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# Continuous Adductor Canal Versus Continuous Femoral Nerve Blocks

## Relative Effects on Discharge Readiness Following Unicompartment Knee Arthroplasty

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**Background:** We tested the hypothesis that, following unicompartment knee arthroplasty, a continuous adductor canal block decreases the time to reach 4 discharge criteria compared with a continuous femoral nerve block.

**Methods:** Subjects were randomized to either an adductor canal or femoral perineural catheter (2-day ropivacaine 0.2% infusion) in an unmasked fashion. The primary outcome was the time to attain 4 discharge criteria: (1) adequate analgesia; (2) intravenous opioid independence; (3) ability to independently stand, walk 3 m, return, and sit down; and (4) ambulate 30 m.

**Results:** Subjects with an adductor canal catheter (n = 15) reached all 4 criteria in a median of 35 hours (interquartile range, 24–43 hours), compared with 40 hours (interquartile range, 27–69 hours) for those with a femoral catheter (n = 15; Wilcoxon rank sum test:  $P = 0.46$ ; log-rank test:  $P = 0.16$ ). However, the percentages of subjects (adductor canal: femoral) who reached the 2 mobilization criteria were 27%:0% on postoperative day (POD) 0, 93%:53% on POD 1, and 100%:73% on POD 2. Of adductor canal subjects, 100% were discharge ready by POD 2, compared with only 73% of femoral subjects ( $P < 0.001$ ).

**Conclusions:** Compared with a continuous femoral nerve block, a continuous adductor canal block did not appreciably decrease the median number of hours to overall discharge readiness, yet did decrease the number of discrete days until discharge readiness. These results are applicable to only unicompartment knee arthroplasty and must be considered preliminary because of the limited sample size of this pilot study.

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Unicompartment knee arthroplasty often produces moderate to severe pain that frequently requires intravenous analgesics and impairs functional mobility, both of which can prolong hospitalization.<sup>1</sup> Effective postoperative analgesia may be provided with a continuous femoral nerve block.<sup>2</sup> Unfortunately, this technique weakens the quadriceps femoris muscle and is associated with an increased risk of falls.<sup>3–10</sup>

An adductor canal block is a relatively new alternative in which local anesthetic is deposited adjacent to multiple afferent sensory nerves within an aponeurotic tunnel in the middle-third of the thigh. However, in contrast to the femoral nerve block that affects all 4 major divisions of the quadriceps muscle, the adductor canal contains only a single efferent motor nerve that innervates the vastus medialis of the quadriceps.<sup>11,12</sup> In clinical trials, a single-injection adductor canal block produces less quadriceps femoris weakness and mobilization disability compared with a single-injection femoral nerve block.<sup>13–15</sup>

A percutaneous perineural catheter is frequently inserted in order to permit extending the single-injection block with additional local anesthetic to extend postoperative analgesia.<sup>14,16–20</sup> At the time of this writing, there were 2 randomized studies published comparing continuous adductor canal and femoral nerve blocks after knee arthroplasty; but both included exclusively tricompartment procedures.<sup>19,21</sup>

Consequently, we designed and executed a dual-center, randomized, active-controlled, parallel-arm pilot study to test the hypothesis that, compared with a continuous femoral nerve block, a continuous adductor canal block decreases the time to attain 4 specific discharge criteria following unicompartment knee arthroplasty: (1) adequate analgesia; (2) independence from intravenous opioids; (3) ability to independently stand; walk 3 m, return, and sit down; and (4) independently ambulate 30 m.

## METHODS

The study was prospectively registered at [clinicaltrials.gov](http://clinicaltrials.gov) (NCT01759277), conducted within the ethical guidelines outlined in the Declaration of Helsinki, and followed Good Clinical Practice. The local institutional review board (University California San Diego, San Diego, California) approved the protocol and oversaw implementation through data analysis. We enrolled adults ( $\geq 18$  years) undergoing primary, unilateral, unicompartment knee arthroplasty involving the medial compartment following written, informed consent. Exclusion criteria included a neuromuscular deficit of the obturator nerve, ipsilateral femoral nerve, or quadriceps femoris; inability to ambulate 30 m preoperatively; long-term opioid consumption (daily oxycodone equivalents  $>20$  mg within 2 weeks prior to surgery and duration of use  $>4$  weeks); history

**TABLE 1.** Anthropomorphic and Prerandomization Surgical Characteristics of the Study Subjects

|                                    | Adductor Canal<br>(n = 15) | Femoral<br>(n = 15) |
|------------------------------------|----------------------------|---------------------|
| Age, y                             | 70 ± 10                    | 68 ± 12             |
| Sex (female), n (%)                | 7 (47)                     | 7 (47)              |
| Height, cm                         | 171 ± 11                   | 167 ± 8             |
| Weight, kg                         | 82 ± 16                    | 83 ± 14             |
| Body mass index, kg/m <sup>2</sup> | 28 ± 3                     | 30 ± 4              |
| Surgeon (A), n (%)                 | 12 (80)                    | 9 (60)              |
| Hospital (Thornton), n (%)         | 12 (80)                    | 12 (80)             |

Values are reported as mean ± SD or number of subjects (percentage of treatment group).

of opioid abuse; known renal insufficiency (creatinine >1.5 mg/dL); allergy to study medications; morbid obesity (body mass index >40 kg/m<sup>2</sup>); pregnancy; and incarceration.

### Treatment Allocation

Investigational Drug Service personnel used a computer to create randomization lists with a 1:1 ratio, in blocks of 4, stratified by both surgeon and treatment center. Using ultrasound with a 13–6 MHz 38-mm linear array transducer (M-Turbo; SonoSite, Bothell, Washington), both adductor canal and femoral anatomic locations were examined. If both sites were deemed acceptable for a perineural catheter, the subject was randomized using numbered, sealed, opaque envelopes to receive either a femoral or an adductor canal perineural catheter.

### Intervention

Preoperatively, subjects had their perineural catheter inserted (FlexBlock; Teleflex Medical, Research Triangle Park, North Carolina) using techniques very similar to those described previously.<sup>20–24</sup> Using a portable, programmable, electronic infusion pump (ambIT PreSet; Summit Medical Products, Inc, Salt Lake City, Utah), a ropivacaine 0.2% infusion was administered via the perineural

catheter (basal rate 6 mL/h; 4-mL bolus; 30-minute lockout). Following joint closure, the surgeon infiltrated the joint using 30 mL of ropivacaine (0.5%), ketorolac (30 mg), epinephrine (5 g/mL), and tranexamic acid (2 g).

### Postoperative Period

Subjects received on a scheduled basis sustained release oxycodone (Oxycontin, 10 mg every 12 hours), celecoxib (200 mg every 12 hours), and oral acetaminophen (975 mg every 6 hours). Rescue opioids were provided for breakthrough pain inadequately treated with a local anesthetic bolus. For moderate or severe pain within the postanesthesia care unit, a 10-mL lidocaine (2%) bolus was given via the perineural catheter a maximum of 1 time. The perineural basal infusion rate was titrated to subject comfort (increased 2 mL/h for Numeric Rating Scale for pain [NRS] >4) up to twice daily (maximum = 12 mL/h). However, to minimize the risk of falling and allow for ambulation, quadriceps strength took precedence. If a subject's standing and/or ambulation was inhibited by muscle weakness as determined by a physical therapist, the basal infusion rate was decreased 2 mL/h up to twice per day (minimum = 2 mL/h).

### Study End Points

The primary outcome measure was the time from the end of surgery until 4 criteria were fulfilled without reversion to unfulfilled status: (1) adequate analgesia (defined as NRS <4 as recorded by nursing staff every 4 hours and at the time of analgesic request), (2) independence from intravenous opioids for at least 12 hours, (3) ability to independently stand and sit down (evaluated with the Timed Up and Go test),<sup>25,26</sup> and (4) unassisted ambulation of at least 30 m (evaluated with the 6-Minute Walk Test).<sup>27</sup> Criteria were assessed following each nursing shift: 8:00 AM, 4:00 PM, and midnight. Subjects participated in physical therapy twice daily, and those who reached the orthopedic wards by 2:00 PM on the day of surgery had a physical therapy session that afternoon. Treatment group assignment was not masked to investigators or study participants. Perineural catheters were removed the morning of postoperative day (POD) 2. Discharge occurred after meeting all 4 discharge criteria, but not prior to POD 2. Subjects were telephoned and verbally completed the Western Ontario and McMaster Universities Osteoarthritis Index

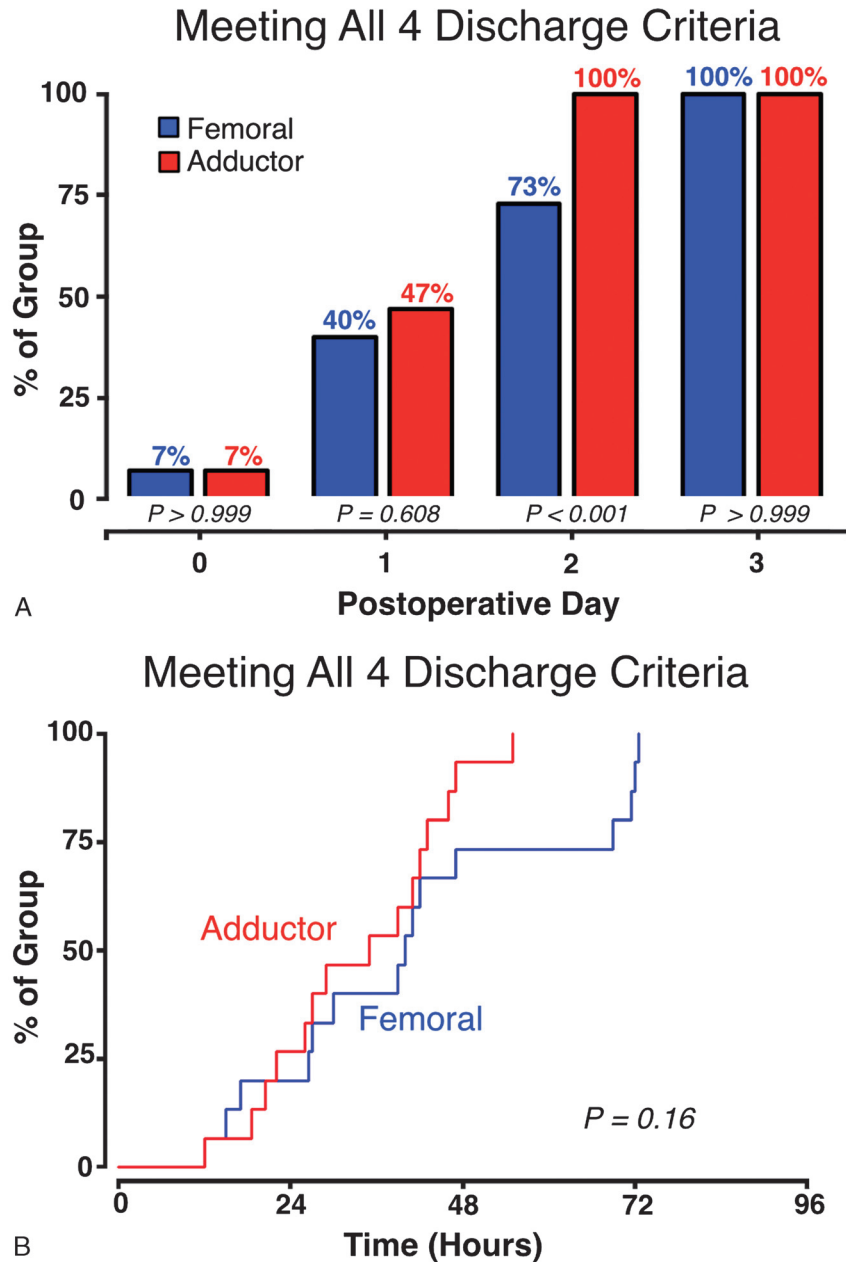
**TABLE 2.** Postrandomization Catheter Insertion and Perioperative Characteristics

|                                      | Adductor Canal (n = 15)    | Femoral (n = 15)              | P    |
|--------------------------------------|----------------------------|-------------------------------|------|
| Catheter insertion time, min         | 3.6 (2.6–4.5)              | 2.8 (2.3–3.5) <sup>1</sup>    | 0.22 |
| Difficulty placing catheter, n (%)   | 0 (0)                      | 0 (0)                         | —    |
| Worst pain during placement (NRS*)   | 0 (0–1)                    | 1 (0–1)                       | 0.19 |
| Fentanyl for catheter insertion, µg  | 100 (50–100)               | 100 (50–100) <sup>1</sup>     | 0.74 |
| Midazolam for catheter insertion, mg | 2 (1–2)                    | 2 (1–2) <sup>1</sup>          | 0.96 |
| General anesthetic, n (%)            | 11 (73)                    | 9 (60)                        | 0.44 |
| Time of incision, hour of day        | 11:00 AM (9:00 AM to noon) | 10:00 AM (8:00 AM to 2:00 PM) | 0.62 |
| Tourniquet duration, min             | 75 (70–96)                 | 78 (68–93)                    | 0.92 |
| Surgical start to stop, min          | 75 (70–96)                 | 80 (73–101)                   | 0.67 |
| OR morphine equivalents, mg          | 6 (5–13)                   | 8 (4–13)                      | 0.99 |

Values are reported as mean ± SD, median (interquartile range), or number of subjects (percentage of treatment group), as appropriate. *P* values were derived from *t* test or Wilcoxon rank sum test for continuous variables and Pearson  $\chi^2$  test or Fisher exact test for categorical variables. All tests were 2-sided. Superscripts represent number of missing values.

\*Scored 0–10: 0 = no pain, 10 = worst pain imaginable.

OR indicates operating room.



**FIGURE 1.** Effects of perineural catheter location—adductor canal versus femoral—on the time to reach 4 important discharge criteria (adequate analgesia, independence from intravenous opioids, independent ambulation  $\geq 30$  m, and the ability to independently stand, walk 3 m, return, and sit down) following unicompartment knee arthroplasty. Data presented are the percentage of each treatment group to achieve all 4 criteria at each time point (A) and Kaplan-Meier estimates of the cumulative percentages of subjects meeting all 4 discharge criteria at each time point and subsequent time points (B). Subjects with an adductor canal catheter reached all 4 criteria in a median of 35 hours (quartiles, 22–43 hours), compared with 40 hours (quartiles, 26.5–69 hours) for those with a femoral catheter (95% CI for difference in medians, –22.5 to 7 hours; Wilcoxon rank sum test:  $P = 0.46$ ; log-rank test:  $P = 0.16$ ).

questionnaire 1 week following surgery ( $\pm 2$  days) to evaluate changes in health-related quality of life.<sup>10,28–35</sup>

**Statistical Analysis**

For this pilot study, we used a convenience sample of subjects. This pilot study was therefore not well powered to be able to detect either the main effects of treatment or the treatment-by-time interactions, and lack of significance might be due to lack

of power. Effect estimates and confidence intervals (CIs) should be given more emphasis than  $P$  values. Standard summary statistics were used to assess the balance between the 2 randomized treatment groups for postrandomization catheter insertion and perioperative characteristics. The effect of perineural catheter location on time to reach all 4 discharge criteria was assessed using the 2-tailed Wilcoxon rank sum test, with difference in medians estimated using the method of Hodges-Lehmann. Kaplan-Meier analysis on these time-to-event outcomes was also conducted,

**TABLE 3.** Infusion-Related End Points

|   | Adductor Canal<br>(n = 15) | Femoral<br>(n = 15)   | P*    |
|---|----------------------------|-----------------------|-------|
| Total local anesthetic administered, mL | 340 ± 69                   | 267 ± 47 <sup>3</sup> | 0.005 |
| Basal rate on morning of POD 1          |                            |                       | 0.11  |
| 4 mL/h                                  | 0%                         | 13%                   |       |
| 6 mL/h                                  | 93%                        | 87%                   |       |
| 8 mL/h                                  | 7%                         | 0%                    |       |
| Basal rate on morning of POD 2          |                            |                       | 0.005 |
| 2 mL/h                                  | 0%                         | 17% <sup>3</sup>      |       |
| 4 mL/h                                  | 0%                         | 33% <sup>3</sup>      |       |
| 6 mL/h                                  | 87%                        | 50% <sup>3</sup>      |       |
| 8 mL/h                                  | 13%                        | 0% <sup>3</sup>       |       |
| Actual discharge                        |                            |                       |       |
| Hours from surgical stop                | 51 (46–71)                 | 68 (47–73)            | 0.71  |
| POD 1                                   | 7%                         | 13%                   |       |
| POD 2                                   | 53%                        | 33%                   |       |
| POD 3                                   | 40%                        | 47%                   |       |
| POD 4                                   | 0%                         | 7%                    |       |

Values are reported as median (interquartile range) or percentage of treatment group, as appropriate. *P* values were derived from *t* test or Wilcoxon rank sum test for continuous or ordinal variables, and Pearson  $\chi^2$  test or Fisher exact test for categorical variables. All tests were 2-sided. We used a significance criterion of 0.003. Superscripts represent number of missing values.

\*Significant if *P* < 0.003 (Bonferroni correction for multiple secondary outcomes).

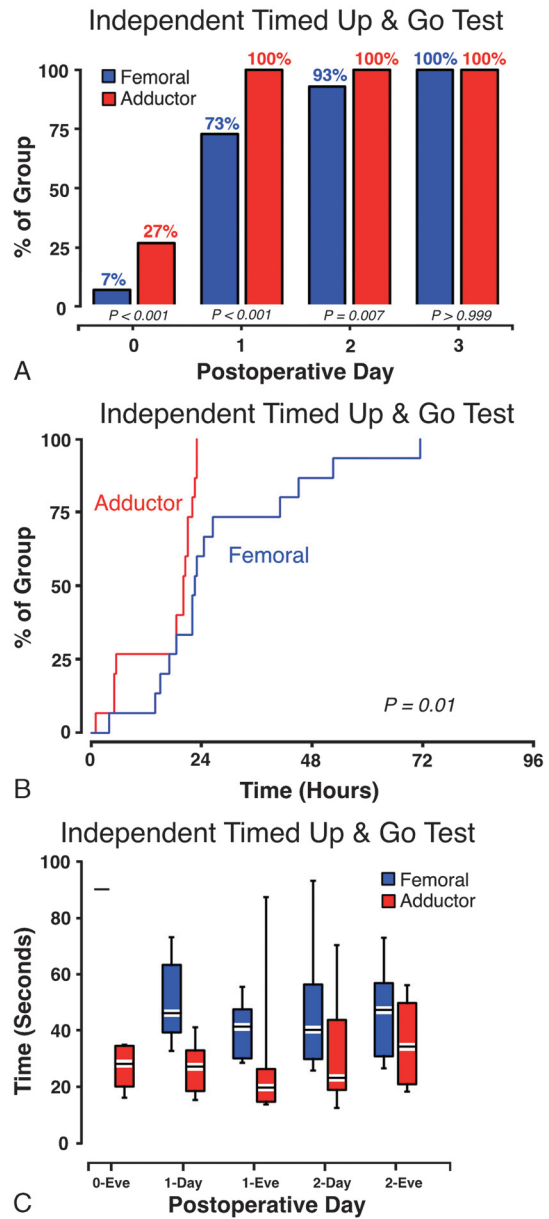
and groups compared using the log-rank test. Hazard ratios were estimated using a Cox proportional hazards regression model, and the proportional hazards assumption was tested by assessing the group-by-time interaction. Most secondary end points were assessed by repeated-measures general linear model with an autoregressive covariance structure. A Student *t* test or Wilcoxon rank sum test was used to compare treatment groups on continuous or ordinal outcomes, as appropriate. Pearson  $\chi^2$  test or the Fisher exact test was used for nominal end points. We controlled the familywise type I error probability at 0.05 across the 17 secondary outcomes by using a significance criterion of 0.003 (ie, 0.05/17, Bonferroni correction). We report 95% CIs to indicate that the significance level was controlled at 5% for each hypothesis. Interactions were deemed significant if *P* < 0.10. SAS software version 9.3 for Windows (SAS Institute, Cary, North Carolina) was used for statistical analyses.

**RESULTS**

Thirty-one subjects enrolled between January 2013 and August 2014 and received either an adductor canal (n = 16) or femoral (n = 15) catheter, all successfully inserted per protocol. However, 1 subject with an adductor canal catheter was inadvertently not followed up for purposes of this study, and thus the various outcome measures are unavailable. The remaining 30 subjects had an evaluable primary end point and were included in the analysis (Tables 1 and 2).

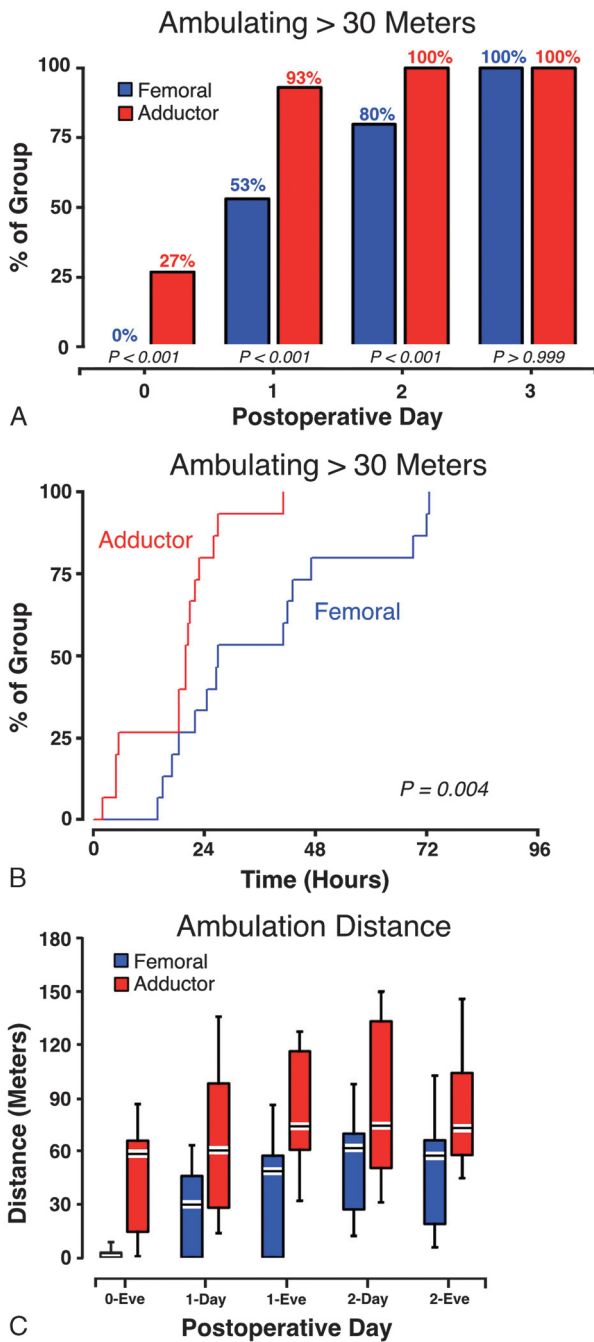
**Primary End Point**

Subjects assigned to an adductor canal catheter (n = 15) met the 4 discharge-readiness criteria in a median of 35 hours



**FIGURE 2.** Effects of perineural catheter location—adductor canal versus femoral—on the Timed Up and Go test (independently stand, walk 3 m, return, and sit down) following unicompartment knee arthroplasty, utilizing a 4-legged walker. Data presented are the percentage of each treatment group to achieve the specified criteria at each time point (A), Kaplan-Meier estimates of the cumulative percentages of subjects meeting the specified criteria at each time point and subsequent time points (B), and time to perform the specified criteria as median (horizontal bar) with 25th–75th (box) and 10th–90th (whiskers) percentiles (C). Subjects with a continuous adductor canal block attained the ability to independently stand, walk 3 m, return, and sit down in a median of 20 hours (quartiles, 5.5–22 hours), compared with 22.5 hours (quartiles, 17–41 hours) for those with a continuous femoral nerve block (Wilcoxon rank sum test: *P* = 0.06; log-rank test: *P* = 0.01).





**FIGURE 3.** Effects of perineural catheter location—adductor canal versus femoral—on ambulation following unicompartment knee arthroplasty, utilizing a 4-legged walker. Data presented are the percentage of each treatment group to ambulate at least 30 m at each time point (A), Kaplan-Meier estimates of the cumulative percentages of subjects ambulating at least 30 m at each time point and subsequent time points (B), and distance of ambulation as median (horizontal bar) with 25th–75th (box) and 10th–90th (whiskers) percentiles (C). Subjects with a continuous adductor canal block attained the ability to ambulate at least 30 m in a median of 20 hours (quartiles, 5.5–23 hours), compared with 27 hours (quartiles, 18.5–47 hours) for those with a continuous femoral nerve block (Wilcoxon rank sum test:  $P = 0.02$ ; log-rank test:  $P = 0.004$ ).

**TABLE 4.** Physical Therapy End Points

|  | Adductor Canal (n = 15)   | Femoral (n = 15)          | P*      |
|--|---------------------------|---------------------------|---------|
| Subjects participating on POD 0                                      | 40%                       | 27%                       |         |
| Quadriceps weakness limiting physical therapy (% of treatment group) |                           |                           | <0.001* |
| POD 0 afternoon  | 0%                        | 75%                       |         |
| POD 1 morning  | 0%                        | 53%                       |         |
| POD 1 afternoon  | 0%                        | 33%                       |         |
| POD 2 morning  | 0%                        | 13%                       |         |
| Passive knee flexion (degrees)                                       |                           |                           | 0.22    |
| POD 0 afternoon  | 96 ± 21 <sup>9</sup>      | 98 ± 12 <sup>11</sup>     |         |
| POD 1 morning  | 101 (95–110)              | 102 (93–115)              |         |
| POD 1 afternoon  | 106 (98–112) <sup>1</sup> | 106 (88–106) <sup>1</sup> |         |
| POD 2 morning  | 98 (95–110) <sup>4</sup>  | 104 (93–105) <sup>2</sup> |         |
| Passive knee extension (degrees)                                     |                           |                           | 0.98    |
| POD 0 afternoon  | 4 (2–4) <sup>9</sup>      | 5 (2–5) <sup>11</sup>     |         |
| POD 1 morning  | 2 (1–3)                   | 5 (2–8)                   |         |
| POD 1 afternoon  | 2 ± 2 <sup>1</sup>        | 6 ± 4 <sup>1</sup>        |         |
| POD 2 morning  | 2 (1–6) <sup>4</sup>      | 5 (0–7) <sup>2</sup>      |         |
| Average pain during session (NRS†)                                   |                           |                           | 0.10    |
| POD 0 afternoon  | 3 (0–4) <sup>9</sup>      | 0 (0–3) <sup>11</sup>     |         |
| POD 1 morning  | 4 (1–5)                   | 1 (0–3)                   |         |
| POD 1 afternoon  | 3 ± 2 <sup>1</sup>        | 3 ± 3 <sup>1</sup>        |         |
| POD 2 morning  | 3 (2–4) <sup>4</sup>      | 1 (0–4) <sup>2</sup>      |         |
| Worst pain during session (NRS)                                      |                           |                           | 0.03    |
| POD 0 afternoon  | 5 (0–7) <sup>9</sup>      | 0 (0–4) <sup>11</sup>     |         |
| POD 1 morning  | 5 (2–7)                   | 1 (0–4)                   |         |
| POD 1 afternoon  | 4 ± 2 <sup>1</sup>        | 3 ± 3 <sup>1</sup>        |         |
| POD 2 morning  | 5 ± 1 <sup>4</sup>        | 3 ± 3 <sup>2</sup>        |         |

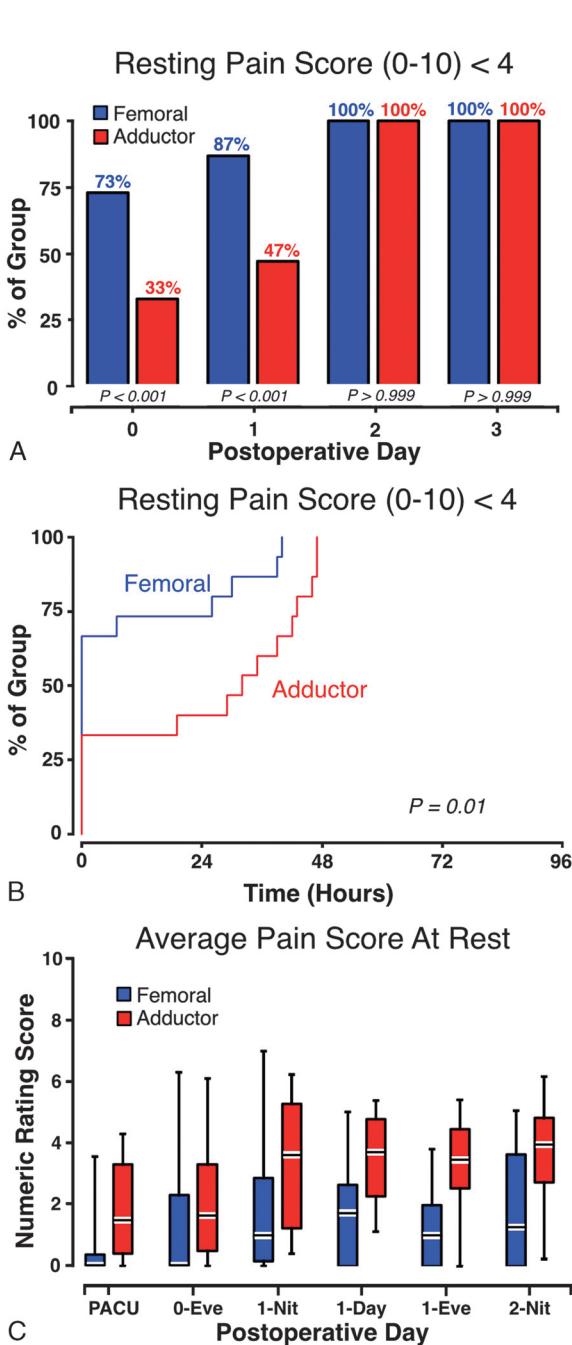
Values are reported as mean ± SD, median (interquartile range), or percentage of treatment group, as appropriate. Superscripts represent number of missing values. Except for the pain scores,  $P$  values were derived from log-rank test for time-to-event outcomes or repeated-measures general linear model with an autoregressive covariance structure for passive knee flexion and extension (after logarithmic transformation). All tests were 2-sided. For the pain scores,  $P$  values were derived from repeated-measures general linear model with an autoregressive covariance structure. All tests were 2-sided. No treatment-by-time interaction:  $P = 0.28$ ,  $P = 0.56$ , and  $P = 0.12$  for ambulation distance, passive knee flexion, and extension, respectively. No treatment-by-time interaction:  $P = 0.21$  and  $P = 0.41$  for average and worst pain score, respectively.

\*Significant if  $P < 0.003$  (Bonferroni correction for multiple secondary outcomes).

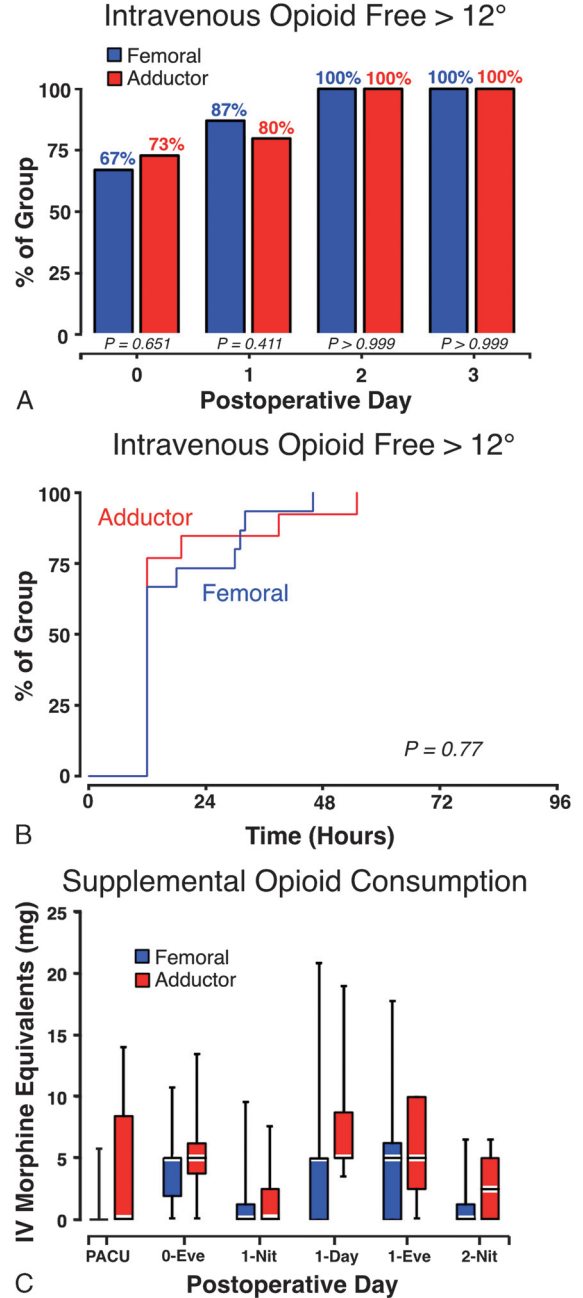
†Scored 0–10: 0 = no pain, 10 = worst pain imaginable.

(interquartile range, 24–43 hours), compared with 40 hours (interquartile range, 27–69 hours) for subjects who received a femoral catheter ( $n = 15$ ; Wilcoxon rank sum test:  $P = 0.46$ ; log-rank test:  $P = 0.16$ ; Fig. 1). The median was an estimated 5 hours less (95% CI, 23 hours less, 6 hours more) for adductor canal than femoral. The estimated hazard ratio of meeting all 4 discharge criteria was 1.8 (95% CI, 0.8–3.9) for adductor canal versus femoral. In other words, although not statistically significant, subjects with an adductor canal catheter were about 1.8 times more likely (range, 20% less likely to 3.9 times more likely) to meet all 4 discharge criteria at any one time than subjects with a femoral catheter.

In terms of discrete days following surgery, on the first POD, 47% of the subjects with an adductor canal catheter met the 4

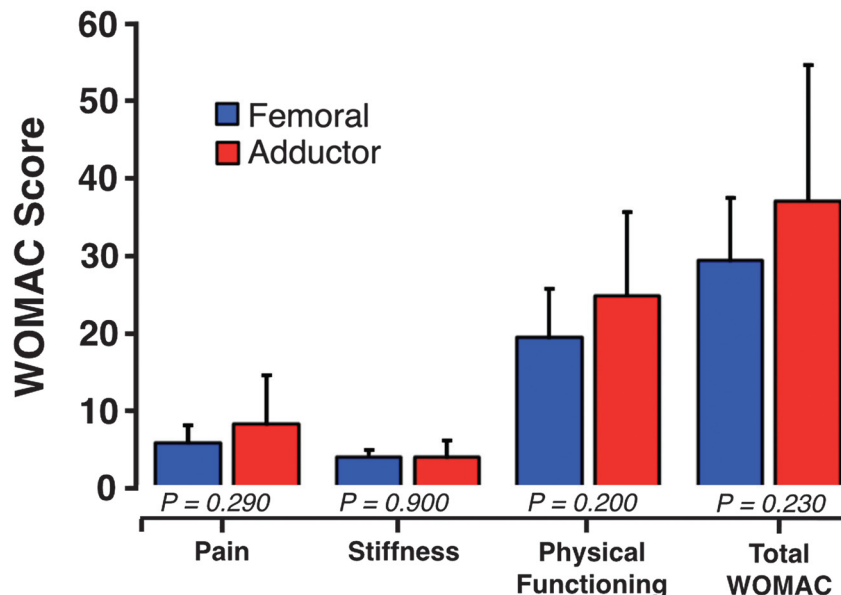


**FIGURE 4.** Effects of perineural catheter location—adductor canal versus femoral—on analgesia following unicompartment knee arthroplasty. Data presented are the percentage of each treatment group to have a mean NRS for pain of less than 4 at each time point (A), Kaplan-Meier estimates of the cumulative percentages of subjects with a mean NRS of less than 4 at each time point and subsequent time points (B), and mean NRS presented as median (horizontal bar) with 25th–75th (box) and 10th–90th (whiskers) percentiles (C). Subjects with a continuous adductor canal block attained a mean NRS of less than 4 in a median of 32 hours (quartiles, 0–43 hours), compared with 0 hours (quartiles, 0–26 hours) for those with a continuous femoral nerve block (Wilcoxon rank sum test:  $P = 0.03$ ; log-rank test:  $P = 0.01$ ).



**FIGURE 5.** Effects of perineural catheter location—adductor canal versus femoral—on supplemental opioid requirements following unicompartment knee arthroplasty. Data presented are the percentage of each treatment group free of intravenous opioids for the previous 12 hours at each time point (A), Kaplan-Meier estimates of the cumulative percentages of subjects free of intravenous opioids for the previous 12 hours at each time point and subsequent time points (B), and mean oral and intravenous supplemental requirements (morphine equivalents) as median (horizontal bar) with 25th–75th (box) and 10th–90th (whiskers) percentiles (C). Subjects with a continuous adductor canal block were free from intravenous opioids for the previous 12 hours in a median of 12 hours (quartiles, 12–19 hours), compared with 12 hours (quartiles, 12–30 hours) for those with a continuous femoral nerve block (Wilcoxon rank sum test:  $P = 0.82$ ; log-rank test:  $P = 0.77$ ).

## Health-Related Quality-of-Life



**FIGURE 6.** Effects of perineural catheter location—adductor canal versus femoral—on the Western Ontario and McMaster Universities Osteoarthritis Index quality-of-life questionnaire following unicompartment knee arthroplasty. Data are presented as mean (SD) for each treatment group. There are no statistically significant differences between treatment groups ( $P = 0.40$ ).

discharge-readiness criteria versus 40% with a femoral catheter ( $P = 0.71$ ). However, by POD 2, 100% of the adductor canal group met all 4 criteria compared with only 73% of the femoral group ( $P < 0.001$ ; Fig. 1). These results suggest that use of a continuous adductor canal catheter might increase the proportion of patients reaching discharge-readiness by POD 2 compared with those receiving a femoral perineural infusion, although this supposition requires confirmation with a subsequent trial adequately powered for this end point. Regarding the actual day of hospital discharge, by POD 2, 60% of the adductor canal group were released home compared with only 46% of the femoral group (Table 3).

### Secondary End Points

The percentages of subjects (adductor canal : femoral) able to fulfill both the Timed Up and Go test (Wilcoxon rank sum test:  $P = 0.06$ ; log-rank test:  $P = 0.01$ ; Fig. 2) and ambulation (Wilcoxon rank sum test:  $P = 0.02$ ; log-rank test:  $P = 0.004$ ; Fig. 3) criteria were 27%:0% on POD 0, 93%:53% on POD 1, and 100%:73% on POD 2 (Table 4). In contrast, there was a trend of femoral catheters providing superior analgesia during PODs 0 and 1 (Wilcoxon rank sum test:  $P = 0.03$ ; log-rank test:  $P = 0.01$ ; Table 4; Fig. 4). Relatedly, subjects with femoral catheters tended to require less supplemental opioid analgesics within the postanesthesia care unit ( $P = 0.017$ ), although there was little difference between groups for this criterion following recovery room discharge (Wilcoxon rank sum test:  $P = 0.82$ ; log-rank test:  $P = 0.77$ ; Fig. 5).

There were minimal differences between the 2 groups regarding passive knee flexion and extension (Table 3) or health-related quality of life at 1 week following surgery (Fig. 6). However, 50% of subjects with a femoral catheter had their basal infusion rate decreased by POD 2 compared with none of the adductor canal subjects ( $P < 0.001$ ), whereas 13% of subjects with an adductor canal catheter had their basal infusion rate increased during the same

period versus none with a femoral catheter ( $P < 0.001$ ; Table 3). This resulted in subjects with an adductor canal catheter consuming more local anesthetic relative that those with a femoral catheter ( $P = 0.005$ ; Table 3). Furthermore, no patients in either group experienced catheter site leakage or inadvertent catheter dislodgement during the first 2 days of infusion.

### Major Protocol Violations and Adverse Events

One subject with a femoral catheter requested catheter removal and study withdrawal on POD 1 after reaching the 4 discharge criteria.<sup>36</sup> There were 2 subjects erroneously discharged a day early on POD 1 after meeting all discharge criteria, both with a femoral catheter that was removed prior to discharge. There were 2 falls (7% total, both in subjects with femoral catheters on PODs 1 and 2 (no resulting injuries or complications).

## DISCUSSION

This dual-center, randomized, controlled, parallel-arm pilot study provides preliminary evidence that compared with a continuous femoral nerve block a continuous adductor canal block decreases the time to achieve adequate mobilization for discharge following unicompartment knee arthroplasty. In contrast, femoral catheters provided superior analgesia at rest, whereas there was little difference between groups in supplemental opioid requirements. Because the advantages of faster mobilization were relatively large for the adductor canal infusions relative to their disadvantages in providing analgesia, all subjects with these catheters were ready for discharge on POD 2 compared with only 73% of subjects with a femoral infusion. It is emphasized that, because of the limited sample size of this pilot study, all results must be considered preliminary and require confirmation with a subsequent clinical trial adequately powered for both the primary and secondary end points. In addition, these results are applicable only to unicompartment—and not tricompartment—knee arthroplasty.



While previously published randomized studies have compared continuous adductor canal and femoral nerve blocks for subjects undergoing tricompartment arthroplasty, to our knowledge this is the first investigation to do so for unicompartment arthroplasty.<sup>37</sup>

An important finding of the current study is the improved analgesia provided at rest with femoral perineural infusions relative to their adductor canal counterparts—a finding previously unreported in comparisons of both single-injection and continuous blocks.<sup>14,16–21</sup> Conventional wisdom has held that the intense pain following knee arthroplasty inhibited mobilization/ambulation.<sup>38</sup> Yet, in randomized controlled studies, a continuous femoral nerve block—while improving postoperative analgesia—has not resulted in increased ambulation distance.<sup>1,39–41</sup> It has been speculated that the analgesic benefits are offset by local anesthetic–induced weakness of the quadriceps femoris muscle.<sup>1,42</sup> The data of the current study support this supposition: femoral catheters were associated with less pain than adductor canal catheters (Fig. 4 and Table 4), but subjects with adductor canal catheters ambulated further than did those with femoral catheters (Fig. 3). The differences between groups for dynamic pain were, at times, dramatic; for example, the median worst pain scores on the NRS (adductor:femoral) were 5:0 and 5:1 on PODs 0 and 1, respectively.

### Limitations

Because the optimal insertion location and technique for adductor canal catheters remain undetermined,<sup>11,43–45</sup> the results of this study are applicable only to catheters and infusions using our protocol. Importantly, the optimal local anesthetic and concentration, basal infusion rate, bolus volume, and infusion regimen (basal-only, basal/bolus combination, repeated bolus doses) remain unknown and require further study. Subjects and investigators were not masked to treatment group. While it is unlikely that subjects had a predisposition toward one insertion site versus another, outcome assessors (nursing staff, physical therapists, and investigators) may have had preconceived bias toward 1 of the 2 treatments. In addition, caretaker bias may have been subconsciously transferred to patients and therefore biased the results. It is emphasized that these results are applicable only to unicompartment—and not tricompartment—knee arthroplasty.

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