16	15.53%
1.5 mm - 2 mm	9	8.73%
> 2 mm	24	23.30%
Total	**103**	**100%**

Deep lateral femoral notch sign

In X-rays, 24 (23.3 %) of ACL torn cases shows positive deep notch i.e. depth of > 2 mm, while 79 (78.22 %) of cases showed negative notch sign.

Mode of injury

Sports was observed as the most common mode of ACL tear (n=29, 28.20%) followed by fall injury and twisting (n=28, 27.20%)

Mode of Injury	Number of cases (n=103)	Percentage of cases
Twisting	28	27.18%
Fall	28	27.18%
Sports	29	28.15%
RTA	13	12.62%
Workplace injury	4	3.88
Others	1	0.97%

Associated Lesion

The most common associated lesion identified among the ACL tear patients were medial meniscus (n=43, 41.7%) followed by isolated ACL tear (n=24, 23.3%) and lateral meniscus (n=15, 14.6%).

Associated Lesion	Number of cases	Percentage
Medial meniscus	43	41.74%
Isolated ACL injury	24	23.30%
Lateral meniscus	15	14.56%
Meniscus, ligaments and	13	12.62%
Medial collateral ligament injury	2	1.94%
Fracture of femoral condyle	3	2.91%
Others	3	2.91%

Time duration after Injury to Reconstruction

The patients who went for ACL reconstruction within one year of injury were found to be 42.71% (n=44). There were very few number of patients (2%) who had undergone ACL reconstruction in early phase (< 3 weeks). This clearly shows that most of the patients visited the hospital for reconstruction after long period of time.

DISCUSSIONS

The lateral femoral notch sign (LFNS) has been described as a sign of chronically ACL-torn knees on conventional radiographs. In chronic injuries, it is defined as a depression more than 1.5 mm deep in the lateral femoral condyle, near the terminal sulcus.[15]

In the present study, mean age group of patients having ACL tear was 35.7 years with majority of patients belong to the age group 20 to 40 years (59.2%) which is similar to the findings derived from the study conducted by Li et al. which depicted the mean age of patients was 37 ± 10.8.[5] Similarly the study conducted by Fahim et al. also showed mean age of male and female was 32.9 and 33.[16] Increase incidence of ACL injury in those young adults is probably due to the active and frequent participation in sports and other outdoor activities.

Males have higher incidence of ACL injury than females whereas this findings is consistent with the study done by Monk et al. where out of 61 patients 40 were male.[17] This may be due to the fact that in the context of Nepal, young male are more engaged in the outdoor activities and sports as compared to the females and males more seek treatment rather than females. However, in this present study left knee was more affected rather than left knee. This findings were contrast than the study done by Kochhal Niharika et al. in India where they identified that 40% of the patients were affected on the left side, 59% on right side, and one percentage on both the side of the knees.[18]

The prevalence of lateral femoral notch sign in ACL tear is identified as 92.9% which is higher prevalence as compared to the study conducted by Berthold et al. which showed the prevalence of 40% of the patients with combined ACL tears and posterior root tears of the lateral meniscus.[19] This prevalence may be higher due to the physical work performed by the patients as well as the ignorance of the clients to seek the treatment in our settings.

In this study, all of the patients whose measurement of notch sign was above 0 mm (0.03 - 3.24 mm) are included which is similar to the findings extracted from the study conducted by Joseph et al. where 124 patients with ACL tear were included in the study.[20]

Among the 103 ACL injury patients, the deep lateral notch sign was present among the twenty-four cases (23.3%) in this study, which corresponds to the findings derived from the study conducted by Herbst et al. which identified 25.78% ACL injury had the deep lateral femoral notch sign.[7] In contrast to this, the study conducted by the Lucidi et al. identified only 10% of cases having the notch greater than two mm which is comparatively lower than that of our study.[21] The variations may be due to the variations in medical practices including radiological diagnostic criteria.

A study conducted by Gong et al. concluded that the lateral femoral notch sign have strong clinical significance in the diagnosis of ACL injuries and the deeper notch often indicates a more complex injury.[22] It identified that the notch depth equal to 0.72 mm can be easily considered for the optimal cut off points for LFNS statistics whereas the notch depth equal to two mm and greater were considered as cut-off points for LFNS in this study.[22]

The incidence of medial meniscus tear was higher (41.7%) than that of lateral meniscus in this study and this is similar to the study conducted by Remer et al. among the 205 patients which identified 43% of medial meniscus tear in the pattern of ACL injury.[23] Similarly the incidence of medial meniscus was higher in the different studies.[24,25] On contrast to this, a study conducted by Kortthaus Alexander et al concluded that the lateral meniscus (41%) was more evident.[26] This is due to the fact that the medial meniscus is more firmly attached to the medial collateral ligament and joint capsule.

Sports was observed as the most common mode of ACL tear (27.2%) which is similar to the study conducted in Nepal in referral tertiary trauma center among the 237 patients (33.3%).[27] Similarly study conducted in China among the 4355 ACL tear inpatients identified sport trauma was the main cause of ACL tear in China.[28] Furthermore, a study conducted in New Zealand among 238488 knee ligament injury identified sports activities are the primary source of ACL injuries resulting in surgery (65 %).[29] This may be due to the involvement of adults in the sports activities.

Due to lack of control group in the study, we were not able to calculate sensitivity, specificities, positive and negative predictive values. Furthermore, it is difficult to calculate receiver operating characteristics curve values. There was difficulty to obtain true lateral view X-ray due to complain of pain so there might be some measurement error due to rotation of the kne.

CONCLUSION

The deep lateral notch sign greater than two mm was considered as positive notch sign in ACL injured patients. In this study, 23.3% of patients shows positive notch sign greater than two mm in their preoperative knee X-ray. Plain radiographs may not be the accurate in diagnosing the ACL injury in the hospital settings as in majority of cases, deep LFNS was not found to be present in 76.7% of cases in this study. So we can conclude that the presence or absence of notch in plain radiograph is inconclusive to identify ACL tear in the patient.

The cut off point for deep femoral notch sign or positive notch sign was considered two mm in this study. The prevalence of positive femoral notch sign will significantly increase if the cutoff point was considered more than 1.5 mm.

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