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Case report

Cadaveric study of the infrapatellar branch of the saphenous nerve: Can damage be prevented in total knee arthroplasty?

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ABSTRACT

Background: The infrapatellar branch of the saphenous nerve (IPBSN) is a purely sensory nerve innervating the anteromedial aspect of the knee and anteroinferior knee joint capsule. Total knee arthroplasty (TKA) is commonly used to treat end-stage arthritis, but the IPBSN is often injured and results in numbness around the anteromedial knee. The aim of this cadaveric study was to describe the course and variability of the IPBSN and to assess whether it is possible to preserve during a standard midline surgical approach in TKA.

Methods: Ten fresh-frozen cadaver legs were dissected using a midline approach to the knee. Skin and subcutaneous flap were reflected to expose both the saphenous nerve and its branches. The branches of the IPBSN were identified, and their vertical distances above the tibial tuberosity (TB) were recorded: TB to inferior branch, to middle branch, and to superior branch.

Results: There were 10 left-sided specimens (6 female, 4 male) with a mean age of 79.9 ± 9.8 years. 8 (80%) specimens had 2 branches of IPBSN while 2 (20%) specimens had 3 branches. The average distance from TB to the inferior branch was 16.8 ± 8.3 mm (3.0–28.0); middle branch, 24.0 ± 1.4 mm (23.0–24.9); and superior, 45.9 ± 7.7 mm (32.0–54.5).

Conclusion: Our cadaveric study found no consistent way to preserve the IPBSN using a standard midline approach in TKA. It is important to provide proper patient education on this complication, and surgeons should be aware of approximate locations and variations of IPBSN while performing other knee procedures.

1. Introduction

Total knee arthroplasty (TKA) has improved joint mobility, limb mobility, and pain relief in patients with end-stage knee arthritis since the late 1960s. With the current incidence of TKA being over 300,000 in the United states annually and the per capita utilization of TKAs among patients with Medicare projected to escalate nearly 300% by 2025, complications of TKA, whether small or large, look to cause significant morbidity for the growing population of patients undergoing TKAs.[1,4,9,15–18] A common approach used in TKA is the midline approach. A well-known postoperative complication of such approach is infrapatellar branch of the saphenous nerve (IPBSN) injury, which results in paresthesia and anesthesia of the anterior skin of the knee.[1–3,5,9,10,12,14,19,22]

IPBSN is a purely sensory nerve innervating the medial, anterior, and part of the lateral aspect of the knee and anteroinferior knee joint capsule.[1,9,12,22] It is one of the two branches that originate from the saphenous nerve, the longest cutaneous branch of the femoral nerve,[1,8,12] and runs superficially between the tibial tubercle and the apex of the patella. Although anatomical variations have been reported, the majority of IPBSN usually forms two branches (superior and inferior branches) of its own.[12]

Due to its anatomical course down the knee, IPBSN is often injured during the incision and, sometimes, by medial retractors.[5,11,12,21] The prevalence of the damage to the nerve as a postoperative complication has been reported in some studies to range from 0.5 to 30% and in others as high as 53%.[9,14] Once damaged, patients note numbness, paresthesia, or hypersensitivity of lateral skin flap of the knee.[7,9,11,13,20,21] Although the knee function largely remains intact, IPBSN injury can lead to patient dissatisfaction by affecting the ability of the patient to kneel in fear

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of damaging the prosthesis due to their sensory deficits.[6,13] In light of the disagreement in current literature on whether improvement of IPBSN damage ever occurs with time, surgeons should attempt to minimize intraoperative injury to the nerve or its branches.[7,8]

The aim of this fresh-frozen cadaveric study was to describe the course and variability of the IPBSN and to assess whether it is possible to preserve it during a standard midline surgical approach in TKA.

2. Methods and materials

Ten above-knee thawed fresh-frozen cadaveric specimens were selected for this anatomic dissection study. None had gross deformities. All dissections were carried out by a board certified orthopedic surgeon using standard scalpels, tweezers, forceps, and probes. All knee specimens were secured at 90° flexion during the dissection and measurements. Skin incisions were made to simulate the standard midline approach utilized for total knee arthroplasty and to completely expose the patella and the appropriate neurovasculature (Fig. 1). This was achieved by running the incision from a point 2 cm above the superior pole of the patella to 1 cm below the anterior tibial tuberosity. With the skin retracted, the fat tissue was carefully dissected through and examined to identify the branches of IPBSN (Fig. 2). Branches of the IPBSN were colored using surgical markers (Fig. 3). The measurement from the tibial tubercle to the marked nerves were made using a digital caliper (Fig. 4). The measurements were recorded and used to make a simple descriptive dataset that consisted of average lengths and standard deviations.

3. Results

This study identified ten left-sided fresh-frozen cadaver leg specimens. The specimen demographics are summarized in Table 1. Of the ten specimens, 6 (60%) came from females and 4 (40%) came from males. The mean age of the donors were 79.9 ± 9.8 years (range: 54–88), and their mean weight 153 ± 37.7 lbs (range: 105–226). 8 legs had two branches of IPBSN whereas 2 legs had three branches.

The detailed perpendicular measurements from the tibial tuberosity to inferior, middle, and superior branches of IPBSN are recorded in Table 2. Our results show that the average distance from the tibial tubercle to the inferior branch of IPBSN is 16.85 mm with standard deviation of 8.32 mm; from tibial tubercle to the middle branch 23.97 mm with standard deviation of 1.37 mm; from tibial tubercle to the superior branch 45.89 mm with standard deviation of 7.66 mm.

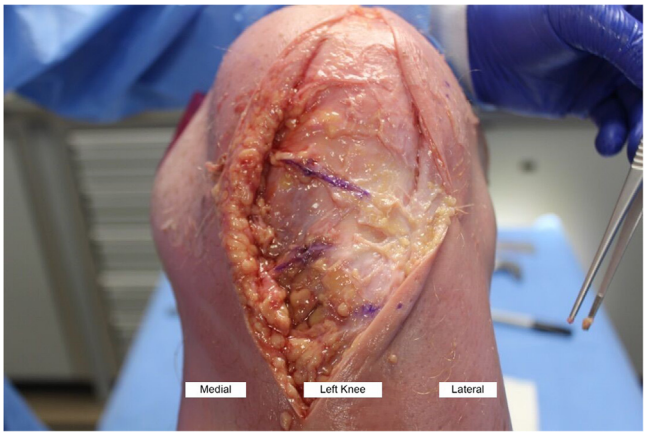

Fig. 1. Image of midline skin incision for patellar dissection.

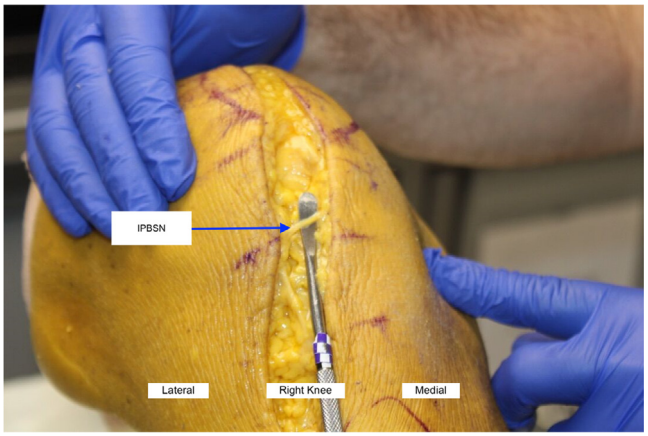

Fig. 2. Image of an IPBSN branch held by a probe.

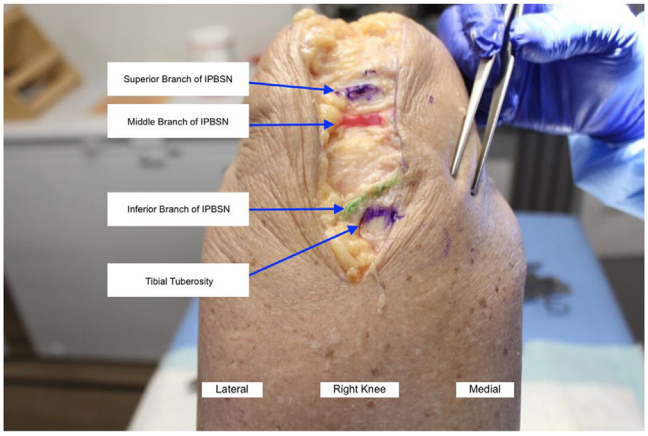

Fig. 3. Colored branches of IPBSN (green, red, & top purple) with tibial tubercle marked in bottom purple.

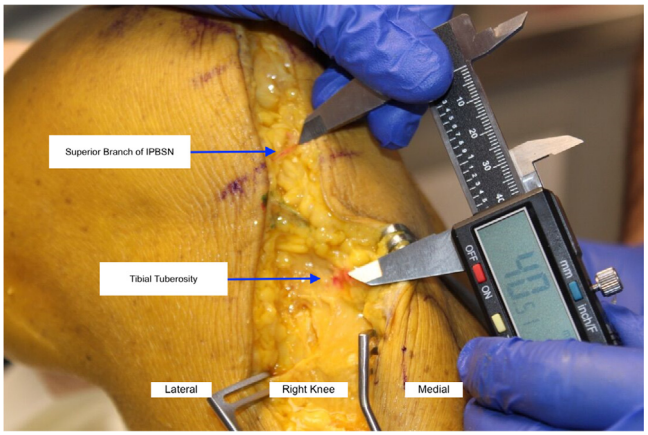

Fig. 4. Image of making measurement using digital caliper.

4. Discussion

With the escalation of the incidence of TKAs reaching new heights, their postoperative complications must be carefully considered and studied by orthopedic surgeons.[1,4,9,15–18] A well-known postoperative complication, especially from the commonly used midline incision, is the injury to the IPBSN.[1–3,9,14,22] Being a

Table 1
Specimen Demographics.

Characteristics	Frequency and Mean (n = 10)
Male	4 (40%)
Female	6 (60%)
Age (years)	79.9 ± 9.8
Weight (lbs)	153 ± 37.7
2 Branches of IPBSN	8 (80%)
3 Branches of IPBSN	2 (20%)

purely sensory nerve running down the anteromedial aspect of the knee, the damage to the distal part of the IPBSN by midline incision often leads to paresthesia, hypersensitivity, or numbness of the lateral and potentially even medial and anterior parts of the knee.[1,9,11–13,20–22]

While many studies have found the association between IPBSN damage and numbness of the knee, only a few have studied the regeneration of normal sensation after IPBSN injury and have shown contradictory findings. Hopton et al., while concluding that the transection of IPBSN is unavoidable in order to achieve adequate exposure of the knee, supports the claim that subjective and objective improvement of the lateral skin flap numbness can be expected as short as 6 weeks post-operatively. In addition, Johnson et al. reports that they have seen 71% decline in area affected by the dermal hypoesthesia over the first 2 post-operative years after IPBSN damage secondary to TKAs. However, Borley et al. accounts a more pessimistic outlook on the improvement of lateral skin flap numbness as they report pin-prick sensation loss area of 86 cm^2 and light touch sensation loss of 46 cm^2 while only 22% of their study cohort experienced any improvement in symptoms at all. With such discrepancy in the prognosis after IPBSN damage, orthopedic surgeons must be made aware of the general course of the branches of IPBSN in an attempt to minimize the likelihood of IPBSN injury and to properly inform patients of the possibility of this complication as a part of their informed consent.[3]

In this cadaveric study, we performed careful dissections on ten thawed fresh-frozen legs to identify branches of IPBSN and to record the distances between the branches and the tibial tubercle to gauge the average locations of the IPBSN branches. The incision for the nerve exposure was standardized to run from a point 2 cm above the base of the patella to 1 cm below the anterior tibial tuberosity in order to best replicate the standard midline incision of the TKA and to visualize nerves vulnerable to potential incisional damage.[17] Our ten knee dissections showed two anatomical variations in the number of the IPBSN branches. Consistent with the findings of Le Corroller et al., who found two main branches of IPBSN in all of their cadaver specimen utilizing ultrasonography, 80% of our specimens had only two branches compared to three branches in the other 20%,[12] verifying two branches to be the more prevalent variation. Furthermore, we found average distance between the tibial tubercle and the inferior branch of IPBSN to be 16.86 ± 8.31 mm (range: 3.00 mm to 28.03 mm), middle branch 23.97 ± 1.37 mm (range: 23.00 mm to 24.94 mm), and superior branch 45.89 ± 7.66 mm (range: 32.05 mm to 55.00 mm). In their study to compare the anterior knee sensory changes in different surgical incisions, Hassaballa et al. reports that the average length of the midline incision is 18.00 ± 3.00 cm[6]. With such length required to adequately expose the knee with a midline incision, we found that it was not possible to consistently protect the branches of IPBSN and that the incidence of sensory alterations would depend largely on the anatomic variations of individual patients.

There are limitations to this study that need consideration. The number of thawed fresh-frozen leg specimens were limited to ten. With greater number of specimens, the study would have been more precise in measurements made and more encompassing in anatomical variations encountered. Furthermore, due to the descriptive nature of this cadaveric dissection study, we were not able to directly obtain the extent of damages that would have been present on live patients with TKAs using the midline approach. Nevertheless, all midline incisions of the knee should be made cleanly through the prepatellar tissues to reduce the risk of neuroma formation. Our findings on the consistency of IPBSN injury was based on our measurements of IPBSN branches and the accepted midline incision lengths found in literature and in the experience of our orthopedic surgeon.

In conclusion, we expect consistent nerve injury when midline approach is utilized in TKA. We advise orthopedic surgeons to always educate their patients on the high likelihood of sensory alterations, including paresthesia, hypersensitivity, and numbness, of the lateral (and potentially even medial and anterior) knee.

Conflict of interest

None.

Acknowledgements

The authors of this study would like to take this time to acknowledge the tremendous gift the cadaver donors and their families have given us to further medical education and science. The chance to carry out this study utilizing body donations was a great privilege granted by these selfless individuals. We are mindful of the sacrifice made by the donors and their family members and hope to meet their generosity by furthering valuable knowledge.

Table 2
Perpendicular Measurements from Tibial Tubercle to Branches of IPBSN.

Specimen #	Number of Branches	Inferior Branch Nerve to Tibial Tubercle (mm)	Middle Branch Nerve to Tibial Tubercle (mm)	Superior Branch Nerve to Tibial Tubercle (mm)
1	2	24.00		41.00
2	3	3.00	23.00	47.17
3	2	18.68		40.51
4	2	21.00		55.00
5	2	11.45		38.65
6	3	11.57	24.94	53.63
7	2	10.66		47.01
8	2	27.74		32.05
9	2	12.35		54.43
10	2	28.03		49.47
Mean ± Standard Deviation		16.86 ± 8.32	23.97 ± 1.37	45.89 ± 7.66

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