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Continuous Femoral Nerve Analgesia after Unilateral Total Knee Arthroplasty: Stimulating versus Non-Stimulating Catheters

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Abstract

Continuous femoral analgesia provides extended pain relief and improved functional recovery for total knee arthroplasty (TKA). Successful continuous peripheral nerve analgesia depends on the catheter proximity to the target nerve. If the catheter is not close to the nerve, high infusion rates may be required to provide analgesia or analgesia may be sub-optimal. Stimulating catheters may allow more accurate placement of catheters in close proximity to the nerve. This randomized prospective study examined the use stimulating catheters versus non-stimulating catheters in 41 patients undergoing TKA. All patients had intravenous patient controlled anesthesia (IVPCA) for supplementary pain relief. The principal aim of the trial was to examine whether the use of a stimulating catheter allowed the use of lesser amounts of local anesthetics than a non-stimulating catheter. Additional parameters examined included post-operative pain scores, opioid use, side effects and acute functional orthopedic outcomes. Analgesia was good in both groups, but there were no statistically significant differences in the amount of ropivacaine administered; the median amount of ropivacaine given to patients in the stimulating catheter group was 8.2 ml/h vs. 8.8 ml/h for patients with non-stimulating catheters, $P = 0.26$ (median difference -0.6; 95% confidence interval, -2.3 to 0.6). No significant differences between the treatment groups were noted for the amount of fentanyl dispensed by the IVPCA, numeric pain rating scale scores, acute functional orthopedic outcomes, side effects or amounts of oral opioids consumed.

Implications: For total knee arthroplasty, there seems to be no significant advantage for the use of stimulating catheters over traditional non-stimulating catheters in continuous femoral nerve blocks.

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Keywords

Anesthesia. Femoral nerve; Nerve block; Continuous analgesia; Volume; Nerve proximity; Opioid consumption; IVPCA; Adverse effects; Administration & dosage; Anesthetics, local; Pain; Pain Measurement; Pain, postoperative; Postoperative Period; Prospective; Randomized; clinical

Background

Total knee arthroplasty (TKA) causes considerable postoperative pain. It can prolong hospitalization, impair rehabilitation and early mobilization (1,2) and may worsen functional outcome (3). Compared to intravenous patient-controlled analgesia (IVPCA), both epidural analgesia and continuous femoral analgesia provide better pain relief and rehabilitation in patients undergoing TKA. However, continuous femoral analgesia is superior to epidural analgesia because it causes fewer side effects (4-8).

Potential limitations of femoral nerve blocks include block failure and toxicity from systemic absorption of local anesthetic. The use of smaller amounts of local anesthetics in continuous peripheral nerve blocks is desirable because it reduces potential toxicity. When performing a continuous femoral nerve catheter block, the operator locates the nerve with the help of a nerve stimulator and subsequently advances the catheter through the needle and into the femoral “sheath”. Nonetheless, injection of local anesthetic through the catheter sometimes fails to produce an adequate nerve block. Failure may occur because the catheter tip is insufficiently close to the nerve (11). The reported rates for this sort of “secondary failure” after successful block with an initial bolus of local anesthetic are roughly 10% (12,13). Recently, a stimulating catheter has become available, whereby nerves can be stimulated by the catheter itself. After nerve localization with an insulated needle and a nerve stimulator, the catheter can then be advanced past the needle tip and the effects of stimulation monitored continuously during and after positioning of the catheter.

Stimulating catheters allow clinicians to position the tip of a catheter close to the target nerve (14) and may thus reduce the amount of local anesthetic needed for a successful block (15). The use of stimulating catheters was reported to increase the success rate of catheter placement in observational studies (16). Furthermore, a study in volunteers demonstrated that stimulating catheters produced significantly better femoral sensory and motor blocks than non-stimulating catheters (14). We thus tested the hypothesis that less local anesthetic would be required for successful femoral nerve blocks with stimulating than non-stimulating catheters in patients undergoing TKA under spinal anesthesia. Secondary parameters were examined for superiority of the stimulating catheter and included post-operative pain scores, opioid use, side effects and acute functional orthopedic outcomes.

Methods

With approval of the Cleveland Clinic IRB, informed consent was obtained from patients aged 40-84 scheduled for unilateral TKA. Exclusion criteria included history of dementia, Alzheimer’s disease or cerebrovascular accident that might impair operating an IVPCA pump or participating in active physical therapy, history of previous ipsilateral TKA, history of vascular surgery involving the femoral vessels on the operative side, contraindications to regional anesthesia such as coagulopathy or local infection, history of drug dependence or abuse, history of chronic pain unrelated to the knee requiring treatment with long-acting opioids, patients undergoing bilateral TKA, history of hepatic or renal insufficiency, or history of arrhythmias or seizures.

Protocol: Patients undergoing unilateral TKA were randomly allocated to: 1) continuous femoral nerve block using a non-stimulating catheter (Contiplex®, B. Braun, Spangenberg, Germany); or, 2) continuous femoral nerve block using a stimulating catheter (StimuCath®, Arrow International, Reading, PA). Patients were randomly assigned to stimulating or non-stimulating catheters with a computer-generated randomization process. Physicians were blinded to the randomization until just before catheter insertion. Patients in both groups were also given IVPCA.

Femoral catheters were inserted under the supervision of anesthesiologists skilled in regional anesthesia techniques. Residents in training were allowed one attempt at placement of the femoral catheters; if unsuccessful, the catheter was inserted by the attending anesthesiologist. If catheter placement was unsuccessful after 30 minutes, the procedure was aborted and the patient was removed from the study. Femoral sheath catheters were inserted pre-operatively using a nerve stimulator. A Contiplex® system (18 gauge, 2 inch insulated needle and 20 gauge catheter) was used in patients assigned to the non-stimulating catheter group. A StimuCath® continuous nerve block set (17 gauge 3.5 inch needle and 19 gauge catheter) was used in patients assigned to the stimulating catheter group.

Following sterile preparation and draping of the femoral area on the operative side, stimulation at 2 Hz and 2 mA was applied after the needle was felt to have gone through two fascial planes, one cm lateral to the femoral artery. When quadriceps contraction was detected, the current was decreased and needle position optimized for evident contraction at a current output of 0.2 to 0.6 mA. The Contiplex® catheter was thread to a depth of 5 cm past the needle tip in patients allocated to the non-stimulating catheter group. In those patients allocated to the stimulating catheter group, the StimuCath® catheter was attached to the nerve stimulator and the catheter thread slowly and maneuvered to a depth of 4-5 cm past the needle tip while maintaining quadriceps contraction at a current ≤ 0.9 mA at all times. The catheter was repositioned as necessary to sustain continuous quadriceps contraction at a current ≤ 0.9 mA.

Given appropriate catheter placement in both groups (5 cm past the needle tip), the needle was withdrawn and the catheter secured in place by tunneling it 5-7 cm subcutaneously laterally. A test dose consisting of 5 ml of 1.5% lidocaine with epinephrine 1:200,000 was then given, and patients monitored for signs and symptoms of intravascular injection such as increased heart rate or metallic taste. Given a negative test dose, the patients were then transferred to the operating room for induction of spinal anesthesia and surgery.

Intra-operatively, patients were given spinal anesthetic with 10-15 mg bupivacaine, 25 µg fentanyl, and 0.2 mg epinephrine injected intrathecally at the second to the fourth lumbar level. No anesthetics were given through the femoral catheter during surgery.

In the recovery room, patients were assessed for return of sensory and motor function. Once spinal anesthesia had regressed to the L1 dermatome level or patients have begun to experience mild knee discomfort, patients were given a 25 ml bolus of ropivacaine 0.2% injected through their femoral sheath catheters. The femoral catheters were then infused with ropivacaine 0.2% at 6 ml/h. An IVPCA with fentanyl 20 µg bolus, no basal rate, and a 6-minute lockout interval was provided to all patients. Patients were assessed in the postoperative period for proximal thigh (above the dressing) numbness by an investigator who was unaware of the designated catheter type. Success of the femoral block was assessed using an alcohol pad over the anterior proximal thigh on the operative side and compared to the non-operative side.

Measurements: Pain level assessed every four hours by ward nurses using a Likert 11-point verbal numeric pain rating scale, with 0 signifying no pain and 10 the worst possible pain. Patients with numeric pain scale score > 4 were given a 10-ml bolus of ropivacaine 0.2% through the femoral catheter and the rate of infusion was increased to 9 ml/h. If four hours later

pain scores still exceeded 4, another 10-ml bolus was given through the femoral catheter and the infusion rate increase to 12 ml/h. No further increases in the infusion rate or femoral catheter boluses were allowed. The IV PCA was discontinued 36-48 hrs following surgery and the femoral catheters removed 24-48 hrs post-operatively. An oral combination of acetaminophen 325 mg and oxycodone 5 mg, 1-2 tablets, was then given every 4-6 hours on as-needed basis. Immediately after surgery, all patients started identical physical therapy regimens.

Outcome measures included ropivacaine use, pain scores, amount of IVPCA fentanyl used, amount of oxycodone used, maximal knee flexion, distance walked during physical therapy 48 hours after surgery, incidence of deep vein thrombosis during the first three post-operative days, incidence of nausea and vomiting (assessed four to six times daily), and the amount of medication used to treat nausea and pruritus.

Statistical Analysis: Our primary endpoint was the volume of local anesthetic needed to achieve adequate analgesia (pain score < 5 on the visual analog scale); other endpoints were considered secondary. A 20% difference in analgesic requirements in the first 72 hours was considered clinically important.

Based on previous work (17) and our experience, we expected ropivacaine analgesic requirements for the two groups to be 330 and 264 mg/24 hours with a standard deviation of 40 in each group. With a mean difference of 66 and a standard deviation of 40 mg/24 hours, 20 patients (10 per group) provided a 90% power at an alpha level of 0.05. Twenty patients (10 per group) offered greater than 80% power to detect a 2 point difference in mean numeric pain rating scores (NRS, 0-10 scale, 0 = no pain, 10 = worse possible pain), assuming a within-group standard deviation of 1.5 point, or a 3.5 point difference with a within-group standard deviation of 2.5 point. We therefore chose to enroll 20 patients/group.

Analgesic requirements and functional parameters in the two groups were compared with a Wilcoxon rank sum test. Results for are presented as medians (interquartile range). This non-parametric test is used for skewed data which are common in pain studies, yet offers adequate power if analgesia doses are normally distributed. In addition, 95% confidence intervals for the difference in medians were estimated. Fisher exact test and the Pearson chi-square test were used to compare complications between the two study groups.

Results

A total of 25 patients were recruited in each group. However, three patients in the non-stimulating catheter group and six patients in the stimulating catheter group were excluded from data analysis. Reasons for exclusion included recruitment error (use of long-acting opioids preoperatively in one patient), failure to record data (current needed to simulate the femoral nerve in three patients) and intolerance of fentanyl IVPCA and having to switch to another intravenous opioid in five patients. A total of 41 patients undergoing unilateral total knee arthroplasty completed the study; 26 were women and 15 men. Patients' ages ranged between 46 and 84 years of age and BMI between 22 and 47 kg/m². There were no signs of intravascular injection in response to any of the preoperative test doses. Among the 41 patients enrolled, 19 were randomized to receive stimulating catheters (StimuCath®) and 22 patients were assigned to the non-stimulating catheter (Contiplex®).

There were no significant differences in currents needed to elicit quadriceps contraction with the stimulating needle with either of the devices. There was also no difference in the number of attempts for needle placement in close proximity to the femoral nerves. As might be expected, the number of attempts for catheter placement was significantly greater for the stimulating catheter group compared to the non-stimulating catheter group (table 1). At the time of placement, the mean current for the stimulating catheters was 0.5 ± 0.2 mA; the median

current was 0.4. Post-operative clinical exam, after resolution of the spinal anesthesia, revealed decreased cold and touch sensation on the proximal anterior thigh ipsilateral to the operative site compared to the contralateral side in all patients, suggesting successful block of the femoral nerve.

There were no statistically significant differences in the amount of ropivacaine administered, or in the amount of fentanyl dispensed by the IVPCA in patients assigned to stimulating and non-stimulating catheters (table 1, figure 1). The median amount of ropivacaine given to patients in the stimulating catheter group was 8.2 ml/h vs. 8.8 ml/h for patients with non-stimulating catheters, $P = 0.26$. These values are not significantly different given that with inclusion of 20 patients (10 in each group), the study would have a 90% power to detect a 20% difference between the groups in local anesthetics used. The corresponding average amounts for fentanyl per hour dispensed *via* IVPCA were 55.5 $\mu\text{g/h}$ vs. 55.0 $\mu\text{g/h}$, respectively (table 1). There were also no significant differences between the two treatment groups in numeric pain rating scale scores (figure 2). In addition, there was no difference between the two groups in the fraction of patients who needed no adjustment in the local anesthetic infusion rate or in the total number of local anesthetic infusion rate adjustments (table 2). There was also no difference between the two groups in the number of patients who never achieved satisfactory analgesia, defined as a numeric pain rating score of < 5 , between 8 and 24 hours postoperatively (table 3).

There were no functional differences in terms of maximal degree of knee flexion or distance walked 48 hours after surgery during physical therapy (table 4). Similarly, no significant differences were noted between the catheter types in terms of oxycodone consumption once the IVPCA was discontinued. And finally, there were no significant differences in the incidence of nausea, vomiting and itching or in the amounts of dolasetron or diphenhydramine used to treat nausea and pruritus (tables 5 and 6); no patient developed urinary retention and only one patient displayed evidence of deep-vein thrombosis within the first 72 postoperative hours.

Discussion

The amount of local anesthetic required for successful femoral nerve blocks after unilateral total knee arthroplasty was similar in patients assigned to stimulating and non-stimulating catheters. Furthermore, secondary outcomes including post-operative pain and intravenous opioid requirements were also comparable in patients given stimulating non-stimulating femoral nerve catheters. Our findings are consistent with those reported by Morin et al. in patients undergoing major knee surgeries under general anesthesia (18). It is also consistent with a retrospective study by Jack et al. in which there were no statistically significant differences in pain scores or morphine consumption in patients receiving stimulating and non-stimulating femoral nerve catheters (19).

While advantageous from a theoretical standpoint and in experimental designs (14), stimulating catheters have not been more beneficial in clinical TKA studies over the non-stimulating catheters. Besides limitations of clinical trial design, other factors may explain this discrepancy. The presumption that nerve stimulation magnitude may reliably quantify proximity of the needle or catheter to the nerve may not be entirely precise (15,20). Indeed, equivalent VAS scores and morphine consumption occurred in patients undergoing painful knee surgeries regardless whether a nerve stimulator was used to place a femoral nerve catheter or a fascia iliaca compartment catheter was placed without a nerve stimulator (21).

A limitation of our study design is that it did not allow patients total control over the amount of local anesthetic used and therefore the amount consumed did not necessarily parallel the intensity of pain. This design was implemented in order to avoid patient confusion with having to operate two PCA devices (IV and femoral nerve analgesia). An alternative design that would

have involved nurse-administered intravenous opioid analgesia and patient controlled femoral nerve analgesia may have resulted in a more accurate reflection of local anesthetic requirements with either catheter type. In fact, significantly lower consumption of ropivacaine has been shown with patient-controlled femoral analgesia with boluses-only techniques compared to techniques that only include a basal infusion in patients undergoing painful knee surgeries (22).

The knee is innervated by the lumbar plexus (femoral and obturator nerve) anterolaterally and the sacral plexus posteriorly (sciatic nerve) (23,24). In patients undergoing TKA under general anesthesia, the combination of single preoperative sciatic nerve block with continuous femoral nerve block achieved good pain control in an observational study by Mansour and Bennetts (25). However, in a double-blinded randomized study in patients undergoing TKA under spinal anesthesia, Allen et al. did not find added benefit when sciatic nerve block was combined with femoral nerve block (26). Other investigators, however, noted better pain control (27) and reduced opioid requirements in patients receiving sciatic nerve blocks in addition to femoral nerve blockade (28). It is clear, though, that continuous femoral nerve blockade following TKA does not provide total analgesia. Posterior knee pain that was not covered by femoral nerve blockade in our patients was addressed with IVPCA.

Some of the post-operative opioid consumption may have compensated for incomplete femoral nerve blockade; however, absence of significant differences in post-operative opioid requirements between stimulating and non-stimulating catheters in this study and others most likely relates to equivalent post-operative posterior knee pain with either type of femoral catheter. Because all major joints in the lower extremities are innervated by nerve branches from both plexuses, it would be difficult to perform comparative studies between stimulating and non-stimulating catheters in lower extremity surgeries.

Though offering significant promise, it appears that in our clinical setting of TKA, use of the newer stimulating catheters is not advantageous. The increased cost and need for additional catheter adjustments during placement with the stimulating catheter thus appears unnecessary, at least in the context of TKA. Whether stimulating catheters increase block reliability and permit the use of lower amounts of local anesthetics for other types of continuous peripheral nerve blocks or under different clinical settings remains to be determined.

References

1. Lorentzen JS, Petersen MM, Brot C, Madsen OR. Early changes in muscle strength after total knee arthroplasty. A 6-month follow-up of 30 knees. *Acta Orthop Scand* 1999;70:176–9. [PubMed: 10366920]
2. Ryu J, Saito S, Yamamoto K, Sano S. Factors influencing the postoperative range of motion in total knee arthroplasty. *Bull Hosp Jt Dis* 1993;53:35–40. [PubMed: 8012266]
3. Kehlet H. Surgical stress: the role of pain and analgesia. *Br J Anaesth* 1989;63:189–95. [PubMed: 2669908]
4. Raj PP, Knarr DC, Vigdorth E, et al. Comparison of continuous epidural infusion of a local anesthetic and administration of systemic narcotics in the management of pain after total knee replacement surgery. *Anesth Analg* 1987;66:401–6. [PubMed: 3555163]
5. Mahoney OM, Noble PC, Davidson J, Tullos HS. The effect of continuous epidural analgesia on postoperative pain, rehabilitation, and duration of hospitalization in total knee arthroplasty. *Clin Orthop* 1990;30:7.
6. Singelyn FJ, Deyaert M, Joris D, et al. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg* 1998;87:88–92. [PubMed: 9661552]

7. Chelly JE, Greger J, Gebhard R, et al. Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. *J Arthroplasty* 2001;16:436–45. [PubMed: 11402405]
8. Barrington MJ, Olive D, Low K, et al. Continuous femoral nerve blockade or epidural analgesia after total knee replacement: a prospective randomized controlled trial. *Anesth Analg* 2005;101:1824–9. [PubMed: 16301267]
9. Knudsen K, Beckman SM, Blomberg S, et al. Central nervous and cardiovascular effects of i.v. infusions of ropivacaine, bupivacaine and placebo in volunteers. *Br J Anaesth* 1997;78:507–14. [PubMed: 9175963]
10. Kaloul I, Guay J, Cote C, et al. Ropivacaine plasma concentrations are similar during continuous lumbar plexus blockade using the anterior three-in-one and the posterior psoas compartment techniques. *Can J Anaesth* 2004;51:52–6. [PubMed: 14709461]
11. Salinas FV. Location, location, location: Continuous peripheral nerve blocks and stimulating catheters. *Reg Anesth Pain Med* 2003;28:79–82. [PubMed: 12677614]
12. Capdevila X, Biboulet P, Morau D, et al. Continuous three-in-one block for postoperative pain after lower limb orthopedic surgery: where do the catheters go? *Anesth Analg* 2002;94:1001–6. [PubMed: 11916812]
13. Grant SA, Nielsen KC, Greengrass RA, et al. Continuous peripheral nerve block for ambulatory surgery. *Reg Anesth Pain Med* 2001;26:209–14. [PubMed: 11359219]
14. Salinas FV, Neal JM, Sueda LA, et al. Prospective comparison of continuous femoral nerve block with nonstimulating catheter placement versus stimulating catheter-guided perineural placement in volunteers. *Reg Anesth Pain Med* 2004;29:212–20. [PubMed: 15138905]
15. Sung DH. Locating the target nerve and injectate spread in rabbit sciatic nerve block. *Reg Anesth Pain Med* 2004;29:194–200. [PubMed: 15138902]
16. Pham-Dang C, Kick O, Collet T, et al. Continuous peripheral nerve blocks with stimulating catheters. *Reg Anesth Pain Med* 2003;28:83–8. [PubMed: 12677615]
17. Singelyn FJ, Gouverneur JM. Extended “three-in-one” block after total knee arthroplasty: continuous versus patient-controlled techniques. *Anesth Analg* 2000;91:176–80. [PubMed: 10866908]
18. Morin AM, Eberhart LH, Behnke HK, et al. Does femoral nerve catheter placement with stimulating catheters improve effective placement? A randomized, controlled, and observer-blinded trial. *Anesth Analg* 2005;100:1503–10. [PubMed: 15845715]
19. Jack NT, Liem EB, Vonhogen LH. Use of a stimulating catheter for total knee replacement surgery: preliminary results. *Br J Anaesth* 2005;95:250–4. [PubMed: 15923268]
20. Wehling MJ, Koorn R, Leddell C, Boezaart AP. Electrical nerve stimulation using a stimulating catheter: what is the lower limit? *Reg Anesth Pain Med* 2004;29:230–3. [PubMed: 15138908]
21. Morau D, Lopez S, Biboulet P, et al. Comparison of continuous 3-in-1 and fascia Iliaca compartment blocks for postoperative analgesia: feasibility, catheter migration, distribution of sensory block, and analgesic efficacy. *Reg Anesth Pain Med* 2003;28:309–14. [PubMed: 12945024]
22. Eledjam JJ, Cuvillon P, Capdevila X, et al. Postoperative analgesia by femoral nerve block with ropivacaine 0.2% after major knee surgery: continuous versus patient-controlled techniques. *Reg Anesth Pain Med* 2002;27:604–11. [PubMed: 12430113]
23. Serpell MG, Millar FA, Thomson MF. Comparison of lumbar plexus block versus conventional opioid analgesia after total knee replacement. *Anaesthesia* 1991;46:275–7. [PubMed: 2024744]
24. Greengrass RA, Klein SM, D’Ercole FJ, et al. Lumbar plexus and sciatic nerve block for knee arthroplasty: comparison of ropivacaine and bupivacaine. *Can J Anaesth* 1998;45:1094–6. [PubMed: 10021959]
25. Mansour NY, Bennetts FE. An observational study of combined continuous lumbar plexus and single-shot sciatic nerve blocks for post-knee surgery analgesia. *Reg Anesth* 1996;21:287–91. [PubMed: 8837184]
26. Allen HW, Liu SS, Ware PD, et al. Peripheral nerve blocks improve analgesia after total knee replacement surgery. *Anesth Analg* 1998;87:93–7. [PubMed: 9661553]
27. Ben-David B, Schmalenberger K, Chelly JE. Analgesia after total knee arthroplasty: is continuous sciatic blockade needed in addition to continuous femoral blockade. *Anesth Analg* 2004;98:747–9. [PubMed: 14980931]

28. Morin AM, Kratz CD, Eberhart LH, et al. Postoperative analgesia and functional recovery after total-knee replacement: comparison of a continuous posterior lumbar plexus (psoas compartment) block, a continuous femoral nerve block, and the combination of a continuous femoral and sciatic nerve block. *Reg Anesth Pain Med* 2005;30:434–45. [PubMed: 16135347]

Figure 1.

Average fentanyl consumption through the IVPCA in patients with stimulating femoral nerve catheters and those with non-stimulating catheters. Horizontal lines within the rectangles refer to the median values and the upper and lower borders of the rectangles represent the 25th and 75th percentile respectively. The vertical bars stretch to the upper and lower limits of the recorded values. No significant differences between the two groups were noted.

Figure 2.

Numeric pain rating scale scores (NRS) as a function of time. Horizontal lines within the rectangles refer to the median values and the upper and lower borders of the rectangles represent the 25th and 75th percentile respectively. The vertical bars stretch to the upper and lower limits of the recorded values.

Table 1

Relationship of catheter type to selected variables. Except for the number of attempts at catheter placement, there were no significant differences in patient demographics or amounts of ropivacaine or fentanyl used. Results are presented as medians (interquartile ranges) and estimated 95% confidence intervals for the difference in medians between the stimulating catheter group and the non-stimulating catheter group.

Factor	Stimulating Catheter		Non-Stimulating Catheter		Difference in median and 95% Confidence Interval	P*
	N	Statistics	N	Statistics		
Age	19	70 (63, 74)	22	72 (64, 76)	-2 (-8, 4)	0.59
mA Needle	19	0.5 (0.4, 0.5)	22	0.5 (0.4, 0.5)	0 (-0.5, 0.08)	0.88
# attempts Needle	19	1.0 (1.0, 2.0)	22	1.0 (1.0, 2.0)	0 (-1, 0)	0.68
# attempts Cath.	19	1.0 (1.0, 2.0)	22	1.0 (1.0, 1.0)	0 (0, 1)	0.016
Ropivacaine cc/hr	19	8.2 (6.7, 10.4)	22	8.8 (7.2, 10.8)	-0.6 (-2.3, 0.6)	0.26
Fentanyl/hr at 12hrs	19	87.5 (71.7, 109.8)	22	94.2 (59.6, 112.5)	-6.7 (-20.8, 21.8)	0.85
Fentanyl/hr at 24hrs	18	67.9 (63.0, 81.0)	21	65.8 (56.0, 90.8)	2.1 (-15.6, 21)	0.71
Fentanyl/hr at 48hrs	12	55.5 (37.5, 66.0)	13	55.0 (33.0, 70.0)	0.5 (-17, 30)	0.75
Total Fentanyl (mcg)	18	2136 (1790, 3035)	22	2507 (1595, 3350)	-371 (-934, 683)	0.89
Total Fentanyl mcg/hr	18	47.5 (37.0, 76.0)	22	59.0 (41.0, 91.0)	-11.5 (-32, 11)	0.44

* Wilcoxon rank sum test

Table 2

Frequency of adjustment of local anesthetic (LA) infusion rate. No significant differences were present in the number of adjustments to the local anesthetic infusion rate needed to achieve satisfactory analgesia between patients in the stimulating femoral catheter group and the non-stimulating femoral catheter group.

	Total	Stimulating Catheter		Non-Stimulating Catheter		P value
		N	(%)	N	(%)	
LA infusion rate adjustments						0.99**
0 (rate=6cc/hr)	8	4	20.0	4	18.2	
1 (rate=9cc/hr)	14	7	35.0	7	31.8	
2 (rate=12cc/hr)	20	9	45.0	11	50.0	

**
Fisher exact test

Table 3

Frequency of achieving adequate analgesia with stimulating and non-stimulating catheters. No significant differences were found between both groups in the fraction of patients achieving adequate analgesia, defined as having numeric pain rating scores (NRS) of less than 5 between 8 hours and 24 hours post-operatively.

	Total	Stimulating Catheter		Non-Stimulating Catheter		P *
		N	(%)	N	(%)	
Achieved NRS <5	33	17	85.0	16	72.7	0.46
Did not achieve NRS <5	9	3	15.0	6	27.3	

* Fisher exact test

Table 4

Functional parameters recorded on post-operative day # 2 following TKA in patients receiving stimulating femoral nerve catheters and those receiving non-stimulating catheters.

Effect	Stimulating catheter		Non-stimulating catheter		Median Difference and 95% Confidence Interval	P* value
	N	Median (25th, 75th)	N	Median (25th, 75th)		
Max Knee flexion	13	58.0 (54.0, 69.0)	20	60.0 (42.5, 70.5)	-2 (-8, 18)	0.63
# feet walked	15	20.0 (14.0, 25.0)	18	15.5 (10.0, 30.0)	4.5 (-6, 10)	0.45

* Wilcoxon rank sum test

Table 5

Relationship of catheter type to Complications. No significant differences were noted between patients receiving stimulating femoral nerve catheters and those receiving nonstimulating catheters.

Factor		Stimulating Catheters		Non-Stimulating Catheters		(%)	Odds Ratio and 95% Confidence Interval	P ^a
		Total	N	(%)	N			
Nausea	No	21	9	47.4	12	54.6	1.3 (0.4, 4.6)	0.65 ^b
	Yes	20	10	52.6	10	45.5		
Urinary retention	No	40	19	100	21	100	NA	NA
	Yes	5	1	5.3	4	19.1		
Pruritus	No	35	18	94.7	17	81.0	0.2 (0.02, 2.3)	0.35
	Yes	5	1	5.3	4	19.1		
DVT	No	40	19	100	21	95.5	NA	0.99
	Yes	1	0	0.0	1	4.6		

^aFisher Exact test P-value unless noted

^bPearson's Chi-Square Test

Table 6

Relationship of catheter type to oral medications use. There were no statistically significant differences in the amounts of oral oxycodone or medication to treat nausea or pruritus.

Factor	Stimulating Catheter		Non-Stimulating Catheter		Median difference and 95% CI	P value *
	N	Statistics	N	Statistics		
Total oxycodone 24hr (tablets)	19	0.0 (0.0, 0.0)	22	0.0 (0.0, 0.0)	0 (0, 0)	0.48
Total oxycodone 48hr (tablets)	19	2.0 (0.0, 6.0)	21	2.0 (0.0, 4.0)	0 (-2, 1)	0.85
Total oxycodone 72hr (tablets)	18	2.0 (1.0, 6.0)	20	2.0 (0.0, 4.0)	0 (-2, 2)	0.57
Total dolasetron	19	0.0 (0.0, 12.5)	21	0.0 (0.0, 12.5)	0 (0, 10)	0.99
Total diphenhydramine	19	0.0 (0.0, 0.0)	22	0.0 (0.0, 0.0)	0 (0, 0)	0.16

* Wilcoxon rank sum test