**RESEARCH ARTICLE**

# MRI-Based Assessment of the Common Peroneal Nerve in ACL-Injured Versus Normal Knees: Implications for Inside-Out Lateral Meniscus Repair

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## Abstract

**Objectives:** This study investigates the risk of CPN injury by measuring the nerve's proximity to the trajectory of a straight needle inserted from the anteromedial portal at the knee joint level during inside-out lateral meniscus repairs in both ACL-injured and normal knees.

**Methods:** In this retrospective study, we examined MRI scans of 30 ACL-injured knees and 30 normal knees. A reference line was drawn 1 cm medial to the patellar tendon at the joint level, extending to the lateral margin of the popliteus and continuing posteriorly. Perpendicular distances from this line to the CPN were measured to compare anatomical variations between the groups. These measurements were analyzed using paired t-tests, with a p-value of less than 0.05, which is considered statistically significant.

**Results:** Analysis of 60 MRI scans revealed that the CPN is located significantly closer to the reference line in ACL-injured knees (mean distance: 1.59 cm) compared to normal knees (mean distance: 2.01 cm), with a p-value of less than 0.005. This finding suggests a higher potential risk of nerve injury in ACL-injured knees during inside-out meniscal repair procedures.

**Conclusion:** The CPN is located significantly closer to potential surgical paths in ACL-injured knees compared to normal knees. These findings highlight the importance of meticulous surgical planning and technique adjustments to minimize the risk of CPN injury during inside-out meniscus repairs especially when using straight needles.

**Level of evidence:** III

**Keywords:** ACL injured knees, Common peroneal nerve injury, Inside-out technique, Lateral meniscus injury, MRI, Normal knees, Straight needle

## Introduction

Magnetic Resonance Imaging (MRI) plays a pivotal role in diagnosing musculoskeletal injuries, providing detailed insights into the soft tissues around the knee, including ligaments, menisci, tendons, muscles, and nerves. Among these structures, the Common Peroneal Nerve (CPN) is of particular interest due to its susceptibility to injury during knee surgeries. The anatomical relationship between the CPN and the posterolateral corner of the knee is critical,[1,2] especially during arthroscopic repairs of the lateral meniscus using the inside-out technique. Retrospective studies report peripheral nerve injury rates ranging from 0.01% to 0.6%,[3-5] while a large prospective study by experienced arthroscopists found an overall complication rate of 1.68% in 10,262 procedures.[5]

Introduced by Charles Henning in the early 1980s,[6] the inside-out technique has been the gold standard for arthroscopic meniscal repair. However, this method carries inherent risks to surrounding neurovascular structures, notably the CPN, due to its trajectory near surgical paths. The common peroneal nerve (CPN), also known as the common fibular nerve, is the lateral branch of the sciatic

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nerve, originating from the L4, L5, S1, and S2[7-9] nerve roots. At the knee joint level, the CPN is situated within a fat pad behind the lateral gastrocnemius tendon, making it vulnerable to injury from needles placed through the meniscus inside out if not adequately protected.

The standard approach to meniscus repair utilizes thin, flexible needles. However, recent reports on the technique have introduced the use of stiff, long hollow needles,[10] which establish a more predictable path through the outer soft tissues. To mitigate this risk, inserting a retractor in front of the lateral gastrocnemius is recommended to prevent nerve entrapment or injury. Alternatively, the outside-in or all-inside techniques can be used.[1]

Other factors contributing to CPN palsy include hematomas, tight dressings, tourniquet compression, diabetes, past neuropathy, genu valgus or varus deformities, and postoperative epidural analgesia.[11-13]

Given the complexity of knee joint anatomy and the proximity of critical structures such as the CPN, understanding these relationships is essential for reducing the risk of nerve damage. This study aims to examine the position of the CPN in ACL-injured versus normal knees using MRI, thereby providing crucial data to enhance surgical outcomes and minimize complications.

This introductory context sets the stage for a discussion on our methodology and findings, which elucidate the anatomical variations of the CPN between injured and normal knees. These insights can be utilized for surgical planning and technique optimization when using both flexible and stiff needles during lateral meniscus repairs.

## Materials and Methods

### *Study Design*

This retrospective study aimed to assess the anatomical position of the Common Peroneal Nerve (CPN) in relation to the knee joint in ACL-injured versus normal knees, using magnetic resonance imaging (MRI) data.

### *Ethical Considerations*

The study protocol was approved by the Institutional Ethical Committee (IECSMCGGH/2024/AP/001). Due to the retrospective nature of the study, the requirement for informed consent was waived. However, all patient data were anonymized prior to analysis to maintain confidentiality and comply with ethical standards.

### *Participants*

Sixty MRI scans from patients treated at our hospital were reviewed, comprising thirty MRIs of ACL-injured knees and thirty of normal knees. The patients ranged in age from 17 to 65 years and presented with varying degrees of knee complaints that necessitated imaging.

### *Imaging Protocol*

All MRIs were performed using a 1.5 Tesla MRI system (PHILIPS). T2-weighted axial images were acquired with a slice thickness of 2 mm and a field of view of 530 × 353 × 112 mm. Each MRI was evaluated at the knee joint level, ensuring consistent imaging parameters across all scans.

### *Measurement Procedure*

A standardized reference line was drawn 1 cm medial to the patellar tendon anteriorly, extending to the lateral margin of the popliteus. A perpendicular line to the CPN was then drawn from this reference line, and the distance between these two lines was measured in centimeters [Figure 1]. To reduce measurement bias, this process was independently performed by two radiologists—one with ten years of experience and the other a junior radiologist with five years of experience.

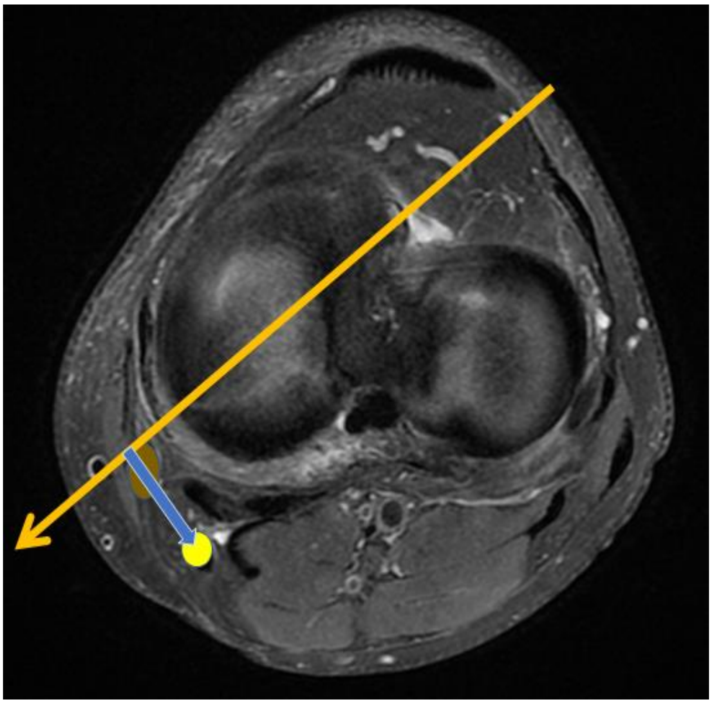

**Figure 1. Measurement method illustrating the reference line drawn from 1 cm medial to the patellar tendon to the lateral border of the popliteus muscle (yellow arrow). A perpendicular line (blue arrow) is drawn from this reference line to the Common Peroneal Nerve (CPN). The yellow circle indicates the CPN, while the brown oval represents the popliteus muscle**

### *Sample Size Calculation*

Based on the calculations from this study:

- Effect Size (Cohen's d): 1.58
- Pooled Standard Deviation: 0.27

The sample size calculation indicates that approximately 8 participants per group (rounded from 7.35) are required to achieve 80% power with an alpha level of 0.05. This small sample size is attributed to the large effect size observed, which suggests a significant difference between the two groups with relatively small variance within each group.

### *Data Analysis*

The mean distances between the CPN and the reference line were calculated for both ACL-injured and normal knees [Figure 2]. These measurements were compared using paired t-tests, with a p-value of less than 0.05 considered statistically significant. The analysis was performed using SPSS and Microsoft Excel software.

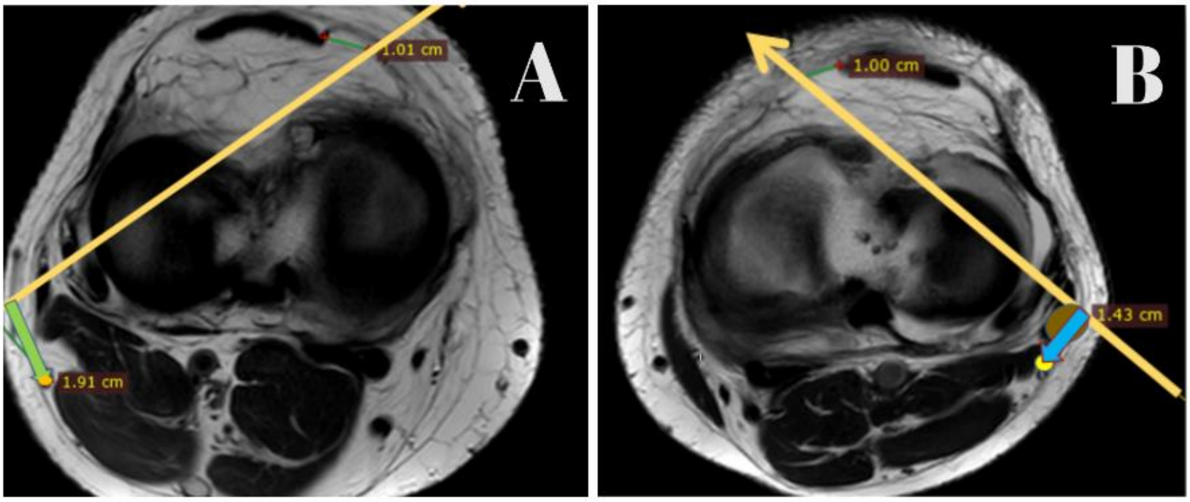


**Figure 2. Axial MRI images comparing a normal knee (A) with an ACL-injured knee (B), demonstrating our measurement method**

## Results

The results for ACL-injured knees and normal knees, categorized by age, gender, and side, are summarized in [Table 1].

### *Statistical Analysis*

The difference in CPN distance between ACL-injured and normal knees was statistically significant, with a p-value of less than 0.05. This finding suggests an increased risk of CPN injury during surgical procedures involving the inside-out technique in ACL-injured knees due to the closer anatomical positioning of the nerve. The mean CPN distance for ACL-injured knees was 1.59 cm, while for normal knees it was 2.01 cm, yielding a t-statistic of -6.14 and a highly significant p-value of $8.06 \times 10.^{8}$

The mean CPN distance for high-energy trauma was 1.63 cm, compared to 1.51 cm for low-energy trauma. The standard deviation for high-energy trauma was 0.28 cm, while for low-energy trauma it was 0.30 cm, resulting in a t-statistic of 1.23 and a p-value of 0.23. Thus, the difference in measurements between high- and low-energy trauma was not statistically significant.

Table 1 Distribution of CPN distance measurements from the reference line, categorized by gender, age, and side, in both ACL-injured and normal knees [Table 1].

Table 2 provides a summary of all parameters related to the sixty patients included in the study [Table 2].

**Table 1. Distribution of measurement of distance of CPN from the imaginary line based on gender, age and side in both ACL injured and normal knees.**

| S no | | ACL injured knee | Normal knee |
|---|---|---|---|
| 1 | **Measurements** | 47.61/30=1.587cm | 60.37/30 = 2cm |
| | *Females* | 5.59/4= 1.39cm | 26.35/13= 2cm |
| | *Males* | 42.02/26= 1.61cm | 34.02/17= 2cm |
| 2 | **Age** | 1139/30= 37.96 yrs | 1025/30= 34.16 yrs |
| | *Females* | 156/4=39 yrs | 496/13 = 38.1yrs |
| | *Males* | 983/26=37.8 yrs | 529/17= 31.1yrs |
| 3 | **Right sided measurements** | 22.67/14= 1.61cm | 27.04/14= 1.93cm |
| 4 | **Left sided measurements** | 24.94/16= 1.55cm | 33.33/16= 2.08m |

**TABLE 2. Tabular form depicting various parameters of all 60 patients included in our MRI study.**

| Patient number | Age | Side involved | Sex | ACL torn | Mechanism of trauma | Any other ligament injury | Measurement |
|---|---|---|---|---|---|---|---|
| 1 | 36 | Right | F | Yes | Low energy trauma | No | 1.98cm |
| 2 | 34 | Right | M | Yes | High energy trauma | No | 1.27cm |
| 3 | 35 | Left | F | Yes | Low energy trauma | No | 1.18cm |

**TABLE 2. Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 26 | Right | M | Yes | High energy trauma | No | 1.54cm |
| 5 | 28 | Left | M | Yes | High energy trauma | No | 1.62cm |
| 6 | 61 | Right | M | Yes | Not known | No | 1.99Cm |
| 7 | 50 | Right | M | Yes | Not known | No | 1.81Cm |
| 8 | 45 | Left | M | Yes | High energy trauma | No | 1.49Cm |
| 9 | 17 | Right | M | Yes | High energy trauma | No | 1.50Cm |
| 10 | 30 | Left | M | Yes | High energy trauma | No | 2.02Cm |
| 11 | 20 | Left | M | Yes | Not known | No | 1.54Cm |
| 12 | 37 | Left | M | Yes | High energy trauma | No | 1.74Cm |
| 13 | 47 | Left | M | Yes | High energy trauma | No | 1.55Cm |
| 14 | 28 | Left | M | Yes | High energy trauma | No | 1.44Cm |
| 15 | 39 | Right | M | Yes | Low energy trauma | No | 1.92Cm |
| 16 | 35 | Right | M | Yes | High energy trauma | No | 1.36Cm |
| 17 | 23 | Left | F | Yes | Low energy trauma | No | 1.01Cm |
| 18 | 42 | Left | M | Yes | Not known | No | 1.67Cm |
| 19 | 45 | Left | M | Yes | Not known | No | 1.06Cm |
| 20 | 65 | Left | M | Yes | Not known | No | 1.98Cm |
| 21 | 25 | Right | M | Yes | High energy trauma | No | 1.45Cm |
| 22 | 52 | Right | M | Yes | Not known | No | 1.46Cm |
| 23 | 42 | Left | M | Yes | Low energy trauma | No | 1.65Cm |
| 24 | 22 | Right | M | Yes | Low energy trauma | No | 1.68Cm |
| 25 | 30 | Right | M | Yes | High energy trauma | No | 1.43Cm |
| 26 | 40 | Right | M | Yes | Low energy trauma | No | 1.37Cm |
| 27 | 62 | Left | F | Yes | Low energy trauma | No | 1.42Cm |
| 28 | 26 | Left | M | Yes | High energy trauma | No | 2.14Cm |
| 29 | 62 | Left | M | Yes | Not known | No | 1.43Cm |
| 30 | 35 | Right | M | Yes | High energy trauma | No | 1.91Cm |
| 31 | 22 | Left | M | No | NA | No | 1.96Cm |
| 32 | 44 | Right | M | No | NA | No | 2.23Cm |
| 33 | 25 | Right | M | No | NA | No | 2.30Cm |
| 34 | 47 | Right | F | No | NA | No | 2Cm |
| 35 | 32 | Left | F | No | NA | No | 2.31Cm |
| 36 | 36 | Left | M | No | NA | No | 2.26Cm |
| 37 | 32 | Left | F | No | NA | No | 1.85Cm |
| 38 | 48 | Left | F | No | NA | No | 2.53Cm |
| 39 | 29 | Left | M | No | NA | No | 1.94Cm |
| 40 | 38 | Left | F | No | NA | No | 2.55Cm |
| 41 | 17 | Right | M | No | NA | No | 1.93Cm |
| 42 | 33 | Left | M | No | NA | No | 2.05Cm |
| 43 | 49 | Right | M | No | NA | No | 2.09Cm |
| 44 | 31 | Left | M | No | NA | No | 2.02Cm |
| 45 | 41 | Left | F | No | NA | No | 2.13Cm |
| 46 | 40 | Right | M | No | NA | No | 1.91Cm |

**TABLE 2. Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 47 | 21 | Right | M | No | NA | No | 1.87Cm |
| 48 | 30 | Left | M | No | NA | No | 2.41Cm |
| 49 | 35 | Right | M | No | NA | No | 1.72Cm |
| 50 | 30 | Left | M | No | NA | No | 1.60Cm |
| 51 | 49 | Left | F | No | NA | No | 1.92Cm |
| 52 | 35 | Right | M | No | NA | No | 1.99Cm |
| 53 | 23 | Right | F | No | NA | No | 1.58Cm |
| 54 | 35 | Left | F | No | NA | No | 2.16Cm |
| 55 | 35 | Right | F | No | NA | No | 1.88cm |
| 56 | 23 | Right | M | No | NA | No | 1.97cm |
| 57 | 29 | Left | M | No | NA | No | 1.77cm |
| 58 | 42 | Right | F | No | NA | No | 1.72cm |
| 59 | 34 | Right | F | No | NA | No | 1.85cm |
| 60 | 40 | Left | F | No | NA | No | 1.87cm |

## Discussion

The Anterior Cruciate Ligament (ACL) is most commonly injured during sporting activities. It can also be injured during activities of daily living and motor vehicle collisions. The majority of these injuries occur through a non-contact mechanism. Contact injuries are typically 2 to 8 times more common in young females.[14,15]

Among the patients studied, 14 (46%) sustained high-energy trauma (e.g., motor vehicle accidents), 8 (27%) experienced low-energy trauma (e.g., falls from standing height, sprains), and 8 (27%) had trauma with unspecified mechanisms. ACL injuries were observed in 26 males (87%) and 4 females (13%).

The mean distance of the Common Peroneal Nerve (CPN) from the reference line is significantly shorter in ACL-injured knees compared to normal knees. The extremely small p-value (much less than 0.05) indicates that this difference is statistically significant, suggesting a strong likelihood that ACL injuries influence the proximity of the CPN to the inside-out needle path, thereby increasing the risk of nerve injury during surgeries such as meniscus repairs.

This finding underscores the importance of thorough preoperative planning and potentially modifying surgical techniques to minimize the risk of CPN injuries in ACL-injured patients.

The anatomical position of the Common Peroneal Nerve (CPN) relative to the knee joint is a crucial consideration during arthroscopic procedures, particularly inside-out lateral meniscus repairs. Our study quantitatively assessed the CPN's proximity to a reference line in ACL-injured versus normal knees using MRI, providing valuable insights into the potential risks of nerve injury during such procedures.

The CPN, a branch of the sciatic nerve, is particularly vulnerable due to its superficial course along the posterolateral knee. It lies within a fat pad behind the lateral gastrocnemius tendon, making it prone to injury during needle insertion for meniscal repair. The nerve courses from the posterolateral side of the knee, wrapping around the biceps femoris tendon and fibular head. Typically, it divides at the level of the fibular neck into three branches: the deep peroneal nerve, the superficial peroneal nerve, and the articular (or recurrent) branch.

The deep peroneal nerve innervates the muscles of the anterior compartment of the leg, including the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius. The superficial peroneal nerve innervates the lateral compartment, specifically the short and long peroneal muscles, and provides sensation to the anterolateral lower leg. The recurrent branch supplies sensory information to the proximal tibiofibular joint.[7,16]

Due to its superficial course, trajectory, and minimal epineurium, the CPN and its branches are highly susceptible to traumatic and other lesions. Studies have demonstrated a strong association between knee injuries, dislocations, and peroneal nerve lesions.[17-30]

Recent studies from Brazil emphasize the pivotal role of imaging methods in evaluating the musculoskeletal system in trauma victims.[31,32] However, the retrospective nature of these studies made it challenging to obtain comprehensive clinical data on the types of injuries in some cases.

Numerous studies have investigated the relationship between the neurovascular bundle and the anteromedial portal trajectory during inside-out lateral meniscus repairs.[33-35] Various cadaveric and MRI-based studies have assessed the location and distance of the CPN from the tibial border. Mihalko et al.[12] evaluated the safety of the pie crusting technique for lateral release in six cadaveric knees, concluding that the peroneal nerve lies approximately 6–12 mm from the posterolateral corner of the tibia in extension. Similarly, Bruzzone et al.[36] found that the CPN was, on average, 13.5 mm (range: 11.2–18.6 mm) from the posterolateral corner of the cut tibial surface.

Two MRI-based studies have reported similar findings. Clark et al.[22] and Jia et al.[19] determined the distance between the CPN and the posterolateral corner of the tibial cut surface to be 14.9 mm and 14.0 ± 2.7 mm, respectively. Our observations confirmed that the CPN is typically located directly behind the popliteus tendon, emphasizing the need to avoid using rigid straight needles in this region during lateral meniscus repair.

Our findings indicate that in ACL-injured knees, the CPN is located closer to the reference line (mean distance: 1.59 cm) compared to normal knees (mean distance: 2.01 cm), which may increase the risk of inadvertent nerve damage. This study corroborates earlier reports, suggesting that ACL injuries could alter the position or tension of nearby neurovascular structures, thereby increasing vulnerability during surgical interventions. Our observations support the use of alternative surgical techniques, such as the outside-in or all-inside techniques, which might reduce the risk to the CPN during meniscus repair.

Our research has also highlighted several limitations that warrant future investigation. One key limitation is the lack of assessment of CPN position variability during knee flexion, commonly used during arthroscopy, as MRI scans were performed with the knee extended. Additionally, edema resulting from the traumatic nature of ACL injuries may have introduced observational bias, potentially affecting the visibility and apparent position of the CPN on MRI scans.

Future studies should consider employing dynamic MRI techniques to gain a more comprehensive understanding of the CPN's behavior during knee movements. Additionally, exploring the relationship between various types of knee injuries and CPN displacement could offer deeper insights, leading to safer surgical practices and improved patient outcomes.

***Limitations:***

***Retrospective Design***

The retrospective nature of the study limits control over variables that may influence the positioning of the Common Peroneal Nerve (CPN). Conducting prospective studies could provide more controlled conditions to validate our findings.

***Knee Position during MRI***

All MRIs were performed with the knee in extension. Since routine arthroscopy is often performed in flexion, the findings may not fully represent the CPN's position during surgical procedures. Future studies should include MRI scans in various knee positions to address this gap.

***Sample Diversity***

The demographic diversity of the sample was limited, potentially affecting the generalizability of the results to broader populations.

***Measurement Technique***

Despite efforts to standardize measurements, the manual drawing of reference lines may introduce slight variations. Utilizing automated or semi-automated measurement tools could improve precision.

***Recommendations:***

***Surgical Planning***

Surgeons should take into account individual variations in CPN location, particularly in ACL-injured knees, to minimize the risk of nerve injury. Pre-operative MRI assessments should be tailored to include specific measurements of CPN proximity to the planned surgical path.

***Technique Modification***

Alternative surgical techniques, such as the outside-in or all-inside approaches, should be considered to reduce the risk of CPN damage, especially when the CPN is positioned closer to the surgical field.

***Future Research***

Dynamic MRI studies are recommended to evaluate the movement of the CPN during knee flexion and extension, providing insights that are directly applicable to surgical settings. Longitudinal studies could also investigate the long-term outcomes of patients with varying CPN positions undergoing meniscus repair.

## Conclusion

This study highlights significant anatomical differences in the position of the CPN between ACL-injured and normal knees. ACL injuries appear to alter the proximity of the CPN to potential surgical paths, thereby increasing the risk of nerve injury during meniscus repair procedures. These findings emphasize the importance of thorough preoperative planning and the consideration of individual anatomical variations when selecting surgical techniques.

Improving MRI protocols and investigating alternative surgical approaches could further enhance patient outcomes and reduce the incidence of CPN injuries.

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