Inside-Out Medial Meniscus Suture: An Analysis of the Risk of Injury to the Popliteal Neurovascular Bundle

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Purpose: To assess the risk of damage to the popliteal neurovascular structures when inserting the needle through the posterior aspect of the knee during inside-out suture of the posterior horn of the medial meniscus. **Methods:** The first stage of our study consisted of simulating a virtual meniscal suture during magnetic resonance imaging by tracing a line from 3 different points (located medially [MP], centrally [CP], and laterally [LP] to the patellar tendon) to the posterior horn of the medial meniscus. This procedure was undertaken both at rest and with valgus stress. The next phase involved the suture of the posterior horns of medial menisci taken from cadaveric specimens, the needle being inserted through 3 separate locations (again located medially [MP], centrally [CP], and laterally [LP] to the patellar tendon). Finally, the distance from each suture thread to the aforementioned neurovascular bundle was measured. **Results:** During the magnetic resonance imaging study, the measured distances at rest were 26.4 mm for MP, 28.8 mm for CP, and 31 mm for LP, whereas those recorded with valgus stress were 21.7 mm for MP, 23.6 mm for CP, and 26 mm for LP. In the second phase of the study (cadaveric specimen suture), the distances obtained were 22.6 mm for MP, 27.6 mm for CP, and 33 mm for LP. **Conclusions:** Our results indicate that when the needle is inserted through the 3 points investigated into the posteromedial region of the knee (10 mm from the posterior horn of the internal meniscus) during inside-out suture, it is far enough from the popliteal neurovascular bundle for the maneuver to be performed with a reasonable safety margin. However, this margin can be increased further still if the needle is inserted into the joint through a point located laterally to the patellar tendon. **Clinical Relevance:** Inside-out suture performed 10 mm from the posterior horn of the internal meniscus through the portals studied offers a sufficient margin of safety to avoid damage to the popliteal neurovascular bundle.

Despite the increasing popularity and use of all-inside meniscal repair systems in arthroscopic surgery, the inside-out technique is still widely used to repair meniscal injuries, yielding very positive results.[1] This is so because, despite the theoretic advantages offered by the all-inside approach (such as the absence of accessory incisions, the potentially shorter surgery time, and an apparently lower risk of complications), it has been proven that all-inside techniques are by no means exempt of intra-articular[2-9] and even vascular[10] complications. There are a number of different techniques and instruments designed for all-inside meniscal repair, of both the first-generation (staples, darts, screws) and second-generation (FasT-Fix, Smith & Nephew, Andover, MA; RapidLoc, De Puy, Raynham, MA) variety. Despite their increasing popularity, they are not exempt from such complications as chondral injury, pain in the area of the implant, and transitory synovitis, which—though also encountered after conventional suture—occur more

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frequently when all-inside meniscal repair devices are used. Protrusion and weakening of the devices themselves have also been reported, as has the formation of subcutaneous granulomas and parameniscal cysts (even where nonresorbable sutures were used).[2-9] Though rare, neurovascular complications and accidental tenodesis have also occurred.[10-12] A further factor to be taken into account is material cost, which is much higher when all-inside techniques are used. In addition, the inside-out method is more conducive to the reduction of chronic bucket-handle tears.[13] Some studies have shown that there are no differences in terms of meniscal healing between inside-out repair techniques and all-inside techniques.[14] Finally, although most existing comparative studies show traditional suture methods to offer greater resistance than the materials used in all-inside suture, flexible all-inside meniscus repair devices also provide a viable alternative to conventional suture techniques.[15-17]

Although some reports have warned of the major complications that may occur when piercing the posterior aspect of the knee during inside-out suture,[1,18] we have not encountered any studies assessing the risk of injury to the popliteal neurovascular structures. Most of the injuries to the popliteal artery reported in the literature occurred during the course of other procedures such as meniscectomy and synovectomy, but this serious complication has also been encountered during meniscal suture.[19-22] There has, however, been research into the potential damage to posterointernal structures such as the saphenous nerve and vein[23] and the semimembranosus and sartorius tendons that inside-out suture of the medial meniscus entails.[12] Also well documented is the possibility of injury to the lateral genicular artery and the risk of entrapment of branches of the peroneal nerve during lateral meniscus suture.[24-27]

The purpose of our study was to assess the potential risk of injury to the popliteal neurovascular bundle during inside-out suture of the posterior horn of the internal meniscus. We hypothesized that there is a sufficient margin of safety to ensure that injury to the popliteal neurovascular bundle is avoided when inside-out suture is performed 10 mm from the posterior horn of the internal meniscus through the portals examined.

METHODS

Our investigation consisted of 2 parts, the first involving magnetic resonance imaging (MRI) carried out on healthy subjects and the second using cadaveric specimens.

Part I: MRI Study

A descriptive study was performed on 10 healthy subjects (6 men and 4 women) aged between 20 and 30 years (mean, 26.1 years), none of whom had any history of knee trouble. Each underwent MRI, the knees being captured first at rest and subsequently bent between 10° and 20° with valgus stress, thus simulating the position in which the joint is typically subjected to arthroscopic examination of its medial compartment. The valgus stress was applied by the same examiner in all cases (A.E.B.). A Syngo MR 2004 version of the Symphony 1.5 T Siemens (Erlangen, Germany) machine was used for these purposes, with a sequence of T2 me2D-powered axial images depicting the whole of the medial meniscus on a single plane.

Three lines were drawn as "virtual needles." The first, labeled "M," was drawn tangentially to the medial edge of the patellar tendon. The second, "C," was drawn perpendicularly to the middle third of the tendon. The third and final line, "L," was traced tangentially to the lateral edge of the tendon. All converged upon a single point on the posterior horn of the medial meniscus, approximately 10 mm from its root, where our "virtual suture" was to be carried out, before continuing to the posterior region of the knee as would occur with the needles used in an actual surgical procedure. The popliteal neurovascular bundle, termed "P," was then located, and a line was drawn from the bundle to intersect with virtual needles M, C, and L. Distances MP, CP, and LP were then measured by use of magnetic resonance images of the knee both at rest and in a forced position, the 2 recordings taken subsequently being compared (Fig 1).

Part II: Cadaveric Study

Part II of the study was undertaken using 8 fresh-frozen cadaveric knee specimens, the age, sex, and side of which were duly recorded. None had previously undergone surgery or exhibited any abnormalities, save for a slight arthrosis. Five female and three male joints were used, the mean age being 78 years (range, 62 to 89 years), and the specimens comprised 5 left and 3 right knees. Each specimen was subjected to arthroscopic examination with the knee flexed to between 10° and 20° with valgus stress to open up the medial femorotibial compartment. The posterior horn of the medial meniscus was located, and the arthroscope inserted through the anteromedial portal in the case of the lateral and central positions and through its anterolateral counterpart for the most medial point.

The stitch was inserted by use of the Sutureasy device, specially designed for inside-out meniscal suture (Stryker Iberia, Madrid, Spain; commercially available only in Spain). Because the instrument in question is a simple needle, it does not need to enter the joint through a portal, merely requiring the skin to be pierced at the desired location (Fig 2).[28] Three stitches were inserted in the joint through different points of entry, the first located tangentially to the lateral edge of the patellar tendon, the second at the center of the same tendon, and the third situated tangentially to its medial edge. All 3 converged at a point on the posterior horn of the medial meniscus, approximately 10 mm from the meniscal root, passing through the meniscus itself before emerging through the posteromedial aspect of the knee. The curve of the suture device is directed medially to keep it away from the popliteal neurovascular bundle. Once the 3 stitches had been inserted, the knees were cut transversally above the menisci to locate both the sutures themselves and the popliteal neurovascular bundle. The distance between each suture and the popliteal artery was then measured and recorded (Fig 3).

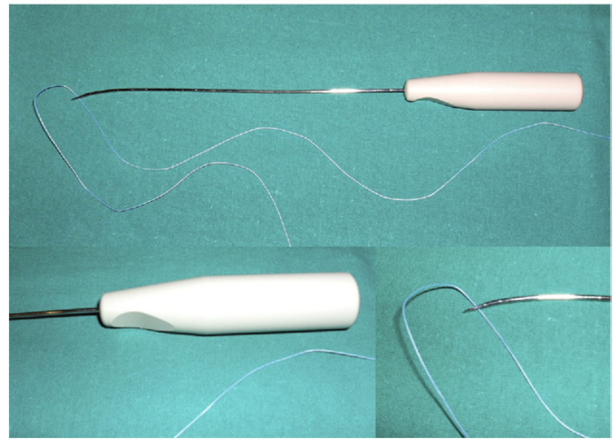

Figure 2. Sutureasy device, specially designed for inside-out meniscal suture.

Figure 1. MRI cross section taken from a T2 me2D axial sequence showing the whole of the internal meniscus in a single shot. The lines drawn from points M (located medially to the patellar tendon), C (located at the center of the patellar tendon), and L (located laterally to the patellar tendon) converge upon a point on the posterior horn of the internal meniscus situated 10 mm from the root. P marks the popliteal neurovascular bundle.

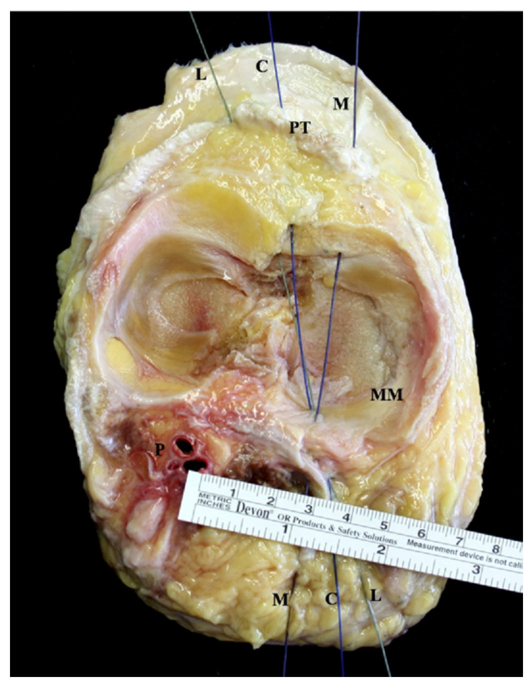

Figure 3. Fresh-frozen cadaveric knee specimen cut transversally. Three stitches were inserted in the joint through different points of entry: M, tangentially to the medial edge of the patellar tendon; C, perpendicularly to the middle third of the patellar tendon; and L, tangentially to the lateral edge of the patellar tendon. The distance between each suture and the nearest section of the neurovascular bundle (P) was measured. (Reprinted with permission.[28])

Table 1. *Measurements Obtained Using Magnetic Resonance Images With Knee at Rest and Forced Positions*

	Rest Position (mm)			Forced Position (mm)		
	Distance MP	Distance CP	Distance LP	Distance MP	Distance CP	Distance LP
1	27.1	29.9	32.6	21.2	24.4	26.7
2	23.5	26.4	31.0	22.2	23.8	24.7
3	25.8	31.2	32.8	20.5	22.0	24.5
4	26.4	28.4	31.7	18.6	21.5	24.0
5	27.4	30.5	31.5	23.5	25.2	28.0
6	20.3	22.0	24.2	19.8	21.2	23.3
7	33.5	34.9	37.0	29.4	31.2	34.4
8	25.5	24.5	25.5	19.3	22.0	24.8
9	28.4	31.4	34.0	24.1	26.3	29.7
10	26.5	28.8	30.1	18.6	18.9	20.2
Mean	26.4	28.8	31.0	21.7	23.7	26.0

NOTE: The line labeled “M” was drawn tangentially to the medial edge of the patellar tendon. The second line, “C,” was drawn perpendicularly to the middle third of the tendon. The third and final line, “L,” was traced tangentially to the lateral edge of the tendon. All converged upon a single point on the posterior horn of the medial meniscus, approximately 10 mm from its root. The popliteal neurovascular bundle, termed “P,” was then located, and a line was drawn from the bundle to intersect with virtual needles M, C, and L. Distances MP, CP, and LP were then measured by use of magnetic resonance images.

RESULTS

Part I: MRI Study

An analysis of the results yielded the following data: the 10 studies carried out with the knee at rest showed a mean LP distance of 31 mm, with a range of 12.80 mm (24.00 to 37.00 mm) and an SD of 3.7834. The mean CP value was 28.8 mm, with a range of 12.90 mm (22.00 to 34.90 mm) and an SD of 3.7190, whereas its MP counterpart was found to be 26.4 mm, with a range of 13.20 mm (20.30 to 33.50 mm) and an SD of 3.3778 (Table 1).

The 10 forced position studies produced a mean LP value of 26 mm, with a range of 14.20 mm (20.20 to 34.40 mm) and an SD of 3.9305. The mean CP distance was 23.6 mm, with a range of 12.30 mm (18.90 to 31.20 mm) and an SD of 3.4261. Finally, the mean MP figure was 21.7 mm, with a range of 10.80 mm (18.60 to 29.40 mm) and an SD of 3.3135 (Table 1).

When we compared the 2 sets of measurements, those taken with the knee at rest were found to be a mean of 0.5 cm longer than those obtained with the joint in a forced position.

The differences detected when we compared the 2 sets of measurements (rest and forced position) were statistically significant ($P < .05$).

Part II: Cadaveric Study

The measurements obtained between each suture and the popliteal artery showed the following: the mean LP value was found to be 33 mm, with a range of 11 mm (29 to 40 mm) and an SD of 4; its CP counterpart showed a mean of 27.6 mm, with a range of 11 mm (22 to 33 mm) and an SD of 4.3732. The mean MP distance was 22.6 mm, with a range of 8 mm (20 to 28 mm) and an SD of 2.722 (Table 2).

We have found statistically significant differences ($P < .05$) between the sutures inserted through the different locations studied. When inserting a suture near the posterior horn (the one that passes closest to the popliteal neurovascular bundle), we use the most medial access point, whereas for sutures performed further away from the posterior horn, we enter the

Table 2. *Cadaveric Measured Distances Between Inside-Out Suturing Through Posterior Medial Meniscus and Popliteal Neurovascular Structures*

Specimen	Medial (mm)	Central (mm)	Lateral (mm)
1	28	32	37
2	22	28	29
3	21	24	30
4	20	23	30
5	25	32	35
6	23	33	40
7	22	27	33
8	20	22	30
Mean	22.6	27.6	33

NOTE: The first suture, labeled “M,” is located tangentially to the medial edge of the patellar tendon; the second, “C,” at the center of the same tendon; and the third, “L,” tangentially to its lateral edge. All 3 converged at a point on the posterior horn of the medial meniscus, approximately 10 mm from the meniscal root.

joint through a more lateral location, thus giving the bundle a wider berth.

DISCUSSION

The most important finding of our study is the existence of a reasonable margin of safety, which ensures that the popliteal neurovascular bundle is not damaged during suture of the posterior horn of the internal meniscus through the portals investigated. We have not encountered any similar studies in the existing literature with which to compare our own.

Henning et al.[29] outlined an inside-out suture technique using a 4-cm posterior incision whose aims were 2-fold: to avoid neurovascular complications and to enable the suture to be knotted directly on the capsuloligamentous structures. As far as suture of the posterior horn of the lateral meniscus is concerned, we believe that said incision continues to be justified in view of the more lateral location of the popliteal neurovascular structures and the presence of the peroneal nerve in the most posterolateral region. However, suture of the posterior horn of the medial meniscus can be carried out with a considerably shorter incision (1.5 to 2 cm), which enables the suture to be knotted directly on the medial collateral ligament without risk of trapping either the saphenous nerve and vein or the tendons located in the posterointernal region of the knee.[12] Although most cases of damage to the popliteal artery reported in the literature occurred during the course of other procedures such as meniscectomy or synovectomy, this most serious of complications has been encountered during meniscal suture.[19-22]

Our study assesses the risk of damage to the popliteal neurovascular structures when a needle is inserted through the posteromedial aspect of the knee during inside-out suture of the posterior horn of the medial meniscus. The first stage of our research involved a virtual study carried out by use of MRI to simulate the position of the knee during actual suture (valgus stress at 10° to 20° of flexion). This procedure shows the mean distance between the virtual needle and the neurovascular bundle to be 21.7 mm when the line is drawn from the medial tangent of the patellar tendon, a value that rises if this line is traced from a more lateral position. When these same measurements are taken with the knee at rest, the distance between the virtual needle and the neurovascular bundle increases by approximately 5 mm from all positions. This difference should be taken into account during suture, because the joint can be placed in a forced position before locating and making contact with the area of the meniscus to be sutured and subsequently relaxed before inserting the needle through the posteromedial aspect of the knee.

The second phase of our study consisted of operating on cadaveric knees in conditions closely simulating real surgery, using the same position (the knee flexed to between 10° and 20° with valgus stress) and instrumentation habitually used during meniscal suture. The results obtained were similar to those yielded by the first stage of our research, and although the suture was performed with valgus stress, the distances were found to be slightly longer than those encountered with dynamic MRI. This could be attributed to the curvature of the actual suture needle, which is directed medially with the express aim of avoiding the popliteal neurovascular bundle.

The limitations of the first part of our study stem from the fact that it was based on a "virtual" suture carried out by use of a cross-sectional MRI scan taken from a T2 me2D axial sequence to capture the whole of the internal meniscus in a single shot, whereas the second part of our study was undertaken using cadaveric specimens. The fact that the knee sizes are not specified is another limitation of our study. The numbers of cases examined was also limited.

CONCLUSIONS

Our results indicate that when the needle is inserted through the 3 points investigated into the posteromedial region of the knee (10 mm from the posterior horn of the internal meniscus) during inside-out suture, it is far enough from the popliteal neurovascular bundle for the maneuver to be performed with a reasonable safety margin. However, this margin can be increased further still if the needle is inserted into the joint through a point located laterally to the patellar tendon.

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