Original Article

Area of Skin Numbness After Total Knee Arthroplasty: Does Minimally Invasive Approach Make Any Difference From Standard Approach?

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Abstract

Background: Skin numbness after total knee arthroplasty (TKA) was reported in relation to injury of the infrapatellar branch of saphenous nerve (IPBSN).

Methods: Phase I study: A nonrandomized and nonconsecutive selection of 30 patients undergoing unilateral TKA, using minimally invasive surgery approach, and 30 patients having standard approach were included. Area of skin numbness was periodically evaluated and compared until 1-year follow-up (FU).

Phase II study: we dissected 15 normal cadaveric knees and followed the course and distribution of IPBSN.

Results: Twenty-nine predominantly female patients in each group completed 1-year FU with no differences in demographic data. Both the groups had significantly improved Knee Society Score clinical and function scores with no statistical differences. The numb areas in both the groups similarly decreased from 2 weeks (51.7 cm² vs 51.1 cm²) to 1 year (2.1 cm² vs 2.4 cm²) with similar percentages of no skin numbness at 1 year (69% vs 65%). The IPBSN branched from saphenous nerve before exiting the adductor canal and ran longitudinally and obliquely. It was found as a single nerve in 20%, a 2-branch nerve in 67% and a 3-branch nerve in 13%. All branches crossed the knee midline between superior patellar pole and tibial tubercle.

Conclusion: Clinical study showed that TKA using minimally invasive surgery approach provided similar area of skin numbness to standard approach. Numbness area gradually decreased at serial FUs in both the groups. The cadaveric study demonstrated that the IPBSN consistently gave no branch passing the knee midline above superior patellar pole.

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Materials and Methods

Phase I: Clinical Study

This study was approved by the institutional review board. A prospectively nonrandomized and nonconsecutive study of 30 patients and a matched-pair group of 30 patients, who underwent uncomplicated unilateral primary TKAs for late-stage knee osteoarthritis between March 2012 and February 2014, was evaluated for areas of skin numbness and clinical outcomes after TKA from a 2-week to a 1-year follow-up (FU). All studied patients had no previous scar around the knee, no clinical symptoms of lumbar nerve roots pathology related to lower spinal problems, no systemic or peripheral nerve disease, and no history of diabetic neuropathy. All surgeries were performed by a single surgeon under spinal anesthesia in a bloodless field with use of pneumatic tourniquet at a pressure of 320 mm Hg. At surgery, all patients underwent a uniform surgical pattern, including a medial parapatellar skin incision, a midvastus arthrotomy, a measured resection surgical technique, and a single prosthetic design (NexGen LPS-Flex; Zimmer, Warsaw, IN). In all knees, the incision was made with the knee flexed to 90 degrees. Each group was divided according to the length of skin incision: MIS skin approach (group A) and STD skin approach (group B). The skin incision in group A, which was defined as an MIS skin approach, was begun from the level of the superior patellar pole to the level of the tibial tubercle. If the U-sign skin edge described by Scuderi [10] was identified with the knee flexed to 60 degrees, then the proximal incision was gradually extended in 1-cm increments, which resulted in a length approximately 8–10 cm, corresponding to the leg size. The skin incision in group B, which was defined as an STD skin approach, was begun at 4 cm above the superior patellar pole and ended at the level of the tibial tubercle, resulting in a length of approximately 12–14 cm, corresponding to the leg size. At FU, all patients were instructed to apply skin moisturizer continuously and to self-perform gentle massage around the surgical scar and the knee area as an everyday activity starting from 3 weeks, postoperatively.

All patients were evaluated for demographic data, preoperative Knee Society Scoring System clinical and function scores, and the length of skin incision. At a serial FU at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year, postoperatively, clinical parameters were evaluated, as well as the area of skin numbness related to surgical incision. During the evaluation for skin numbness, the patient was in a supine position, and the knee was in full extension. The patient was asked to close his/her eyes, and the skin numbness was defined by the loss of pinprick sensation, which was tested by a single evaluator according to the method of Borley et al [1]. The numb area was marked on the patient’s skin and then transferred to a transparent paper that had a 1-cm² square grid for area measurement. The area of hypesthesia was calculated by counting all squares to the nearest half centimeter according to the method of Sundaram et al [4].

Statistical analysis was performed using GraphPad Prism version 6.00 for Windows (GraphPad Software, La Jolla, CA, www.graphpad.com). The mean, standard deviation, range, and percentage were used for descriptive statistics. The Student’s t test was used for comparing the area of skin numbness between 2 groups at each FU. The P value of <.05 was considered significant.

Phase II: Cadaveric Study

Fifteen soft cadavers of 8 males and 7 females with normal lower limb and knee profile were carefully dissected by a single surgeon to determine the distribution of the IPBSN. In every knee, the skin flap was made from 10 cm above the superior pole of the patella to 5 cm below the tibial tubercle (Fig. 1). The saphenous nerve distribution and its branches, considered the IPBSN, were investigated from the proximal area to the adductor’s canal. At proximal to the knee, the relationship of the IPBSN and its branches related to the adductor canal and the sartorius muscle was evaluated. At the knee level, the horizontal distance between the medial border of midpatellar bone and the IPBSN (distance A) and the vertical distance from the inferior patellar pole to the main IPBSN branch crossing the knee midline (distance B) were measured as illustrated in Figure 2.

Results

Phase I: Clinical Study

One patient in group A and 1 patient in group B could not complete a 1-year FU. Therefore, 58 patients, including 29 females in group A and 4 males and 25 females in group B, were evaluated. Both group A and group B had similar preoperative demographic data with significant improvement in clinical parameters after surgery, in terms of pain relief and Knee Society Scoring System clinical and function scores with no statistical difference (Table 1). There was no readmission in the studied group. Beside skin numbness, there were no complications related to the surgery.

The mean length of the skin incision in group A and group B was 9.1 cm (range, 7.5–10.0 cm) and 13.6 cm (range, 12.5–14.5 cm), respectively. All evaluated patients sustained a certain area of skin numbness lateral to the medial parapatellar incision, which decreased corresponding to the time of each FU. At serial postoperative evaluations, the mean area of skin numbness in group A was 51.7 cm² (range, 10–102 cm²), 40.9 cm² (range, 10–95 cm²), 29.6 cm² (range, 9–90 cm²), 9.6 cm² (range, 0–44 cm²), and 2.1 cm² (range, 0–11 cm²) at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year, respectively. In group B, the mean area of skin numbness was 51.1 cm² (range, 17.5–110.2 cm²), 39.5 cm² (range, 14–88 cm²),...
27.7 cm² (range, 10-60 cm²), 11.8 cm² (range, 0-25 cm²), and 2.4 cm² (range, 0-10 cm²) at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year, respectively. There were no differences in area of skin numbness between group A and group B at all serial FU (Fig. 3). At the 1-year FU, 69% (20/29) of patients in group A and 65% (19/29) in group B reported no skin numbness without any significant difference.

**Phase II: Cadaveric Study**

At proximal to the adductor canal, the IPBSN branched from the saphenous nerve and ran longitudinally along the lower limb axis (Fig. 4). Two patterns of exiting point of the IPBSN from the adductor canal were related to the sartorius muscle, including posterior to the muscle in 27% (4/15) and piercing through the muscle in 73% (11/15). After exiting the adductor canal, the IPBSN ran obliquely toward the medial side and split into branches before it passed the knee joint. All branches of the IPBSN went across the referencing line (a longitudinal line from the superomedial patellar border to just medial to the tibial tubercle), which is the landmark for a medial parapatellar skin incision. The IPBSN was identified as a single nerve in 20% (3/15 knees); as 2 branches in 67% (10/15 knees), of which 90% (9/10 knees) had smaller inferior branches than the superior branch; and as 3 branches in 13% (2/10 knees), of which the largest branch was the middle one (Fig. 4). The average distance A (horizontal distance from the medial midpatellar border to the nerve) was 6.7 ± 1.0 cm (range, 4.8-8.8 cm), and the average distance B (vertical distance from the inferior patellar pole to the main branch of the nerve) was 2.4 ± 0.8 cm (range, 1.1-3.0 cm). In 1 cadaver, the main branch of the nerve was found to cross the midline at the level of the patella bone.

**Discussion**

The aim of the present study was to evaluate the area of skin numbness clinically after TKA, to compare the MIS approach and the STD approach, and to evaluate the course and distribution of the IPBSN in the cadavers in relation to anatomic landmarks commonly used for medial parapatellar skin incision in TKA that resulted in similar areas of skin numbness at all FU periods, corresponding to the cadaveric demonstration of the same possibility of IPBSN injury from skin incision of both approaches.

The limitation of the present study included no randomization, nonconsecutive series, and a limited number of patients, predominantly female. Initially, randomization for patient selection for either MIS or STD skin approach was well planned, and all patients were informed that they might have either the MIS or the STD skin approach. The study provided valuable insights into the clinical and cadaveric aspects of skin numbness after TKA, emphasizing the importance of understanding the anatomic variations and distribution of the IPBSN.

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**Fig. 2.** Distance A was the horizontal distance measured from the infrapatellar branch of the saphenous nerve (IPBSN) (red line) to the medial border of the midpatella bone, and distance B was the vertical distance measured from the main branch of the IPBSN, crossing the knee midline, to the lower pole of the patella.

**Fig. 3.** Loss of pinprick skin sensation (mean ± standard deviation) at serial follow-ups (FUs) from 2 weeks, 6 weeks, 3 months, 6 months, and 1 year in group A and group B, which gradually decreased according to FU time without statistical difference. MIS, minimally invasive surgery.

**Table 1**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Final Studied Group</th>
<th>Group a MIS Approach</th>
<th>Group b STD Approach</th>
<th>P Value</th>
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<td>29/29</td>
<td>29/29</td>
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<tr>
<td>No. of male:female</td>
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<td>No. of left:right side</td>
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<tr>
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<td>(+)7.9</td>
<td>(+)8.1</td>
<td>&gt;.05</td>
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</tbody>
</table>

MIS, minimally invasive surgery; STD, standard; BMI, body mass index; ROM, range of motion; KSS, Knee Society Score; Anat varus, anatomical varus.
approach. However, most patients declined to participate in the study based on the concern that they would undergo the STD skin approach rather than the MIS approach at TKA. Although the demographic data of the present study had a very high number of female patients, it was in agreement with previous reports in Thai patients [9,11] and other Asian patients [12,13]. In fact, there was a higher female-to-male ratio in Asian patients undergoing TKA than in Caucasian patients.

In the STD-TKA approach, the skin incision is usually 4-6 cm above the superior patellar pole to the level of the tibial tubercle, which inevitably causes injury to the IPBSN, resulting in lateral skin numbness around the knee [1-5]. Previous studies of the IPBSN demonstrated that it branches from the saphenous nerve after exiting the adductor canal with a variation in number of branches running across the knee midline [6,8]. According to the variation in the IPBSN branches, different lengths of skin incisions in TKA may affect different numbers of injured branches of the IPBSN and result in different areas of lateral skin numbness. Since the past decade, the MIS-TKA approach has become popular and well accepted worldwide; the skin incision is reduced from 14-20 cm in length to 8-10 cm in length. Therefore, the MIS skin approach may easily lead surgeons to assume that it will provide less injury to the IPBSN than that of an STD skin approach.

Regarding area of skin numbness after the STD approach in TKA, studies have shown that the area of skin numbness varied and gradually decreased according to the FU time [1-5]. At a mean 1-year FU, lateral skin numbness was reported at 86 cm² [1]. At longer FUs, the area of numbness decreased to 33 cm² at 2 years [2] and to 24-29 cm² at 2.5 years [4]. In the present study, the average area of skin numbness in both group A and group B continuously decreased at later FUs, which agreed with those of previous studies. However, the average areas of skin numbness at all periods of FU of the present study were less than those previously reported. Furthermore, approximately two-thirds of patients had no skin numbness at the 1-year evaluation. Because all patients in the present study had no abnormal neurologic characteristics, we believed that smaller areas of skin numbness in the present study might relate to the small size of the Asian female knee, which applied to most of the evaluated subjects. In addition, all patients were instructed to apply skin moisturizer continuously and to self-perform gentle massage around the surgical scar and the knee, which might encourage sensation and function of the sensory nerves in the peripheral area. However, we assigned a single evaluator to perform the skin numbness test in all patients at all visits of FU to avoid the variation of testing method in both the groups.

The study by Sundaram et al [4] compared a medialized skin incision and a lateralized skin incision at TKA and reported that a straight midline skin incision provided slightly less area of numbness than that of the medial parapatellar incision (24 cm² vs 29 cm²) with no significant difference. Berg and Mjoberg [14] reported that a laterally placed incision provided significantly less dysesthesia than that of a medially placed incision. The design of the clinical phase in the present study addressed different lengths of longitudinal medial parapatellar skin incision in 2 groups without addressing the lateralized incision. However, the cadaveric phase of the study demonstrated that at the midpatellar level, the IPBSN located far medial to the medial border of the patella (distance A = 6.7 ± 1.0 cm) and all IPBSN branches, regardless of the number of branches, consistently passed the referencing line used for medial parapatellar incision (between the superomedial border of the patella and just medial to the tibial tubercle). Therefore, we postulate that the medial parapatellar skin incision always injures the IPBSN. It also implied that a midline skin incision, which is slightly lateral to the medial parapatellar incision, should cause a similar IPBSN injury as that of a medial parapatellar incision. Although the cadaveric dissection in the present study did not demonstrate any IPBSN branches running proximal to the superior patellar pole, and the additional 4-cm skin incision above superior patellar pole in group B of our clinical study did not show any difference in skin numbness from those who had MIS skin approach, we concluded that the MIS approach in TKA did not spare injury to the IPBSN that resulted in similar areas of lateral skin numbness in the STD approach.

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