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# Comparison of peripheral nerve block with local infiltration analgesia regarding walking ability after total knee replacement: A retrospective, propensity-score matched-pair cohort study

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## Abstract

**Purpose:** It is unclear whether perioperative analgesic techniques affect the functional outcome of total knee replacement (TKR). We investigated the effects of peripheral nerve block (PNB) and local infiltration (LI) on walking ability after TKR. **Methods:** The medical records of 7143 patients who underwent TKR using general anesthesia with PNB or LI techniques were reviewed. Factors affecting independence and/or improvement of walking after surgery were investigated using multivariate regression analysis. To adjust for baseline differences and minimize selection bias for the chosen analgesic technique, patients were matched by propensity scores. **Results:** The multivariate regression analysis showed that PNB was associated with independence and/or improvement of walking. Of the 7143 patients, 2755 (39%) received PNB analgesia and 4388 (61%) LI analgesia. After the propensity score matching, the analgesic types were not associated with walking ability. Independence reflected by the total score of daily living activities was higher in the PNB group than in the LI group. The PNB group started rehabilitation later but performed rehabilitation for longer in the initial period than the LI group. Consumption levels of fentanyl, pentazocine, and antiemetics were lower in the PNB group than in the LI group. The PNB group had fewer hypertensive episodes during surgery than the LI group. There was no significant difference in total hospitalization costs between the two groups. **Conclusions:** No significant difference in postoperative walking ability was found between PNB and LI groups. However, PNB offered some advantages over LI. Future detailed investigations to improve TKR surgery are needed.

## Keywords

joint replacements, knee, local anesthetics, nerve block

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## Introduction

Traditionally, in the absence of preventive measures, the rate of venous thromboembolism after total knee arthroplasty (TKA) has been noted to be as high as 40% to 84%.[1] Thromboprophylaxis has thus been routinely provided to reduce the risk. With the spread of anticoagulant therapy, perioperative analgesic techniques of TKA have shifted from central neuraxial blocks to peripheral nerve blocks (PNBs) or local infiltration (LI) analgesia because the neuraxial blocks have a potential risk of spinal or

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epidural hematoma. On the other hand, perioperative analgesic techniques have been considered to influence the surgical outcome of TKA[2] because TKA can result in severe postoperative pain at the surgical site. Some studies reported that LI analgesia is a safe and effective treatment option for early functional recovery and pain control in TKA.[3–5] However, the safety and effectiveness of PNBs have also improved with the spread of ultrasound-guided techniques in combination with nerve stimulus techniques. In recent studies, it has remained controversial which analgesic technique is appropriate for TKA.[3,6,7]

Compared with nonsurgical treatments, TKA is more effective for pain relief and functional improvement.[8] Therefore, functional disorder is an important motivation for undergoing TKA. Fenten et al.[6] investigated the effects of analgesic techniques on functional performance at 3 and 12 months after TKA surgery. However, many previous studies on TKA tended to focus more on postoperative pain rather than long-term functional status.[3–5,7,9,10] To the best of our knowledge, few large-scale studies have focused on the relationship between perioperative analgesic techniques and walking ability at discharge.

Against this background, the aim of this study was to investigate the effects of perioperative analgesic technique (PNB and LI) in patients who had undergone TKA under general anesthesia. The primary outcome was knee function, assessed by measuring walking ability on a flat floor and total score of Barthel Activities of Daily Living (ADL) Index at discharge. Secondary outcomes were postoperative pain, rehabilitation, complications, and hospital cost.

## Methods

The present study was approved by the ethics review boards of our hospital and the National Hospital Organization (NHO). The protocol of this study was made available to the public via the NHO website, in accordance with Japanese ethics guidelines for human medical research. To ensure patient privacy, all types of personal identification were encrypted in a security room of the NHO data bank. Owing to the anonymity of the data, the need to obtain written informed consent from individual patients was waived by the ethics review boards.

### Data sources

The study period was from April 1, 2010, to March 31, 2018. We collected data from from 74 hospitals of the NHO group using the Diagnosis Procedure Combination (DPC) database. The DPC database is a diagnosis-dominant, case-mix system administered by the Japanese Ministry of Health, Labor and Welfare.

Data from the DPC database included age, sex, height, weight, comorbidities at admission, complications (ICD-10 code, T80-88) related to the surgery, medications and rehabilitation during admission, modified Barthel ADL Index at both admission and discharge, length of hospital stay (LOS), and total hospitalization cost. The modified Barthel Index includes 10 parameters: self-feeding, transfer, grooming, toilet use, bathing, mobility, use of stairs, dressing, defecation, and micturition.[11]

### Selection of patients and variables

The inclusion criteria were that all patients had undergone surgery of total knee replacement (TKR; K0821) during the study period. To focus our investigation on daily living activities after surgery, we excluded TKR surgery cases with atypical progress, such as in-hospital death, postoperative respirator user, reoperation, long hospitalization (>100 days), and long preoperative hospitalization (>14 days). We also excluded cases operated on under spinal and/or epidural anesthesia, cases operated on without long-acting local anesthesia, and cases with missing baseline data.

The PNB group was defined as cases undergoing TKR under general anesthesia with PNBs. The PNBs included femoral nerve block, sciatic nerve block, and modified versions of these or their use in combination. The LI analgesia group was defined as cases undergoing TKR under general anesthesia without PNBs (L100) and in which long-acting local anesthetics (ropivacaine and levobupivacaine) were used during surgery.

Of the 10 functional status parameters, we focused on mobility (walking on a flat floor) and the sum of all parameters. The mobility was ranked as follows: bedridden (score 0), completely assisted (score 1), partially assisted (score 2), and independent (score 3). We defined a satisfactory status after surgery as a score of 3 and/or improvement of the score.

Body mass index (BMI) was calculated using the height and weight. A modified version of the Charlson Comorbidity Index (CCI) was calculated for each patient based on Quan coding algorithms.[12]

### Multivariate analysis

The dependent variable for the multivariate analysis was whether the patient achieved a satisfactory or unsatisfactory status. The independent variables were age, sex, BMI, CCI score, comorbidities at admission (renal/urinary: N00-39; mental: F00-99; anemia: D50-64), LOS, and existence of PNB. These selected variables, except PNB, were based on previous studies and empirical observations.[12–14]

### Propensity score matching

We used propensity score-matched analyses to reduce the selection bias and potential baseline differences between the PNB and LI groups. Propensity scores were calculated

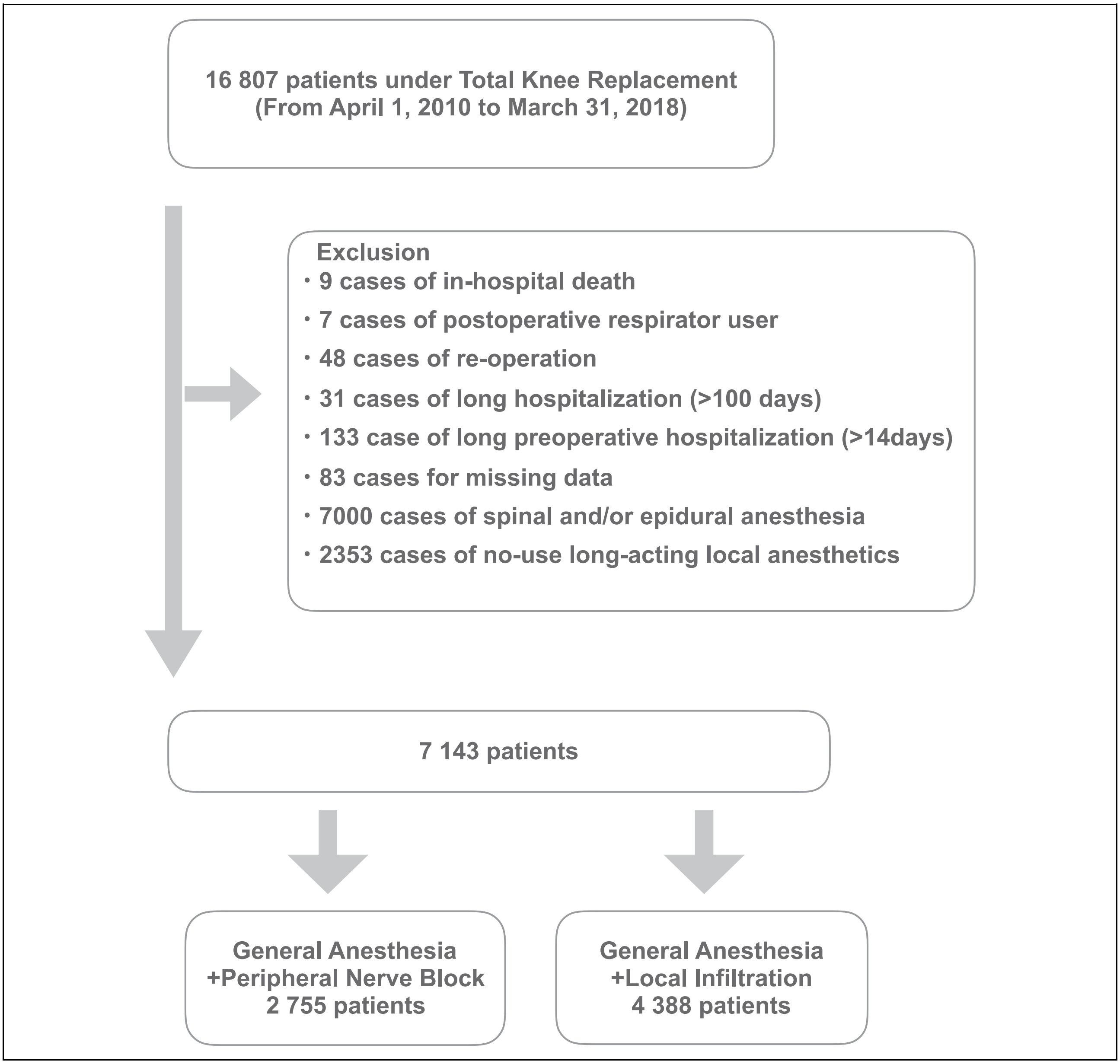


**Figure 1.** Characteristics of excluded and eligible patients in the analytical data set.

using a logistic regression model in which the dependent variable was whether the patient was given a PNB. The independent variables were age, sex, BMI, modified CCI score, ADL dependence at admission, mobility dependence at admission, LOS after surgery, comorbidities at admission (circulatory: I00-99; respiratory: J00-99; digestive: K00-93; metabolic: E00-90; renal/urinary: N00-39; neuro/muscle: G00-99/M00-99; mental: F00-99; and hemal diseases: D50-89). These variables were selected according to previous reports.[13–16] After adjustment with the propensity scores, none of the variables remained significantly different between the two groups. The multivariate regression model of propensity for patients given a PNB had a C-statistic of 0.622. The postoperative pain was inferred from analgesic consumption.

### *Statistical analysis*

SPSS software version 24 (IBM, Armonk, New York, USA) was used for this study. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined. Patient characteristics were compared between the PNB and LI groups using the *t*-test or the paired *t*-test for continuous variables and the $\chi^2$ test for categorical variables. The value of $p < 0.05$ was considered significant for all statistical tests.

## Results

Cases with atypical progress ($n = 228$), missing baseline data ($n = 83$), spinal and/or epidural anesthesia ($n = 7000$),

**Table 1.** Multivariate analysis: Factors affecting the walking independence and/or improvement.

| Variables | *B* | OR | 95% CI | *p* Value |
|---|---|---|---|---|
| Age (years) | | | | |
| <80 | 0.645 | 1.905 | 1.643 to 2.209 | 0.000 |
| 80+ | | 1 | | |
| Sex | | | | |
| Male | 0.050 | 1.051 | 0.873 to 1.265 | 0.600 |
| Female | | 1 | | |
| BMI | | | | |
| <20 | −0.379 | 0.684 | 0.524 to 0.893 | 0.005 |
| 30+ | 0.004 | 1.005 | 0.812 to 1.243 | 0.967 |
| 20-30 | | 1 | | |
| CCI | | | | |
| 0 | 0.227 | 1.255 | 1.085 to 1.451 | 0.002 |
| 1+ | | 1 | | |
| Renal/urinary | | | | |
| (−) | 0.353 | 1.423 | 1.047 to 1.933 | 0.024 |
| (+) | | 1 | | |
| Mental | | | | |
| (−) | 0.657 | 1.930 | 1.437 to 2.592 | 0.000 |
| (+) | | 1 | | |
| Anemia | | | | |
| (−) | 0.403 | 1.496 | 1.130 to 1.982 | 0.005 |
| (+) | | 1 | | |
| Length of hospital stay after surgery (days) | | | | |
| 21+ | 0.520 | 1.682 | 1.457 to 1.941 | 0.000 |
| <21 | | 1 | | |
| PNB | 0.227 | 1.255 | 1.080 to 1.459 | 0.003 |
| LI | | 1 | | |

OR: odds ratio; CI: confidence interval; BMI: body mass index; CCI: Charlson Comorbidity Index; PNB: peripheral nerve block; LI: local infiltration.

and without long-acting local anesthetics ($n = 2353$) were excluded. After these exclusions, 7143 of the initial 16,807 patients remained for the analysis. The PNB and LI groups contained 2755 and 4388 patients, respectively (Figure 1).

The results from the multivariate regression model showed that being younger than 80 years old, lower CCI score, higher BMI (21+), no renal/urinary comorbidities, no mental disease, no anemia, longer hospital stay (21+ days), and PNB were associated with a satisfactory status after surgery. PNB group patients were more likely to have a satisfactory status after surgery than LI ones (OR 1.26, 95% CI 1.08 to 1.46; $p < 0.01$) (Table 1).

Table 2 compares the characteristics of the PNB and LI groups. Before propensity score matching, 6 of the 15 factors differed significantly between the two groups. After 1:1 matching, there was a total of 2547 patients in each group, with no significant baseline differences.

Table 3 summarizes the effects of PNB on ADL independence at discharge, rehabilitation, consumption of analgesic, complications, and total hospitalization cost in the matched sample. Among patients in the PNB group, there was a significantly higher proportion who were independent as reflected by the sum of total ADL scores at discharge than among patients in the LI group (PNB vs. LI: 78% vs. 75%; $p < 0.027$). However, there was no significant difference in walking independently at discharge between the two groups (PNB vs. LI: 88% vs. 87%; $p = 0.353$). Patients in the PNB group started their rehabilitation later but performed rehabilitation for longer in the initial period than patients in the LI group. The proportion of patients who used fentanyl (400+ µg) was significantly lower in the PNB group than in the LI group (10.9% vs. 29.9%, $p < 0.001$). The proportion of patients who used pentazocine was also lower in the PNB group than in the LI group ($p < 0.001$). Moreover, the proportion of patients who used antiemetics after surgery was significantly lower in the PNB group than in the LI group (23.2% vs. 30.4%, $p < 0.001$). Among the PNB group patients, there was also a significantly lower rate of hypertensive episodes during surgery than among LI group patients (2.2% vs. 5.7%, $p < 0.01$). The frequencies of infectious complications were 1.2% and 0.9% in the PNB and LI groups, respectively, which were not significantly different. Finally, there was no significant difference in the total hospitalization cost between the PNB and LI groups ($p = 0.304$).

## Discussion

In regard to the walking independence after TKR, the multivariate analysis suggested the PNB might have some advantages. As a result of the propensity score-matched analyses, however, no significant difference in the ratio of dependence/independence when walking was found between the PNB and LI groups. Interestingly, the PNB group maintained higher independence as reflected by the total ADL score than the LI group. Compared with the LI group, the PNB group started rehabilitation later but performed rehabilitation for longer in the initial period. The levels of consumption of fentanyl and pentazocine were significantly lower in the PNB group. Moreover, both the use of antiemetics and the frequency of hypertensive episodes were significantly lower in the PNB group. There was no significant difference in the hospital costs between the PNB and LI groups.

A meta-analysis reported that the group with femoral nerve block had a wider range of motion and higher Knee Society Score than those with LI at postoperative day 2 and 6 weeks after surgery, respectively.[9] However, the functional differences between these two groups could not be detected upon longer observation periods. Another recent meta-analysis also showed no significant differences in postoperative functional status (range of motion and Knee Society Score) between the femoral nerve block and LI groups.[7] Our results regarding walking ability at discharge appear to match those in previous studies.

In the present study, patients in the PNB group showed higher independence as reflected by the total ADL score than patients in the LI group, despite their similar walking ability. We speculated that the factors related to the LI

**Table 2.** Demographic and clinical characteristics.[a]

| | Before propensity score matching | | | After propensity score matching | | |
|---|---|---|---|---|---|---|
| | PNB | LI | *p* Value | PNB | LI | *p* Value |
| n | 2755 | 4388 | | 2547 | 2547 | |
| Age (years) | 74.6 ± 7.8 | 74.4 ± 7.8 | 0.236 | 74.5 ± 7.8 | 74.4 ± 7.6 | 0.512 |
| Sex | | | | | | |
| Male | 470 (17.1%) | 822 (18.7%) | 0.077 | 445 (17.5%) | 427 (16.8%) | 0.527 |
| Female | 2285 (82.9%) | 3566 (81.3%) | | 2102 (82.5%) | 2120 (83.2%) | |
| BMI | 26.0 ± 4.0 | 25.8 ± 4.2 | 0.095 | 25.9 ± 4.0 | 25.8 ± 4.2 | 0.376 |
| CCI | | | | | | |
| 0 | 1638 (59.5%) | 2744 (62.5%) | <0.01 | 1527 (60%) | 1527 (60%) | 1.000 |
| 1+ | 1117 (40.5%) | 1644 (37.5%) | | 1020 (40%) | 1020 (40%) | |
| Prehospital ADL dependency | | | | | | |
| (−) | 2210 (80.2%) | 3096 (70.6%) | <0.01 | 2017 (79.2%) | 1989 (78.1%) | 0.356 |
| (+) | 545 (19.8%) | 1292 (29.4%) | | 530 (20.8%) | 558 (21.9%) | |
| Prehospital walking dependency | | | | | | |
| (−) | 2384 (86.5%) | 3516 (80.1%) | <0.01 | 2185 (85.8%) | 2150 (84.4%) | 0.181 |
| (+) | 371 (13.5%) | 872 (19.9%) | | 362 (14.2%) | 397 (15.6%) | |
| Length of hospital stay after surgery (days) | 23.3 ± 8.3 | 23.0 ± 10.6 | 0.095 | 23.2 ± 8.1 | 23.7 ± 10.1 | 0.068 |
| Circulatory | | | | | | |
| (−) | 1066 (38.7%) | 2314 (52.7%) | <0.01 | 1042 (40.9%) | 1012 (39.7%) | 0.408 |
| (+) | 1689 (61.3%) | 2074 (47.3%) | | 1505 (59.1%) | 1535 (60.3%) | |
| Respiratory | | | | | | |
| (−) | 2658 (96.5%) | 4237 (96.6%) | 0.894 | 2454 (96.3%) | 2447 (96.1%) | 0.660 |
| (+) | 97 (3.5%) | 151 (3.4%) | | 93 (3.7%) | 100 (3.9%) | |
| Digestive | | | | | | |
| (−) | 2294 (83.3%) | 3689 (84.1%) | 0.374 | 2135 (83.8%) | 2090 (82.1%) | 0.101 |
| (+) | 461 (16.7%) | 699 (15.9%) | | 412 (16.2%) | 457 (17.9%) | |
| Metabolic | | | | | | |
| (−) | 1792 (65.0%) | 2978 (67.9%) | <0.05 | 1665 (65.4%) | 1678 (65.9%) | 0.723 |
| (+) | 963 (35.0%) | 1410 (32.1%) | | 882 (34.6%) | 869 (34.1%) | |
| Renal/urinary | | | | | | |
| (−) | 2635 (95.6%) | 4199 (95.7%) | 0.952 | 2431 (95.4%) | 2447 (96.1%) | 0.297 |
| (+) | 120 (4.4%) | 189 (4.3%) | | 116 (4.6%) | 100 (3.9%) | |
| Neuro/muscle | | | | | | |
| (−) | 1721 (62.5%) | 3161 (72.0%) | <0.01 | 1644 (64.5%) | 1654 (64.9%) | 0.792 |
| (+) | 1034 (37.5%) | 1227 (28.0%) | | 903 (35.5%) | 893 (35.1%) | |
| Mental | | | | | | |
| (−) | 2645 (96.0%) | 4205 (95.8%) | 0.759 | 2449 (96.2%) | 2447 (96.1%) | 0.942 |
| (+) | 110 (4.0%) | 183 (4.2%) | | 98 (3.8%) | 100 (3.9%) | |
| Hemal | | | | | | |
| (−) | 2595 (94.2%) | 4104 (93.5%) | 0.268 | 2401 (94.3%) | 2427 (95.3%) | 0.115 |
| (+) | 160 (5.8%) | 284 (6.5%) | | 146 (5.7%) | 120 (4.7%) | |

BMI: body mass index; CCI: Charlson Comorbidity Index; PNB: peripheral nerve block; LI: local infiltration; ADL: activities of daily living.
[a]The C-statistic of the logistic regression model used to generate the propensity scores was 0.62.

group being more dependent were pain and pain-related changes. The levels of fentanyl and pentazocine consumption in the PNB group were lower than those in the LI group. Since antiemetic use in the PNB group was lower than that in the LI group, the frequency of postoperative nausea and vomiting (PONV) in the PNB group was speculated to be lower than that in the LI group. Postoperative nutrition is an important factor for rehabilitation. The physiological weakening and psychological impact of PONV and severe pain are speculated to push patients toward a dependent status. As such, the LI group patients might be less independent as reflected by the total ADL score than the PNB ones. Since the main purpose of the present study was to evaluate the effect of PNB on walking ability after TKR, we did not use other Barthel Index items besides mobility and total score in the propensity score matching. The results showed that there were no significant differences in almost all items at baseline, although the transfer independence of the PNB group was lower than that of the LI group at admission. Since the initial conditions were not uniform, analyses of each item were just performed as a reference, but the independence in bathing of the PNB group was significantly higher than that of the LI group at discharge. Washing in a bathtub is more common than

**Table 3.** Effects of PNB on the ADL, walking ability, rehabilitation, analgesics, antiemetics, complications, and hospital cost in propensity score-matched patients.[a]

| | PNB | LI | *p* Value |
|---|---|---|---|
| n | 2547 | 2547 | |
| Total ADL ability at discharge | | | |
| Dependent/independent | 562/1985 | 629/1918 | <0.05 |
| Walking ability at discharge | | | |
| Dependent/independent | 310/2237 | 332/2215 | 0.353 |
| Rehabilitation | | | |
| Start day (days) | 1.89 ± 1.20 | 1.57 ± 1.11 | <0.01 |
| Units/first day | 1.61 ± 0.69 | 1.41 ± 0.68 | <0.01 |
| Units/second day | 1.84 ± 0.76 | 1.70 ± 0.83 | <0.01 |
| Total units | 32.9 ± 21.1 | 34.5 ± 24.0 | <0.05 |
| Analgesics after surgery (∼3 days) | | | |
| Fentanyl (400+/0–400 μg) | 277/2270 | 761/1786 | <0.01 |
| Pentazocine (+/−) | 386/2161 | 485/2062 | <0.01 |
| NSAIDs[c] (+/−) | 2210/337 | 2256/291 | 0.05 |
| IV acetoaminophen (+/−) | 965/1582 | 552/1995 | <0.01 |
| Antiemetic after surgery(∼3days) | | | |
| (+/−) | 590/1957 | 774/1773 | <0.01 |
| Complications | | | |
| Total (+/−) | 151/2396 | 204/2343 | <0.01 |
| HT during surgery (+) | 55 | 144 | <0.05 |
| Surgical site infection (+) | 31 | 24 | |
| Other (+) | 65 | 36 | |
| Hospital cost (US$) | 17 264 ± 4 021 | 17 381 ± 4 149 | 0.304 |

ADL: activities of daily living; IV: intravenous medicine; HT: hypertension; LI: local infiltration; NSAIDs: nonsteroidal anti-inflammatory drugs; PNB: peripheral nerve block.
[a]Values are represented as mean ± SD.
[c]NSAIDs include flurbiprofen, loxoprofen, dichrofenac, and celecoxib.

showering in Japan. Since there is a need to stand on one leg when getting into or out of a bath, a slight difference in knee restoration, which did not influence the walking ability, might have affected the independence regarding bathing.

Berninger et al.[3] reported that the PNB group presented a significant lower grade of mobilization than the LI group at only postoperative day 1. Since local anesthetics of most PNBs act on both sensory and motor nerves simultaneously, transient motor paresis can occur, leading to a delay in the initiation of rehabilitation. In the present study, the PNB group started rehabilitation later but performed rehabilitation for longer in the initial 2 days than the LI group. PNBs probably provide patients with powerful pain control and enable them to perform rehabilitation for longer in the initial stage.

The present study showed that the consumption of fentanyl and pentazocine in the PNB group was significantly lower than in the LI group, which is in accordance with the findings of previous studies.[4,6] However, three meta-analyses demonstrated that there were no significant differences in pain scale and analgesic consumption between the PNB and LI groups.[7,9,10] In prospective clinical studies related to pain control, it might be difficult to find clear differences between the treatment and control groups due to ethical considerations. The incidence of hypertensive episodes during surgery in the PNB group was significantly low compared with the LI group. Almost all PNBs are completed before the start of surgery, but many LI analgesia techniques are performed at the end of surgery. Therefore, we speculated that LI techniques did not prevent hypertension during surgery. The incidences of infectious complications were about 1% in both the PNB and LI groups, which is in agreement with another report.[17] Moreover, Kopp et al.[18] reported that the use of PNBs does not influence the incidence of surgical site infections in patients undergoing total joint arthroplasty. We clarified that both PNBs and LI techniques do not affect the incidence of infectious complications of TKR.

Another finding in this study was that there was no significant difference in the total hospitalization cost between the PNB and LI groups. In the propensity score matching, we matched LOS between the PNB and LI groups because LOS affects walking or other ADL abilities. If we did not match the LOS, hospitalization cost might have differed between the PNB and LI groups.

The present study has several limitations. First, the types and durations of PNB were inconsistent. Second, the doses and concentrations of local anesthetics used in PNB and LI were also inconsistent. Third, severe cases were excluded before the analyses because the primary outcome was walking ability during the typical progress of TKR.

Therefore, there might have been bias in the results regarding complications. Fourth, the details of the complications were unknown due to the general categories provided in the DPC database. Fifth, almost all patients in this study were Japanese, so it may not be appropriate to extrapolate the results to the situation in other countries.

## Conclusions

No significant differences in walking ability after TKR were found between the PNB and LI groups in this study. However, PNB offered some advantages over LI because the PNB group here was more independent as reflected by the total ADL score at discharge and had a shorter rehabilitation period, lower consumption of analgesic and antiemetics, and lower frequency of hypertensive episodes during surgery. Future investigation of databases, including detailed medical information, especially the PNB techniques used and the complications that occurred, should be considered in order to improve the progress of TKR.

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