

Assessing the relationship of the peroneal nerve to the posterolateral corner of the knee and influence of race on its dimensions— A MRI based study in Indian population

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ABSTRACT

Background: The relationship of Common peroneal nerve (CPN) to the posterolateral corner of the knee joint is important for surgeons who perform total knee arthroplasty to avoid injury to the nerve during surgery. This relationship varies among different races on account of anthropometry. This study aims to evaluate the anatomical location of this nerve in Indian patients using an MRI based reference system. **Methods:** 213 knee magnetic resonance images (MRIs) were evaluated in axial plane 8 mm below the joint line for distance of the CPN from the closest posterolateral capsule. The angle of the CPN from the center of the tibial anteroposterior axis and relation of CPN with respect to the popliteus were evaluated. A comparative analysis of these measurements among Caucasian, Chinese and Indian patients was made to evaluate for any differences.

Results: The mean distance between the CPN and the knee capsule was 15.55 mm (range, 7.8–26.2 mm). The mean angle of the CPN from the center of the AP axis was 50.1° (range, 38–63). CPN was found to be in line with the popliteus from center of the knee in 62% cases. There was no significant difference among the different races among the measured parameters ($p > 0.005$).

Conclusion: This study establishes a “danger zone” and a “safe zone” to avoid CPN injury in total knee arthroplasty in Indian patients and identifies anatomic landmarks to localize the nerve before the soft-tissues release in order to avoid direct injury.

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1. Introduction

The knowledge of the relationship of the Common Peroneal nerve (CPN) to the posterolateral corner of the knee joint is important for knee surgeons performing arthroplasty. Even though the reported incidence of CPN injury after knee arthroplasty is 0.3%–9.5%,^{1–3} studies using electromyography have shown that relying on clinical assessment significantly underestimates this injury and the incidence could be as high as 16.7%.^{4,5} Various factors such as preoperative flexion or valgus deformity, compression from hematomas, prolonged tourniquet inflation time, constrictive

dressings, postoperative epidural analgesia, and previous neuropathy may predispose to this injury.^{6–8} The increased popularity of local Infiltration Anesthesia (LIA) in which local anesthesia cocktail is infiltrated into the posterior capsule during surgery is another risk factor that may predispose to this injury.⁹ Direct injury to peroneal nerve can be avoided by proper knowledge of the anatomic location of the nerve during arthroplasty which can reduce the complications ensuing from such an injury.

Few studies have been published studying the anatomic relationship of the CPN to different bony landmarks or soft tissues either in Cadavers or on Magnetic Resonance Imaging (MRI).^{10,11} However, these studies were done in Caucasian or Chinese population whose anthropometry is entirely different from Indian patients and may not be useful to precisely extrapolate those measurements in this race. The aim of this study is to evaluate the anatomic proximity of CPN to the posterolateral corner of the knee

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and the relationship of the popliteus tendon at the level of standard tibial cut in Indian patients using MRI.

2. Material & methods

2.1. Subjects

This retrospective study to evaluate the position of CPN in Indian Knees was performed between April 2016 to March 2017 after obtaining the approval from Institute Human Research ethics committee and therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. A total of 243 consecutive knees who underwent MRI scan of the knee for various knee problems were obtained from the hospital data and assessed. Patients younger than 18 years, having a history of prior surgery to the knee joint, severe varus deformity $>15^\circ$, history of subluxation or dislocation were excluded from the study group. All the images were acquired using 1.5 T MRI system (Philips Achieva) with a slice thickness of 4 mm and field of view of $160 \times 160 \times 97$ mm. In all the patients, T-2 weighted TSE axial images at the level of a standard tibial bone “cut” during TKA were examined. The level of tibial bone “cut” was taken as the axial slice approximately 8 mm distal to the articular surface of the lateral tibial plateau which was consistently one or two slices below the joint line which was prescribed by Jenkins et al.¹²

2.2. Measurements

The Anteroposterior (AP) dimension of the tibia was measured by drawing a line connecting the medial edge of the tibial tuberosity with the middle of the Posterior Cruciate Ligament which was traced upward 8 mm distal to the chondral surface of the tibia. The AP dimension was measured at this level which was one to two slices below the joint line and reflects the actual level of tibial cut while performing total knee arthroplasty in most cases. The mediolateral (ML) dimension of the tibia was calculated by drawing a line that was perpendicular to the AP axis intersecting it at its mid-point (Fig. 1). The angle of the CPN to the tibial surface was calculated by drawing a line connecting the center of CPN to the tibia center along the AP axis (Fig. 2). The distance of CPN to the capsule was calculated by the method described by Jia et al.¹⁰ by measuring the distance between the closest extraarticular edges of the knee capsule to the anterior edge of the CPN (Fig. 3). Finally, the CPN was recorded as lying either medial, behind or lateral to the popliteus tendon. All the measurements were recorded by a board-certified radiologist and an Orthopedic surgeon independently on two separate occasions.

2.3. Statistical analysis

Statistical analysis was performed using SPSS version 16.0 software (IBM-SPSS, Armonk, USA). The descriptive statistics were calculated and interobserver reliability between radiologist and Orthopedic surgeon was assessed using Spearman-Brown prediction formula. Pearson Correlation Coefficient was used to assess the relationship between distance of CPN to the angle of the nerve, distance of nerve to ML and AP dimensions of the tibial cut surface and between angle of the nerve to ML and AP dimensions of tibial surface. A value of $p < 0.05$ was considered significant for correlations.

3. Results

A total of 243 patients MRI were available for the study among

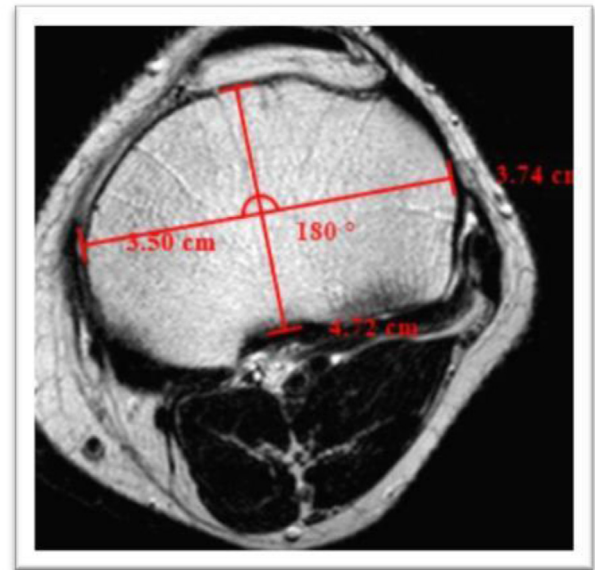


Fig. 1. T2 weighted magnetic resonance image at the level of tibial cut, showing A-P and M-L dimension of tibia.

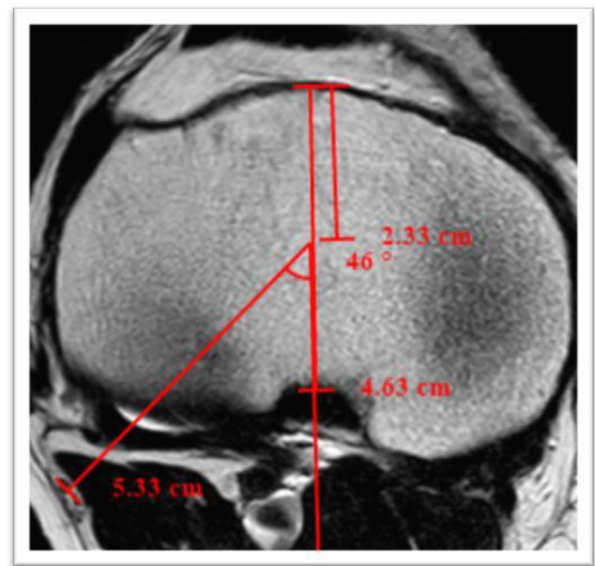


Fig. 2. T2 weighted magnetic resonance image at the level of tibial bone cut, showing angle of CPN with respect to tibial centre and relationship of the CPN to the popliteus tendon from the center of the tibia. In this case, CPN was in line with the popliteus tendon.

which 213 MRIs were included in the study and assessed. The study group consisted of 61 women and 152 men with an average age of 36.7 years (Range 18–68 years) who presented with varied complaints to the knee joint requiring MRI. Among total knees, 59 knees were reported normal, 77 knees had Osteoarthritis changes, 56 knees had meniscal injuries, 46 knees had cruciate ligament injuries, and 9 knees had collateral ligament injuries. Many knees had combined injuries.

3.1. Distance between CPN and posterolateral knee capsule

The mean distance between the CPN and the knee capsule at the

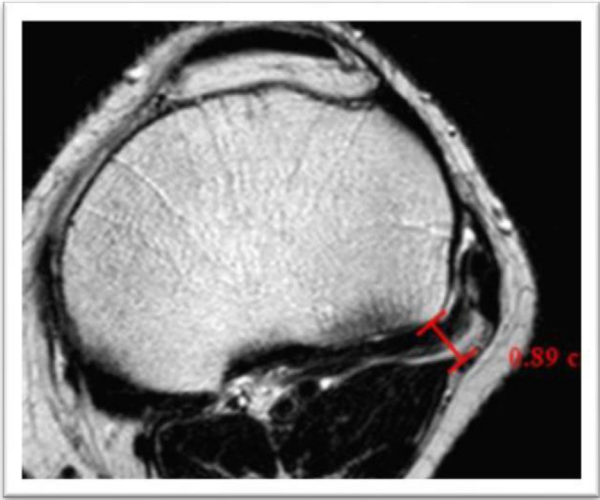


Fig. 3. T2 weighted magnetic resonance image at the level of tibial bone cut, showing closest distance between CPN to posterolateral capsule.

level of tibial cut was 15.55 mm (range, 7.8–26.2 mm) with a mean reported distance of 15.95 mm in men and 14.55 mm in females (Table 1). A comparison between both the sexes revealed no significant difference. The CPN was found to lie immediately behind the popliteus in a majority of knees (132 knees, 62%) and was found to be lateral to popliteus in 59 knees (27.7%) and medial to popliteus in 22 knees (10.3%).

Table 1
Showing the distance of CPN and the dimensions of tibial surface as measured on MRI.

Group	Mean value	95%CI	Range
Distance of CPN to Posterolateral Capsule (mm).	15.55 mm	15.13–15.97 mm	7.8–26.2 mm
Angle of CPN from AP axis of tibia (Degrees)	50.1 (Degrees)	49.35–50.85 Degrees	38–63°
AP distance of tibia at the level of bone cut (mm).	44.28 mm	43.77–44.79 mm	34.9–53.6 mm
ML distance of tibia at the level of bone cut (mm)	71.84 mm	71.17–72.51 mm	60.6–85.1 mm

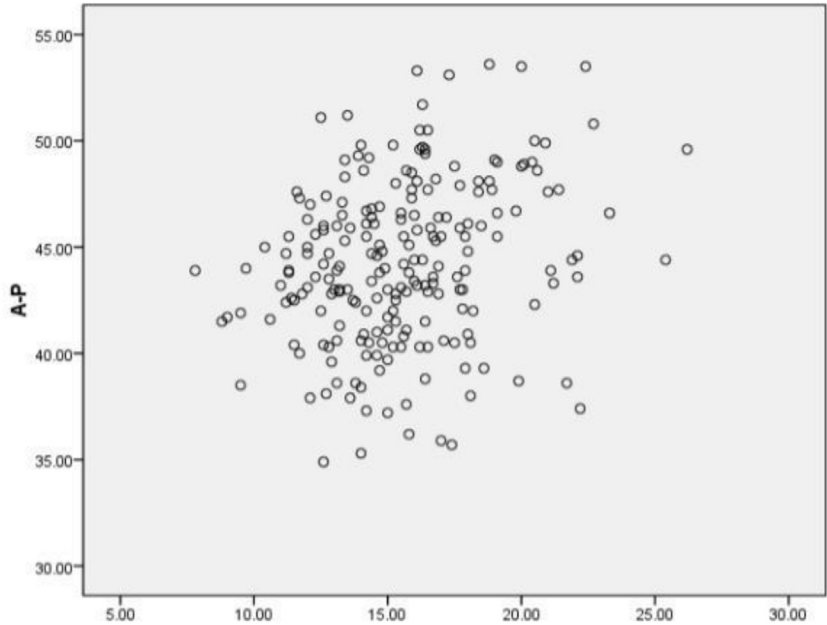


Fig. 4. Scatter diagram showing correlation between CPN distances to anteroposterior dimension of cut tibial surface.

3.2. Angle of CPN and its correlation with different measurements

The mean angle of the CPN to the center of the AP axis was 50.1° (range 38.9°–61.3°) with no significant difference among both the sexes (Table 1). The distance of the CPN had no or negligible correlation with the angle of the nerve (Pearson Correlation coefficient –0.0996, $p = 0.0147$) but had a positive correlation with the ML and AP dimensions of the cut tibial surface (increasing CPN distance, increasing ML dimensions; Pearson correlation +0.3285, $p < 0.001$) similarly (increasing CPN distance, increasing AP dimensions; Pearson correlation +0.249, $p < 0.001$) (Figs. 4 and 5). However the angle of CPN to the midline axis did not have any significant correlation with the AP or ML dimensions of the tibial surface (angle of CPN & ML dimension; Pearson correlation –0.07411, $p = 0.282$. Similarly angle of CPN & AP dimension; Pearson correlation +0.0565, $p = 0.412$.

4. Discussion

The results of our study in Indian patients have shown similar results to previously published studies (Table 2). There are however, some minor differences on account of variation among different races which are not significant ($p > 0.005$). The mean distance of the CPN from the knee capsule at the level of tibial cut was 15.55 mm in our study with a mean angle of 50.1° from the midline of the AP axis. Moreover, the CPN was observed to lie behind the popliteus tendon in majority of knees (62%) and the “safe zone” was estimated to be between 38.9° and 61.3° (Fig. 6.) and the minimum safe distance recorded was 7.8 mm. Our study also

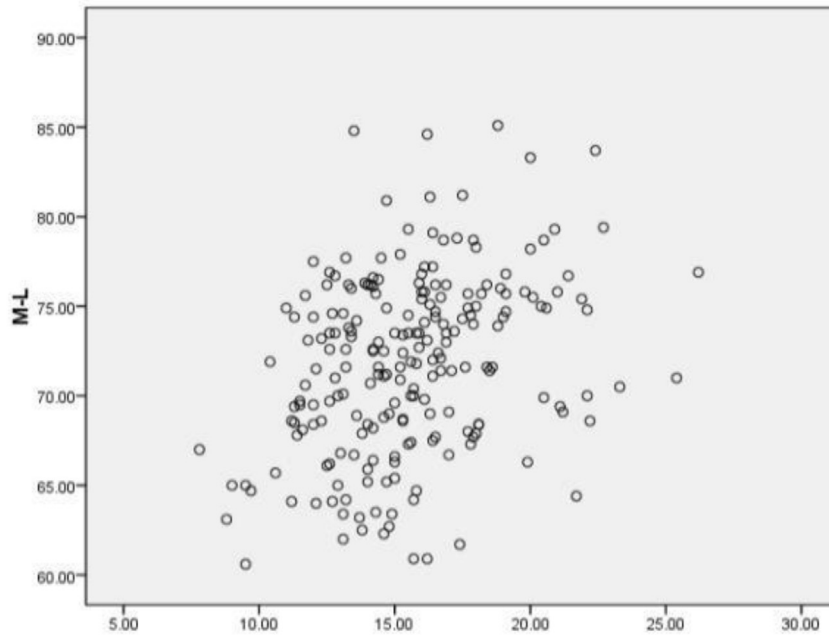


Fig. 5. Scatter diagram Showing correlation between CPN distance to posterolateral corner and mediolateral dimension of cut tibial surface.

Table 2

Shows a comparative study of distance of CPN from the posterolateral corner in various races.

	Type of study	Race	Sample size	Mean(mm)	Range(mm)
Mihalko et al.	Cadaver model	Caucasian	6	—	6–12
Bruzzone et al. ²	Cadaveric	Caucasian	20	13.5	11.2–18.6
Clark et al. ¹⁰	MRI	Caucasian	60	14.9	9.1–21.8
Jia et al. ³	MRI	Chinese	100	14	8–23.2
Jenkins MJ et al. ⁴	MRI	Caucasian	200	11.9	4.7–22.13
This study	MRI	Indian	213	15.55	7.8–26.2

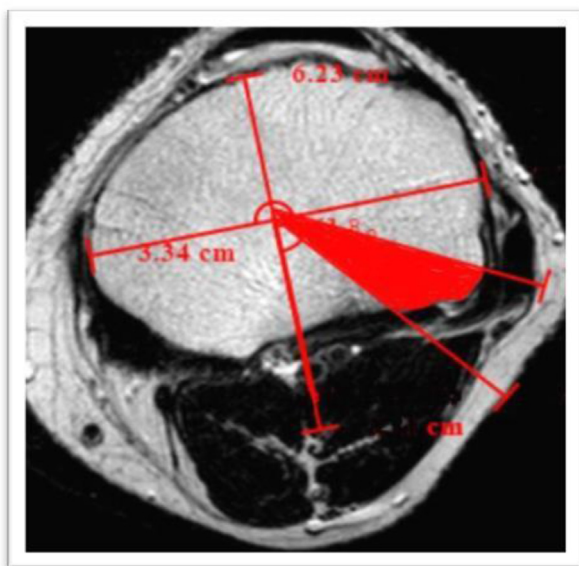


Fig. 6. T2 weighted magnetic resonance image at level of tibial cut showing the danger zone, which represents the central 2 standard deviations; lower limit of danger zone 38.9° and upper limit of danger zone 61.3° from the AP axis.

concludes that there is a significant positive correlation between the distance of the nerve from capsule and dimensions of the proximal tibia. There have been numerous other studies published evaluating the relation of CPN to the tibial border and knee capsule but have utilized different methodologies to calculate the distance and hence have given varying measurements. This study validates the results from previous studies in Indian patients on account of different anthropometric parameters in this subgroup of patients.

Injury to CPN during total knee arthroplasty can be devastating injury which is difficult to recover and can persist with residual motor or sensory deficits in the operated knee.¹³ The nerve is at risk of injury during various steps in surgery such as lateral release, local infiltration analgesia and therefore, it is of paramount importance for the clinician to have a topographic location of the nerve during surgery. Numerous cadaver based or MRI based studies have been published evaluating the location and distance of the nerve from tibial border. Using a cadaver of six knees, Mihalko et al.,⁷ evaluated the safety of pie crusting technique for lateral release and concluded that the peroneal nerve lies approximately 6–12 mm from the posterolateral corner of the tibia in extension. Similarly, Bruzzone et al.¹¹ evaluated the distance of the CPN from the posterolateral corner of cut tibial surface and found it to lie at a mean distance of 13.5 mm (range, 11.2–18.6 mm). They further found a positive correlation between the distance of the nerve and medio-lateral dimensions of the cut tibial surface. Three MRI based

Table 3
Correlation of CPN distance to the AP and ML distances of cut tibial surface.

Bruzzon et al. ³	Correlated both AP and ML dimensions of cut tibial surface
Clarke et al. ¹⁰	Correlated to ML dimension of cut tibia, and the AP dimension of leg (including soft tissue)
Jia et al. ³	Correlated with AP dimension of lower leg (including soft tissue)
Jenkins MJ et al. ⁴	Correlated with ML dimension of tibial cut surface
Our study	Correlated both AP and ML dimension of cut tibial surface

(CPN–Common Peroneal Nerve, AP–Anteroposterior, ML– Mediolateral).

studies have been previously published in which two studies calculated the distance of CPN from posterolateral corner of tibial surface and one study from the posterolateral capsule. Clark et al.¹⁴ and Jia et al.¹⁰ reported the distance between CPN and posterolateral corner of tibial cut surface as 14.9 mm and 14.0 ± 2.7 mm respectively. Jenkins et al.¹² calculated the mean distance of 11.9 mm (range, 4.7–22.13 mm) from the posterolateral capsule and concluded that the nerve lies closer to capsule than the tibial border. All the studies have reported significant correlation between the dimensions of the proximal tibia and the distance of the nerve which assumes that surgeons should be careful in patients having small knees (Table 3).

The concept of “danger zone” defining the area where the peroneal nerve is most likely to lie in the posterolateral corner has been formulated based on its relationship to popliteus tendon or based on the angle of the CPN to the centre of the A-P axis. Bruzzon et al.¹¹ described a “danger zone” between lateral edge of popliteus, tibial cut surface and posterior fibers of iliotibial band and advocated against going deep in this region. Jenkins et al.¹² determined the mean angle of CPN from the center of AP axis and identified a “danger zone”. between 29.95 and 54.57° from the AP axis as 95% cases CPN lies in this zone. In our study, we identified mean angle of CPN from tibial centre to be 50.1 (range, 38–63) degrees and established the “danger zone” lying between 38.9 and 61.3° (Fig. 6.). We also observed that the CPN was found lying directly behind the Popliteus in 62% of cases and hence care should be taken to avoid release or infiltration in this region.

This study does have some limitations. This study did not assess the relationship of the nerve during flexion which is the position in which knee replacement is done due to the use of knee specific coils which require knee extension. However, the change in values may be minimal on account of the relative fixed nature of the peroneal nerve in relation to the posterolateral corner of the knee. The second limitation is that the presence of preexisting cartilage loss in osteoarthritis knees may account for some variations in the measured values. However, the knees included in our group had only early arthritic changes and the patients did not have any symptoms of osteoarthritis. We do believe that the use of a dynamic MRI that can be performed during flexion and extension of knee will allow us to assess the relationship of structures more realistically. Furthermore, intergroup comparisons between normal knees, osteoarthritic varus knees and valgus knees will give more accurate data to avoid CPN injury during knee replacement and understand the changes in relationship of the nerve with deformity even though a recent study has proved no difference in the relationship of the nerve between well aligned and valgus knees¹⁴.

This study concludes that the average distance of CPN from the posterolateral corner of the knee is 15.55 mm with a minimum safe

distance of 7.8 mm. The safety distance is smaller in knees with smaller dimensions and the any infiltration or release should be preferably avoided between 38.9 and 61.3° from the tibial centre.

Conflicts of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2018.09.013>.

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