



Measurement of Distance Between Femoral Insertion of Fibular Collateral Ligament and Popliteus: A Cadaveric Study in Indian Population

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Abstract

Background Injuries to posterolateral corner (PLC) of knee are often neglected. The three key components of PLC are lateral collateral ligament (LCL), popliteofibular ligament (PFL) and popliteus tendon (PT). For adequate reconstruction, anatomic location of these ligaments should be well understood.

Material and methods Twenty formalin fixed cadaveric knees were dissected. PT and LCL identified. Circumference of the two structures marked with pen just after cutting them close to bone surface. Distance between the centre of LCL and PT was measured along with the measurement of distal femoral medio-lateral dimension (MLD) and Anteroposterior dimension (ALD) of lateral condyle.

Result The mean distance between PT and LCL measured in 20 specimens was 8.3 ± 0.84 mm, with a range of 7 mm to 10 mm. MLD was 81.0 ± 3.6 mm and APD was 62.7 ± 3.2 mm.

Conclusion The distance in Indian population is significantly smaller compared to the western. This has clinical implication in drilling the tunnels for PLC reconstruction.

Keywords Posterolateral corner · Lateral collateral ligament · Popliteus tendon · Knee injuries · Ligament reconstruction · Cadaveric

Introduction

Posterolateral corner (PLC) of knee has a vital significance in its stability [1]. Main components of PLC are lateral collateral ligament (LCL), popliteofibular ligament (PFL) and popliteus tendon (PT). Other structures providing additional stability to PLC, are biceps femoris, iliotibial tract, mid-third lateral capsular ligament, fabellofibular ligament, posterior arcuate ligament, lateral coronary ligament, posterior capsule [2, 3]. These structures play key role in resisting varus and external rotation [4–7]. In 30 degree flexion, LCL and PFL functions as static stabilizers resisting varus and external rotation, whereas, PT works as dynamic stabilizers of posterior tibial translation and external rotation in increasing knee flexion [4, 8–11].

Isolated injuries to PLC are rare. Injuries occur either in combination to posterior cruciate ligament (PCL) or anterior cruciate ligament (ACL) [12, 13]. If PLC injuries are not adequately treated then the reconstructed cruciate ligaments has significantly higher chances of failure and in long run it can lead to osteoarthritis of the knee [14–17]. Anatomic PLC

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reconstruction can only be done if the accurate location of various structures with relation to lateral epicondyle and to each other is well known. LaPrade et al. [9] mentioned that the distance between femoral insertion of LCL and popliteus is 18.5 mm, on the contrary, Takeda et al. [18] concluded the average distance to be 8.18 mm in Japanese population. The average height and distal femur dimensions of Asian population, including Indians, is less. So, for anatomical reconstruction, assessment of this distance is necessary.

Materials and methods

Thorough literature search was done and it was found out that several studies were conducted on 7–34 cadavers. In our anatomy department, we could get a maximum of 20 cadaveric knees [9].

Formalin fixed cadaveric knees with well preserved bone and soft tissue having no sign of any knee surgery or disease altering the anatomy were chosen. Cadavers were specifically screened for any un-united or malunited distal femur fractures expected to obscure the proper visualisation of structures and were excluded.

Skin, subcutaneous tissue from distal thigh and proximal leg removed. Iliotibial tract and biceps tendon cut and retracted. LCL and popliteus identified and cut 2 cm distal to the femoral insertion and held with a suture (Fig. 1). Fascia and fat around the stumps of both ligaments was removed to demarcate the bony attachments. The stumps cut, as close to the bone as possible, and the outline of bony insertions marked with a marking pen. Then, the centre points of both the ligament insertion marked as the mid-point of maximum and minimum dimensions. The distance between the two was measured (Fig. 2). The

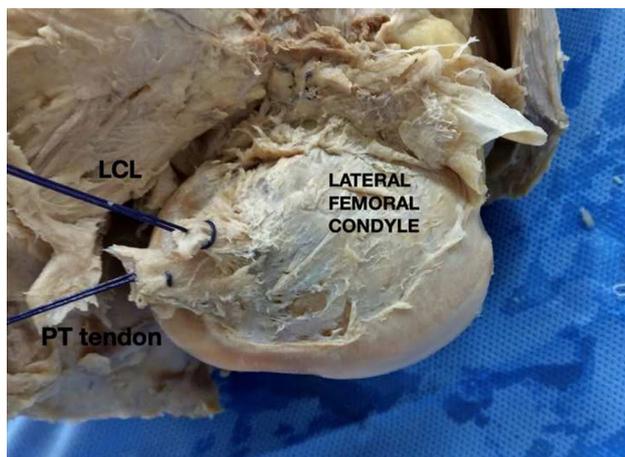


Fig. 1 Dissected specimen of Lateral Femoral Condyle showing attachments of LCL and PT tendon



Fig. 2 Dissected specimen of Lateral Femoral Condyle showing distance between centre point of LCL and PT tendon

maximum medio-lateral dimension (MLD) was measured as distance between medial and lateral epicondyle using a vernier caliper (Fig. 3). Anteroposterior dimension (ALD) of lateral femoral condyle was also noted in similar way (Fig. 4).



Fig. 3 Maximum mediolateral distance (MLD) of distal femoral condyle using a vernier caliper

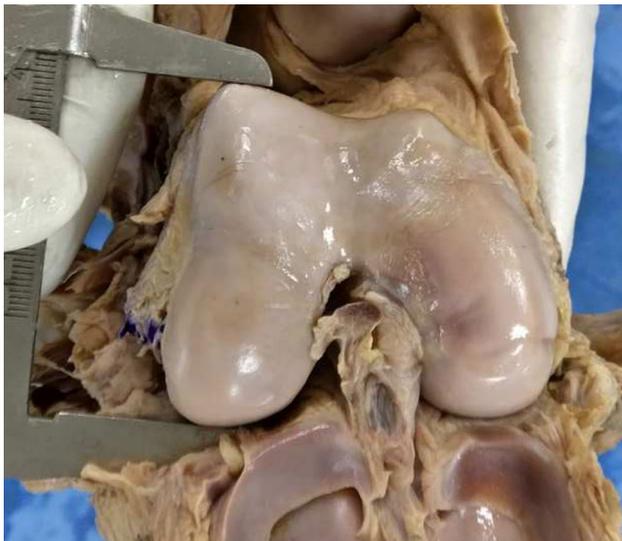


Fig. 4 Anteroposterior dimension (ALD) of lateral femoral condyle using a vernier caliper

Result

Most of the specimens were amputated limbs, hence, the gender could not be ascertained in the study. The findings noted are compiled in Table 1. The mean distance between PT and LCL measured in 20 specimens was 8.3 ± 0.84 mm, with a range of 7 mm to 10 mm. MLD was 81.0 ± 3.6 mm and APD was 62.7 ± 3.2 mm.

In our dissection, we noted that LCL inserts just posterior to lateral epicondyle and PT inserts on the most anterior part of popliteal sulcus.

Discussion

It is the first cadaveric study done on Indian population to measure the distance between femoral insertion of LCL and PT, the mean was found out to be 8.3 mm. This distance is significantly smaller than reported by several western authors. In 2003, Laprade et al. [9] in a study of 10 cadavers in Minnesota, reported that the popliteus tendon invariably inserts anterior to LCL insertion, 18.5 mm obliquely, in anterior one-fifth and proximal half of the popliteal sulcus. Similar conclusion was reached by Kim et al. after studying seven cadaveric knees in 2009 in Korean population. Brinkman et al. [22] in 34 human cadavers in the Netherlands, found that popliteus tendon inserts parallel to long axis of femur, a mean of 11 mm distal. They also noted that it inserts 0.84 mm anterior to LCL insertion with variation between 8.5 mm posterior 9.5 mm anterior to LCL. Jung et al. [20] in the year 2010 revealed that in most of the cases PT is attached at the postero-inferior site of the LCL attachment

Table 1 Measurements in cadaveric specimens (Present study)

	Medio-lateral dimension of distal femur (in cm)	Lateral condyle (AP dimension in cm)	Distance b/w popliteus and LCL (in mm)
1	8.12	6.52	8
2	8	6.2	8
3	7.2	5.65	7
4	8	6.63	7
5	8.17	6.2	8
6	8.36	6.46	9
7	8.56	6.43	10
8	8.23	6.34	8
9	7.46	5.84	7
10	8.2	6.45	8
11	8.2	6.42	10
12	8.24	6.12	9
13	8.15	6.2	8
14	7.34	5.56	8
15	8.16	6.44	9
16	8.42	6.4	8
17	8.45	6.38	8
18	8.24	6.34	9
19	8.43	6.9	9
20	7.56	5.86	8

and is very close to it and did not mention it qualitatively. Study was conducted on Korean population (Table 2).

There was just one study, by Takeda et al., which described almost comparable results in Japanese population. In 2014, they noted that the mean distance between LCL and PT femoral insertions was 8.18 mm.

Qualitatively, LaPrade et al. [9] and Staubli and Birrer [21] described the PT tendon as inserting proximally, at the anterior end of the popliteal sulcus on the lateral femoral condyle. Jung et al. mentioned that the position is variable and in 13 out of 18 knees, it was located in centre of the popliteal sulcus (Table 3).

The difference in the PT–LCL distance noted compared to other study is most likely due to the difference in the

Table 2 Distance between popliteus and LCL in various cadaveric studies

	Distance b/w popliteus and LCL (in mm)	Country
Laprade et al. [9] (2003)	18.5	Norway
Kim et al. [19] (2009)	18.5	Korea
Brinman et al. [20] (2005)	11	Netherlands
Takeda et al. [18] (2014)	8.18	Japan
Present study	8.3	India

Table 3 Measurements of MLD and ALD in various studies

Ethnicity	Femoral antero-posterior dimension (mm)	Femoral medio-lateral dimension (mm)
Kim et al. [24] (2016)		
White	62	74
Black	63	69
East Asia	59	71
Indian	59	65
Hussain et al. [23] (2013)		
Malay male	63.93 ± 3.36	74.88 ± 3.55
Malay female	57.39 ± 3.29	64.53 ± 3.12
Chinese male	66.6 ± 2.40	74.4 ± 3.10
Chinese female	61.0 ± 2.70	66.8 ± 3.11
Indian male	61.09 ± 3.74	69.64 ± 3.11
Indian female	54.47 ± 1.91	61.06 ± 3.11
Present study		
Indian	62.7 ± 3.2	81.0 ± 3.6

dimensions of distal femur. Western population has been found to have a larger AP and ML dimension [24]. The mean AP dimension was in conjunction with other studies, but ML dimension was more. This could be for the reason that we took epicondyles of cadaver as the measuring points which are farthest, however, other authors took measurement from the surface of condyles, that too of dried bone specimens or CT images [23,24].

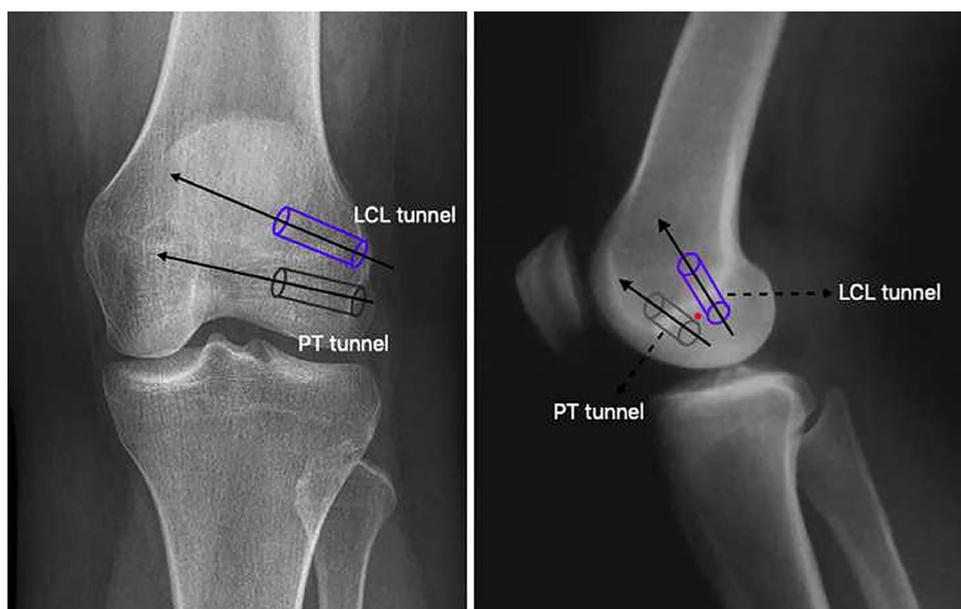
Cruz et al. [25] recommended drilling femoral tunnels for both LCL and PT with 9 mm bit, which is out of question here, as the average distance between LCL and PT

was 8.35 mm in Indian population. As the smallest dimension among the specimen was 7 mm, so even the tunnels with size of 7 mm each, would also confluence with each other. Hence, we advocate that one should not drill the tunnels parallel to each other as described by foreign authors, but in a diverging manner in both planes as shown in the Fig. 5. Our recommendation is to use 6 mm reamer for males and 5 mm for short stature female patients. The direction of each tunnel and the divergence should be individualised depending on the additional procedure or ligament reconstructed, so as to avoid collision to ACL tunnel and damage to the trochlea.

There are certain weaknesses in the study. First, the sample size is small and hence the data cannot be authenticated very well. Second, the gender specific measurements could not be done as the dissection was done on already amputated specimens. Finally, India is a conglomerate of different races and these findings might not hold true for each one of them.

Conclusion

The anatomy and dimension of bones, which is the basis of orthopaedic surgery, vary among different races. These things should be kept in mind whenever operating a patient as most implant designs and surgical steps are described according to western population. Moreover, while interpreting data from different geographical regions, one should analyse the patient characteristics also before applying it on an altogether separate race.

Fig. 5 Proposed divergent tunnel positions

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Availability of Data and Material We have supported our study with adequate data. If further information is required, we fully cooperate.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval The study was done in compliance with ethical standards of our institutional research ethics committee.

Consent for Publications We give our consent for the publications.

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