EXPERIMENTAL STUDY

# An anatomical examination of iatrogenic nerve injury during inside out meniscus repair with flexion and extension of the knee

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## ABSTRACT

**BACKGROUND:** In this study, we aim to assess the safe, risky and high-risky zones by measuring the proximity of the needles to the peroneal and saphenous nerves in millimeters for the repair of tears of the anterior, middle and posterior horns of the medial and lateral menisci at flexion and extension position during inside-out repair technique.

**METHODS:** First, a cadaveric study was conducted on 10 cadaver knees in which both (lateral and medial) menisci were divided into anterior, corpus and posterior with the longitudinal tear simulating in each section. The next phase involved the suture of the simulated tears of the menisci while the knee was at 90° of flexion and full extension. Finally, the distance from the exit points of the K-wire being inserted through meniscal anterior, corpus and posterior tears to the aforementioned nerves was measured with a digital caliper.

**RESULTS:** The distance between K-wire exit points and neurovascular structures concerning corpus and anterior horn tear repair of both menisci were considered far away and not included. However, closer posterior menisci measurements were taken to avoid the risk of iatrogenic nerve injury. The measured distances for lateral meniscus posterior tears were recorded 11±5.2 mm at 90° of flexion and 8±4.5 mm at extension, whereas those recorded 17.3±5.7 mm at 90° of flexion and 13.7±4.7 mm at extension for medial meniscus. These variables were evaluated statistically using a paired t-test; the mean of t value was not considered statistically significant.

**CONCLUSION:** Our results show that the inside-out technique at knee flexion is safe even in the posterior meniscus tears. However, safety distance can be increased with the higher flexion degrees of the knee. Lastly, in posterior meniscal tear repair, we recommend either retractor assisted mini-open technique at knee flexion, or all-inside suture technique, to avoid nerve injury risk in this zone. Although many surgeons do not prefer inside-out techniques for posterior menisci tears, inside-out posterior meniscal repair of both menisci is as safe as an all-inside technique using retractor assisted mini-open technique with the knee at higher than 90° flexion.

**Keywords:** Inside-out meniscus repair; peroneal nerve injury; saphenous nerve injury.

## INTRODUCTION

Since Fairbank et al.'s research on knee degeneration after meniscectomy, meniscal-sparing techniques have been popularized with improved outcomes.[1–4] It is stated that subtotal or total meniscectomy increase weight-bearing on per square unit of the cartilage surface approximately three and half-times.[5] Today, it is widely accepted that the meniscal repair indications should be expanded and that keeping menisci (even with chronical tears) as much as possible is a necessity.[6]

Repair of a meniscal tear is first defined by Scottish surgeon Annandale in 1885,[7] and both open and arthroscopic repair are still being conducted. Today inside-out, outside-in or all-in-

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side techniques are used in the arthroscopic repair of meniscal tears, which was first initiated by Henning.[8] Although there are promising results on meniscal healing rates with these techniques, the gold standard remains the inside-out vertical mattress suture repair.[6,9–11] However, the inside-out repair technique may cause iatrogenic nerve and vein injury, especially in posterior horn meniscal tears. Moreover, many cases and reports about iatrogenic peroneal nerve and popliteal artery injury during lateral meniscal repair and iatrogenic nerve injury in medial meniscal repairs were reported in the literature.[12–15] To our knowledge, no reported studies have described to which extent the position of the knee (flexion and extension) can increase the neurovascular injury risk. Thus, it is crucially important to know the right knee positioning and safe zones to avoid iatrogenic nerve injury risk with patients who will have undergone inside-out meniscal repair.

The present study aims to investigate the nerve injury risk and assess the safety, risky and high-risky zones by measuring the proximity of the needles to the peroneal and saphenous nerves during the inside-out meniscal repair technique.

## MATERIALS AND METHODS

An anatomic study was performed by the use of 6 right and 4 left, totally 10 fresh cadaver knees (3 female, 7 male), The average cadaver age was measured as 75.1 (range 63–90 years), average weight 82.6 kg (range 41–117 kg) and average height 174.2 cm (range 152–190 cm), respectively. No previous operation scar was observed on the knee specimens. Standard medial and lateral anteroinferior arthroscopic portals were marked on the knees. The anteroinferior medial portal was marked 1 cm. medial, anteroinferior lateral portal was marked 1 cm lateral to the patellar tendon, with 1 cm proximal of tibial joint surface both. After midline skin incision, medial and lateral parapatellar arthrotomy was performed by applying sharp incisions to separate patellar tendon from tibial tuberosity (Fig. 1). Both menisci were visible. Then, medial and lateral meniscuses were divided into three equal parts as posterior, corpus and anterior by marker pen. The longitudinal tear was simulated in each part. First, 1-mm K-wire was entered from the medial portal and passed through the simulated tears at the lateral meniscus, and then, was removed from the skin at the level of the joint line. Once the K-wire was got out of the skin, the posterior of the knees were cut between biceps femoris and iliotibial band with a 15 cm. skin incision to locate the exit point and the peroneal nerve. After blunt dissection, the peroneal nerve was observed by retracting the biceps femoris and iliotibial band. The dissection was not extended to preserve the relationship of the peroneal nerve with the surrounding soft tissue. The distance between the K-wire exit point and the peroneal nerve was then measured in millimeters with a digital caliper and recorded (Fig. 2). Measurements were performed separately while the knee was positioned at 90° of flexion and full extension for 1/3 anterior, 1/3 corpus and 1/3 posterior, respectively. Then, the medial meniscus was divided into three equal and lateral portals were used for K-wire. The saphenous nerve was viewed at posteromedial after dissecting the medial skin-subcutaneous tissue. The 1 mm K-wire was passed throughout the longitudinal tear simulated at the medial meniscus and removed from skin while the knee was positioned at 90° of flexion and full extension (Fig. 3). The distance between the saphenous nerve and K-wire was measured in millimeters for all three parts in 90° of flexion and at full extension like lateral measurements (Fig. 4). Results, taken from both meniscuses in both positions, were transferred to Stata/SE 11.0 program and the average, minimum and maximum values and standard deviations were identified. $P<0.5$ was considered as statistically significant. Furthermore, lateral and medial meniscus posterior measurements were compared, whether the flexion and extension positions of the knee made a statistical difference at this significance level. Statistical evaluation included a paired t-test.

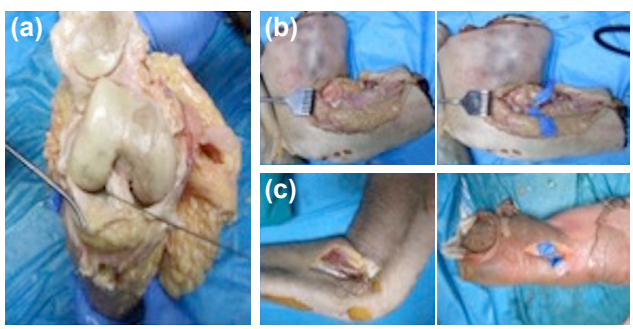


**Figure 1. (a)** Parapatellar arthrotomy and **(b, c)** posteromedial and posterolateral dissections to identify the nerves.

## RESULTS

In one cadaver knee, K-wire was passed through the peroneal nerve during posterior lateral meniscus repair while the knee was extended. The measurements obtained between each K-wire exit point and the peroneal nerve and the saphenous nerve showed the following: The mean distance between K-wire exit point and peroneal nerve in 1/3 posterior horn tear was found to be 11±5.2 (range, 0.9–18 mm) at 90-degree

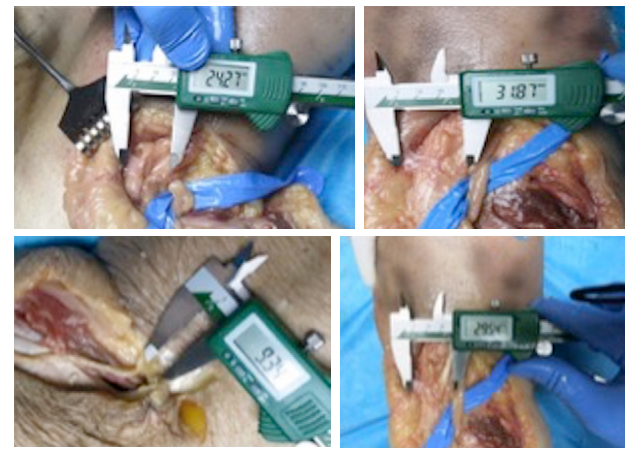

**Figure 2.** Measurements were done by a digital caliper.

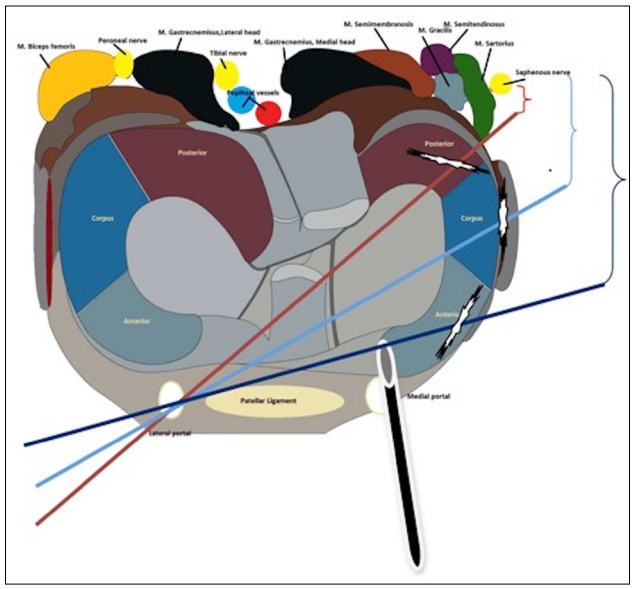


**Figure 3.** Illustration shows the distance between K-wire and the saphenous nerve. Measurements were taken at full extension and 90° of flexion.

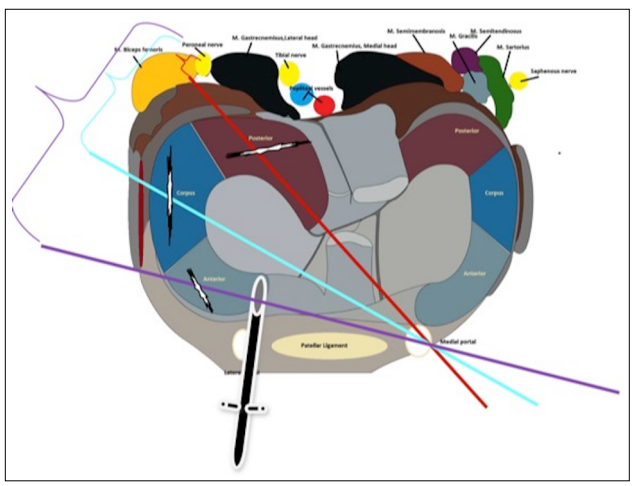


**Figure 4.** Illustration shows the distance between K-wire and peroneal nerve. Measurements were taken at full extension and 90° of flexion.

knee flexion, while 8±4.5 (range, 0–12.7 mm) at extension. İt is found 31.3±6.4 (range, 22.3–40.8 mm) at 90-degree flexion and 38±5.9 (range, 26.2–49 mm) at extension for 1/3 middle horn, while 50.6±7.2 (range, 37.2–61.9 mm) at 90-degree flexion and 52.5±5.4 (range 45.2–61.8 mm) at extension was recorded for 1/3 anterior horn. Similar measurements were performed for medial meniscus. The mean distance between K-wire exit point and saphenous nerve in 1/3 posterior horn tear was found to be 17.3±5.7 (range, 5.3–24.1 mm) at 90-degree knee flexion, while 13.7±4.7 (range, 5.3–19.8 mm) at extension. İt is found 35.8±7.4 (range, 30–56 mm) at 90-degree flexion and 40.8±6.4 (range, 36.2–57.8 mm) at extension for 1/3 middle horn, while 53.3±6.2 (range, 42.8–63.6 mm) at 90-degree flexion and 54.4±8.2 (range, 42.8–70.4 mm) at extension was recorded for 1/3 anterior horn (Table 1). There

**Table 1.** Measurements performed for both menisci

| | Anterior horn | Middle horn | Posterior horn |
|---|---|---|---|
| Medial meniscus (mm) | | | |
| 90° flexion | 53.3±6.2 | 35.8±7.4 | 17.3±5.7 |
| Extension | 54.4±8.2 | 40.8±6.4 | 13.7±4.7 |
| Lateral meniscus (mm) | | | |
| 90° flexion | 50.6±7.2 | 31.3±6.4 | 11±5.2 |
| Extension | 52.5±5.4 | 38±5.9 | 8±4.5 |

are no statistically differences ($p<0.5$) between the K-wire exit points through the different locations studied.

## DISCUSSION

It is widely accepted that choosing arthroscopic meniscal repair in lieu of meniscectomy for meniscal tears is necessary when the effects of the meniscus on the knee mechanics and its chondroprotective characteristics are taken into consideration.[1–4,16–19] Today, inside-out meniscal repair technique is a preferred method with a success rate of almost 80% at isolated meniscal tears, and 90% at accompanying anterior cruciate ligament repair.[20,21] Despite that this technique requires practical experience and that takes a lot of time, it is still being used at repairable posterior and medial horn tears. The technique requires that the suture material is transferred with the help of entering cannula and needle at a point close to the tear on the meniscus. Both the structures through which the needle passes the skin and the subcutaneous tissues that remain inside the tied knot are at risk. The most important finding of our study is the existence of the safety margin, which ensures that the higher degrees of knee flexion are not as dangerous as other ranges concerning saphenous and peroneal nerve damages.

The most probable complication after arthroscopic inside-out meniscal repair technique is a major blood vessel or nerve injury. In the literature, there are many studies indicating a high risk of neurovascular injury in posterior horn repairs.[9,12,22–25] In a study conducted on a cadaveric knee, Jurist et al.[22] reported that the K-wire used for the repair of lateral meniscus passed through the peroneal nerve. In a similar study, Anderson et al.[26] reported a common peroneal nerve neuropraxia after arthroscopic inside-out lateral meniscus repair. Raza et al.[27] reported a case with saphenous nerve damage after arthroscopic meniscus repair, and Choi et al.[28] reported in their study where inside-out and all-inside techniques were compared, resulting two patients with temporary saphenous nerve lesion after inside-out repair. In Small's retrospective meta-analysis involving large numbers of patients, it is reported that the most frequent complication observed after a meniscal repair is nerve injury and saphenous nerves are more affected than peroneal nerve.[12] In our

study, in one specimen, peroneal nerve damage occurred. However, unless a retractor is used in posterior horn meniscal repairs, both peroneal and saphenous nerves are reported to be under high risk. In our study, in the posterior horn meniscal repair, the average distance of the needle to the peroneal nerve and saphenous nerve is noted as 8 mm and 13 mm at an extension of the knee, respectively. Moreover, the anatomical variations of the nerves may increase the risk of iatrogenic neurovascular injury. Some cadaveric studies were conducted to identify the risks. Deutsch et al.[23] emphasized that the variation of the nerve is also a risk factor causing different clinical conditions after iatrogenic neurovascular injury, by manifesting in 70 cadaveric knees that the relevant anatomy of the common peroneal nerve is divided into deep and superficial branches above, at and below the knee joint level. In a similar study, Rodeo et al.[29] stated that if the bifurcation of the peroneal nerve is 4 cm above the knee joint, exploration is inevitable for common peroneal nerve injury after knee arthroscopy. In our study, in all cadaveric knees, including the one with a peroneal nerve injury, anatomical exploration was applied to the nerve to observe whether this risk is relatively high or not, and it is observed that the nerve continued as common peroneal at knee joint level.

To prevent the nerve injury complications, the authors advise that the capsule should be viewed by placing a retractor over the gastrocnemius tendon with a small posterior incision. Thus, the needles piercing the posterior capsule are easily deflected medially or laterally toward the surgeon. Otherwise, tying the knot without seeing the capsule may increase the risk of neurovascular injury risk because of the soft tissues trapped within the knot.[22,30,31] Espejo-Baena et al.[9] conducted a medial meniscus repair with the vertical mattress on cadaveric knees. They reported the complications as the infrapatellar branch of the saphenous nerve injury in one knee and in the other three saphenous nerve injury itself occurred after saturation. Henning et al.[32] emphasize the importance of making an exposure with 4 cm incision on the posterior for prevention of neurovascular complication risk, and for tying the knot in a safe manner. In a similar study Espejo-Baena et al.[33] argued about the necessity of posterior exposure and added that the posterior incision might be smaller than that of the one made for medial meniscal repair. Mini open exposure both prevents the soft tissues from remaining in the knot and iatrogenic nerve injury. In accordance with the aforementioned studies, we are also of the opinion that using appropriate exposure and retractor in the inside-out technique for meniscal posterior horn tear may reduce the risk of nerve injury. In the medial and anterior horn repairs, due to the distance between the trace of the peroneal and saphenous nerve, inside-out technique can be applied safely without the need for any exposure.

Intraoperative knee flexion angle is another important point to be considered concerning neurovascular injuries. There is no optimal knee position to avoid nerve injury; however, the optimal knee position is ranging from 90° flexion to 10-30° of flexion to full extension.[34] According to many authors, meniscal repair surgery can usually be applied at the following knee positions; varus/valgus stress in slight flexion (10–15°) or at 90–100° of flexion.[34,35] Cuéllar et al.[15] in their study, where they measured distances between the suture material used and the peroneal nerve with the knee at 90°, 45°, and 0° of flexion, reported that the 90° of flexion is the safest knee flexion angle for repairing the meniscus. With the flexion of the knee, the posterior neurovascular structures go further away from the meniscal tissue. Similar to the study of Cuéllar et al., basing on the values measured during our study, due to the millimeter proximity, the risk of nerve injury in inside-out posterior horn meniscal repairs was found significantly higher than that of the medial and anterior horn repairs. Supporting the literature, in our study, it is determined in the posterior horn repairs that the measurements taken millimetrically while the knee was in extension position, K-wire pass closer to the nerve than that of the flexion position. The results are found consistent with the literature, and it is statistically significant that placing the suture material while the knee is in flexion position reduces the risk of nerve injury ($p<0.5$).

While nerve symptoms have been described as the most serious complication of this technique, it has more advantages over all-inside repair technique concerning less-soft-tissue irritation, implant breakage, implant migration and implant failure.[36] Moreover, suture placement versatility, lower implant cost with lower profile needle usage for multiple suturing that allow a stable meniscal construct may be considered as the preferability of the technique.

To our knowledge, our study is the first study, concerning which both menisci are included in cadaveric knees, and mill metrical measurements of the distance between the needles used in the inside-out meniscal repair technique to the nerve are taken, and the effects of the flexion angle of the knee on the risk of nerve injury in an unwanted complication is manifested. Our study puts forward that the intraoperative preferences of the surgeons would affect the results.

## Conclusion

As a result, it should be well-noted that operation in a high-risk zone would take place if the inside-out meniscal repair technique is planned to be used in the posterior repair. We are in the favour of either retractor assisted mini-open technique at knee flexion, or all-inside suture technique, to avoid nerve injury risk in this zone.

The safe zones where the use of the inside-out technique is recommended are the medial and anterior horn tears, where there are no nerve injury risks. At 1/3 middle meniscal tear repairs, we consider the inside-out meniscal repair technique as the most ideal method, as it is the easiest to apply without any nerve injury risk.

In the treatment of anterior horn tears, although the inside-out technique is safe, due to surgical technical difficulties, outside-in suture technique may also be preferred.

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DENEYSEL ÇALIŞMA - *ÖZET*

# Diz fleksiyon ve ekstansiyon pozisyonundayken içten-dışa menisküs tamiri sırasında iyatrojenik sinir hasarının anatomik muayenesi

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AMAÇ: Diz fleksiyon ve ekstansiyon pozisyonundayken, medial ve lateral menisküslerin anterior, orta ve posterior boynuz yırtıklarının içten-dışa onarım tekniği sırasında tamir edilmesi için iğnelerin peroneal ve safen sinire milimetre cinsinden yakınlığını ölçerek güvenli, riskli ve yüksek riskli bölgeleri belirlemektir.

GEREÇ VE YÖNTEM: İlk olarak, 10 kadavra dizinde her iki (lateral ve medial) menisküste longitudinal yırtık simülasyonu ile menisküsün anterior, korpus ve posterior olarak bölündüğü kadavra çalışması yapıldı. Bir sonraki aşama, diz 90° fleksiyonda ve tam ekstansiyondayken menisküsün simüle yırtıklarının dikilmesini içeriyordu. Son olarak, anterior, gövde ve posterior meniskal yırtıklar boyunca yerleştirilen K-teli çıkış noktasının yukarıda bahsedilen sinirlerden uzaklığı bir dijital kumpas ile ölçülmüştür.

BULGULAR: Her iki menisküsün gövde ve anterior boynuz yırtıklarının tamiri sırasında K-teli çıkış noktaları ile nörovasküler yapılar arasındaki mesafe çok uzak olarak kabul edildi ve dahil edilmedi. Ancak, iyatrojenik sinir hasarı riskinden kaçınmak için daha yakın arka menisküs ölçümleri yapıldı. Lateral menisküs posterior yırtığı için ölçülen mesafeler 90° fleksiyonda 11±5.2 mm ve ekstansiyonda 8±4.5 mm iken, medial menisküs için 90° fleksiyonda 17.3±5.7 mm ve ekstansiyonda 13.7±4.7 mm olarak kaydedildi. Bu değişkenler bağımlı örneklem t-testi kullanılarak değerlendirildi ve istatistiksel olarak anlamlı fark bulunamadı.

TARTIŞMA: Sonuçlarımız diz fleksiyondayken içten-dışa tekniğinin posterior menisküs yırtıklarında bile güvenli olduğunu göstermektedir. Bununla birlikte, güvenlik mesafesi dizin daha yüksek fleksiyon dereceleri ile arttırılabilir. Son olarak, arka menisküs yırtık tamirinde, bu bölgedeki sinir hasar riskini önlemek için diz fleksiyonda iken retraktör yardımlı mini açık tekniğini veya tamamen içeriden dikiş tekniğini öneriyoruz. Her ne kadar birçok cerrahın arka menisküs yırtıklarında içten-dışa tekniğini tercih etmediği bilinmesine rağmen, diz 90°'den daha fazla fleksiyonda iken retraktör yardımlı mini açık teknik kullanılarak her iki menisküsün içten-dışa arka menisküs tamiri tamamen içeriden dikiş tekniği kadar güvenlidir.

Anahtar sözcükler: İçten-dışa menisküs tamiri; peroneal sinir hasarı; safen sinir hasarı.

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