Is Sciatic Nerve Block Advantageous When Combined With Femoral Nerve Block for Postoperative Analgesia Following Total Knee Arthroplasty?

A Systematic Review

Faraj W. Abdallah, MD and Richard Brull, MD, FRCPC

Abstract: Sciatic nerve block (SNB) is commonly performed in combination with femoral nerve block (FNB) for postoperative analgesia following total knee arthroplasty (TKA). This systematic review examines the effects of adding SNB to FNB for TKA compared with FNB alone on acute pain and related outcomes. Four intermediate-quality randomized and 3 observational trials, including a total of 391 patients, were identified. Three of 4 trials investigating the addition of single-shot SNB and 2 of 3 trials investigating continuous SNB reported improved early analgesia at rest and reduced early opioid consumption. Only 2 trials specifically assessed posterior knee pain. We were unable to uncover any clinically important analgesic advantages for SNB beyond 24 hours postoperatively. At present, there is inconclusive evidence in the literature to define the effect of adding SNB to FNB on acute pain and related outcomes compared with FNB alone for TKA.

(*Reg Anesth Pain Med* 2011;36: 493–498)

Total knee arthroplasty (TKA) is associated with moderate to severe postoperative pain.[1] Even in the setting of a well-functioning femoral nerve block (FNB), 60% to 80% of patients will complain of clinically significant knee pain.[2,3] Sciatic nerve block (SNB) has been purported to provide an analgesic benefit when added to FNB in patients undergoing TKA.[3–5] Indeed, adding SNB to FNB is standard practice for postoperative analgesia following TKA in many centers,[6–9] including our own. Whereas TKA is one of the most frequently performed orthopedic procedures in the United States,[10] SNB, in its various approaches, remains among the least performed peripheral nerve block by anesthesiologists.[11–13]

The decision to perform an SNB in the setting of TKA[14–18] is not without risk and should be based in evidence. At least 1 reason for the relative unpopularity of SNB may be the ambiguity of the available evidence and inconsistent recommendations regarding the addition of SNB to FNB for postoperative analgesia following TKA.[19–21] Indeed, two recently published meta-analyses[20,22] and one systematic review[19] concluded that SNB does not provide any analgesic advantage when added to FNB, but these conclusions were drawn exclusively from one small randomized trial.[2] The goal of this systematic literature review was to evaluate the effect of adding SNB to FNB for postoperative analgesia following TKA.

From the Department of Anesthesia and Pain Management, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ontario, Canada.

Accepted for publication May 27, 2011.

Address correspondence to: Richard Brull, MD, FRCPC, Department of Anesthesia, Toronto Western Hospital, 399 Bathurst St, Toronto, Ontario, Canada M5T 2S8 (e-mail: richard.brull@uhn.on.ca).

This work was supported by departmental funding.

None of the authors report any conflict of interest.

ISSN: 1098-7339

DOI: 10.1097/AAP.0b013e318228d5d4

METHODS

The authors searched the electronic databases MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Clinical Trials (from January 1970 to January 2011) using the following population search terms: "total knee replacement" OR "total knee arthroplasty" OR "knee operation" OR "total-knee replacement." These search results were combined with "sciatic nerve block" and "femoral nerve block" using the Boolean operator AND. Only studies in English language involving human adults were considered. Results were further limited by combining with "analgesia" OR "acute pain relief" OR "acute pain management" using the Boolean operator AND.

Each abstract was examined to identify comparative trials investigating the combination of SNB and FNB versus FNB alone for analgesia following TKA; both single-shot and continuous nerve blocks were included for the purposes of the present review. Studies comparing FNB to SNB,[23] studies comparing the combination of FNB and SNB to SNB alone,[24] and non-comparative studies[25] were excluded. Authors also excluded studies if surgery other than TKA was performed. The references of the retrieved articles were manually searched for any relevant articles not identified in the original search.

An independently created template was used to extract and compare data. Extracted trial characteristics included study design, primary outcome measure, type of surgical anesthesia, and the use of multimodal analgesia (defined to include paracetamol, nonsteroidal anti-inflammatory drugs, or cyclooxygenase 2 inhibitors, plus strong intravenous opioids).[19]

Specific outcomes sought in each article were based on the American Society of Regional Anesthesia and Pain Medicine's Acute Postoperative Pain Database initiative.[26] Acute pain outcomes sought were (1) pain severity and location (ie, back of knee), (2) sensory block duration, (3) opioid consumption, and (4) time to first analgesic request. Both pain severity and opioid consumption were further divided into early (<24 hrs) versus late (>24 hrs); pain severity was also categorized as rest versus dynamic. If not otherwise stated, it was assumed that pain severity was assessed at rest.

Additional related outcomes were broadly classified as follows:

(1) Patient-related outcomes: (*a*) opioid-related adverse effects (nausea, emesis, pruritus, sedation, urinary retention, and respiratory depression), (*b*) patient satisfaction with pain control, (*c*) incidence of cognitive deficit, and (*d*) quality of recovery.

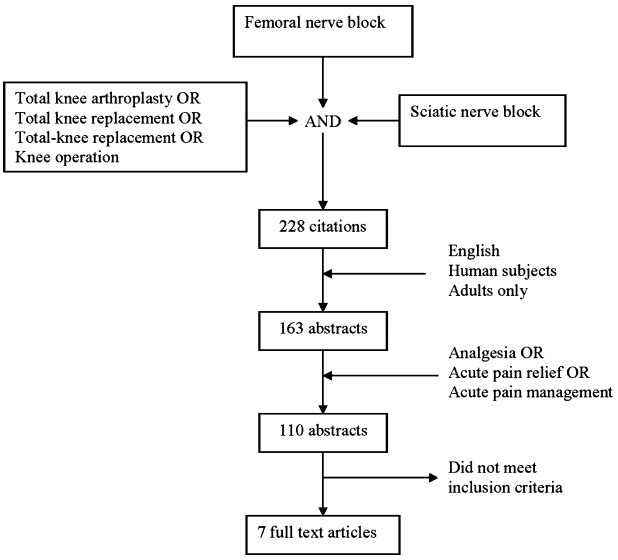

FIGURE 1. Flowchart of screened, excluded, and analyzed studies.

(2) Anesthesia-related outcomes: (*a*) incidence of undesirable motor block, (*b*) morbidity (nerve damage, vascular puncture, local anesthetic toxicity, infection at block site, hematoma), and (*c*) development of chronic pain.
(3) Surgery-related outcomes: (*a*) unplanned hospital readmission and (*b*) rehabilitation indices (range of motion or ability to ambulate defined as ambulating sufficient distance as determined by surgical team).
(4) Hospital-related outcomes: (*a*) length of hospital stay and (*b*) hospital costs.

The methodological quality of each randomized trial was assessed using the Jadad score[27] and/or the Oxford 2011 levels of evidence.[28] The two authors independently extracted the data and reviewed and scored each trial using this methodology. Differences in extracted data or scoring were resolved through discussion.

RESULTS

We identified 7 trials, including a total of 391 patients, which compared SNB combined with FNB to FNB alone for

TABLE 1. Summary of Trial Outcomes

Author/Year	Type	Jadad/ Oxford	N	Groups	Surgical Anesth	MM Analg	Primary Outcome	Pain	Postop Knee Pain	Sensory Block Duration
SSNB										
Allen et al[2] (1998)	R	3 1b	36	(1) SFNB + sham sciatic (n = 12) (2) SFNB + SSNB (n = 12) (3) Sham femoral + sham sciatic (n = 12)	Spinal	•	Opioid consum	•		
Weber et al[4] (2002)	O	N/A 2b	40	(1) CFNB (n = 12) (2) CFNB + SSNB (n = 24)	Spinal or cont-spinal		VAS score	•	•	
Cook et al[3] (2003)	O	N/A 2b	97	(1) SFNB (n = 30) (2) SFNB + SSNB (n = 67)	GA or spinal		VAS score, opioid consum	•		
Hunt et al[29] (2009)	R	1 2b	88	(1) Sham femoral (n = 24) (2) SFNB (n = 33) (3) SFNB + SSNB (n = 31)	GA		Opioid consum	•		
CSNB										
Ben-David et al[5] (2004)	O	N/A 2b	12	(1) CFNB (n = 2) (2) CFNB + CSNB (n = 10)	GA or spinal	•	VAS score	•	•	
Pham Dang et al[31] (2005)	R	2 2b	28	(1) CFNB (n = 14) (2) CFNB + CSNB (n = 14)	GA		VAS score	•		
Morin et al[30] (2005)	R	3 1b	90	(1) CFNB (n = 30) (2) CFNB + CSNB (n = 30) (3) CPCB (n = 29)	GA	•	Opioid consum	•		

Analg indicates analgesia; anesth, anesthesia; cog dysf, cognitive dysfunction; consum, consumption; cont, continuous; CPCB, continuous psoas compartment block; GA, general anesthesia; Jadad, Jadad score; MM, multimodal; morbid, morbidity; N/A, not applicable; O, observational; Oxford, Oxford level of evidence score; Post, posterior; R, randomized; readm, readmission; rehab, rehabilitation; satisf, satisfaction; VAS, visual analog score.

postoperative analgesia following TKA (Fig. 1). Of these, 4 trials were randomized[2,29–31] (R), and 3 were observational[3–5] (O). All 4 randomized trials achieved a Jadad score of 3 or less.[2,29–31] Four trials (R[2,29] and O[3,4]) investigated the addition of single-shot SNB (SSNB) to FNB, whereas 3 (R[30,31] and O[5]) investigated the addition of continuous SNB (CSNB) to FNB. Table 1 summarizes the specific outcomes sought for this review.

Acute Pain Outcomes

Four trials (R[2,29] and O[3,4]) evaluated early (first 24 hrs) postoperative pain at rest. Three trials (R[29] and O[3,4]) reported reduced early pain scores at rest when SSNB was added to FNB, and one randomized trial[2] reported no difference (Table 2). Two randomized trials[2,29] compared late (>24 hrs) pain scores at rest and found no difference when SSNB was added. The effect of adding SSNB to FNB on early and late dynamic pain was studied by only one randomized trial,[2] which reported no difference.

Of the 3 trials (R[30,31] and O[5]) that examined the addition of CSNB to FNB, 2 (R[31] and O[5]) reported reduced early pain scores at rest, whereas one randomized trial[30] reported no difference. The 2 randomized trials[30,31] found that CSNB did not influence pain scores at rest beyond 24 hours or early or late dynamic pain scores.

Only 2 observational trials[4,5] specifically reported posterior knee pain, one using SSNB[4] and the other using CSNB.[5] Both demonstrated an improvement in early posterior knee pain when SNB was added.

Among the 4 trials (R[2,29] and O[3,4]) that examined early opioid consumption, 3 (R[29] and O[3,4]) reported a reduction with the addition of SSNB, whereas 1 randomized trial[2] found no difference. Two trials (R[2] and O[3]) continued to study opioid consumption beyond the first 24 hours and found no difference when SSNB was added. The effect of adding CSNB to FNB on opioid consumption was examined by 2 randomized trials[30,31]; both reported a reduction in early opioid requirements by as much as 86% when CSNB was initiated,[31] but with no differences after 24 hrs. None of the trials assessed patients for sensory block duration or time to first analgesic request.

Patient-Related Outcomes

Only one randomized trial[2] evaluated the impact of adding SSNB on opioid-related adverse effects and found no difference in the incidence of nausea and vomiting, pruritus, and sedation. One randomized trial[2] using SSNB measured patient satisfaction with pain control and found no difference. None of the trials reviewed evaluated patients for postoperative cognitive deficit. The quality of recovery following CSNB was captured in a single randomized trial,[30] which did not report any difference.

First Analg Request	Opioid Consum	Opioid Adverse Effects	Cog Dysf	Patient Satisfaction	Quality Recovery	Morbid	Chronic Pain	Block Perform Time	Undesired Motor Block	Readm	Rehabilitation Indices	Length Hospital Stay	Hospital Cost
	•	•		•									
	•												
	•					•						•	
	•					•		•					
	•					•			•				
	•	•				•		•			•		
	•				•		•	•	•		•		

TABLE 2. Summary of Trial Results

Author/Year	Groups	Pain Severity (Rest)		Pain Severity (Dynamic)		Posterior Knee Pain	Opioid Consumption	
		Early	Late	Early	Late		Early	Late
SSNB								
Allen et al[2] (1998)	(1) SFNB + sham sciatic (n = 12) (2) SFNB + SSNB (n = 12) (3) Sham femoral + sham sciatic (n = 12)	←→	←→	←→	←→		←→	←→
Weber et al[4] (2002)	(1) CFNB (n = 12) (2) CFNB + SSNB (n = 24)	+				+	+	
Cook et al[3] (2003)	(1) SFNB (n = 30) (2) SFNB + SSNB (n = 67)	+					+	←→
Hunt et al[29] (2009)	(1) Sham femoral (n = 24) (2) SFNB (n = 33) (3) SFNB + SSNB (n = 31)	+	←→				+	
CSNB								
Ben-David et al[5] (2004)	(1) CFNB (n = 2) (2) CFNB + CSNB (n = 10)	+				+		
Pham Dang et al[31] (2005)	(1) CFNB (n = 14) (2) CFNB + CSNB (n = 14)	+	←→		←→		+	←→
Morin et al[30] (2005)	(1) CFNB (n = 30) (2) CFNB + CSNB (n = 30) (3) CPCB (n = 29)	←→	←→	←→	←→		+	←→

Arrows ←→ indicates no difference; +, favors SNB; −, favors comparator; CFNB, continuous FNB; CPCB, continuous psoas compartment block; IV PCA, intravenous patient-controlled analgesia; satisf, satisfaction; SFNB, single-shot FNB; VAS, visual analog score.

Anesthesia-Related Outcomes

Two trials (R[30] and O[5]) using CSNB reported undesirable sciatic motor block in patients receiving CSNB that prompted temporary discontinuation of infusion to permit assessment for potential neurologic injury.

Four trials (R[29,31] and O[3,5]) assessed patients for block-related complications. None reported that addition of SSNB or CSNB resulted in any block-related complications. One randomized trial[30] using CSNB examined the effect of adding sciatic block on the development of chronic pain and found no difference.

Surgery-Related Outcomes

Two randomized trials[30,31] included comparison of postoperative rehabilitation indices; both found no differences between study groups when CSNB was added. None of the trials evaluated differences in unplanned readmission to hospital.

Hospital-Related Outcomes

The effect of adding SSNB on length of stay in hospital was assessed by 1 observational trial[3] that found no difference. Differences in hospital costs were not assessed by any of the trials.

DISCUSSION

Our review of the literature found insufficient evidence to qualitatively define the effect of adding SNB to FNB for analgesia following TKA. Although the majority of the studies reviewed herein signal superior early pain control[3–5,29] and less early opioid consumption[3,4,29–31] in favor of SNB, we were unable to uncover any analgesic benefit in favor of SNB beyond 24 hrs, even in the setting of a continuous catheter-based local anesthetic infusion. One plausible explanation for this trend may be that, beyond the very immediate postoperative period, the sciatic nerve is not an important contributor to postoperative pain

Opioid Adverse Effects	Patient Satisf	Chronic Pain	Undesirable Motor Block	Rehab Indices	Length Hospital Stay	Remarks
←→	←→					
					←→	• SSNB reduces rest posterior knee pain (VAS): FNB 73.3, SSNB 2.2 ($P < 0.05$) when block is added • SSNB reduces rest pain (VAS) at 12 hrs: FNB 18.9, SSNB 5 ($P = 0.043$) • SSNB reduces frequency of analgesic supplementation: FNB 42%, SSNB 25% • SSNB reduces rest pain (VAS) at 2 hrs: FNB 52, SSNB 39 ($P = 0.014$) • SSNB reduces rest pain (VAS) at 24 hrs: FNB 54, SSNB 44 ($P = 0.023$) • SSNB reduces IV PCA morphine consumption (mg) in the first 24 hrs: FNB 43.4, SSNB 27.8 ($P = 0.002$) • SSNB reduces rest pain on day of surgery ($P < 0.05$) • SSNB reduces IV PCA morphine consumption on day of surgery and first postoperative day ($P < 0.05$)
			–			• CSNB reduces rest posterior knee pain (VAS): FNB 73, CSNB 24 ($P < 0.05$) when block is added • CSNB causes undesirable motor block in 20%
+				←→		• CSNB reduces rest pain at all measured time intervals up to 36 hrs ($P < 0.05$) • CSBN reduces IV PCA morphine consumption (mg) at 2 hrs: FNB 7, CSNB 1 ($P = 0.001$) • CSNB reduces incidence of nausea: FNB 64.3%, CSNB 21.4% ($P = 0.014$) • CSNB reduces incidence of vomiting: FNB 50%, CSNB 14.3% ($P = 0.042$)
		←→	–	←→		• CSNB reduces 24 hrs IV PCA morphine consumption (mg): FNB 24, CSNB 6.7 ($P < 0.0001$) • CSNB causes undesirable motor block in 3.3%

following TKA. Another consideration is that the quality of the evidence reviewed is modest at best. Among the 4 randomized trials identified, 2 lack statistical power to detect clinically significant differences in pain scores[2] or opioid consumption,[31] 3 each lack double-blinding and control groups,[29–31] and 1 lacks appropriate randomization.[29] Moreover, the present review highlights existing deficiencies in the regional anesthesia literature as many clinically relevant acute pain and related outcomes outlined by the American Society of Regional Anesthesia and Pain Medicine's Acute Postoperative Pain Database initiative[26] were not assessed. Importantly, our results are presented in "vote counting" format primarily to facilitate descriptive presentation of the literature rather than offer any quantitative data analysis. The heterogeneity between each of the 4 randomized trials also prohibits statistical meta-analysis. For example, there is gross variability regarding SNB technique (single-shot or continuous), location, and needle approach, as well as the type, concentration, volume, and frequency of local anesthetic administered. In fact, for all 7 studies reviewed herein, many important SNB procedure-related outcomes are missing, such as objective confirmation of SNB onset[3–5,29] or success,[2,3,5,29,31] as well as designated end points for needle advancement[3,4,29,31] or catheter advancement.[31] Finally, none of the studies employed US for sciatic nerve localization.[32]

Future Directions

Designing a randomized study to faithfully measure the relative analgesic benefit of adding SNB to FNB for postoperative analgesia following TKA is challenging. The pain that follows TKA stems from multiple generating nerve distributions (femoral, sciatic, obturator), which may be challenging to isolate with sufficient reliability. Despite their observational nature,[4,5] two studies included herein sought to indirectly measure posterior knee pain by exclusion, a thoughtful design feature that may be borrowed for more rigorous future randomized trials. Reliable measurements of posterior knee pain

can be further compromised by a well-functioning FNB that may artificially accentuate the degree of pain in the distribution of the sciatic nerve. The type of FNB, whether single-shot or continuous, that is most effectively paired with SNB[20] is another key subject of future investigation. Upcoming trials must also account for multimodal and patient-controlled analgesia regimens, which may diminish or mask the relative severity of sciatic nerve pain. It is noteworthy that only 3 trials (R[2,30] and O[5]) reviewed herein incorporated, in whole or in part, a multimodal analgesia regimen,[19] and none included adjunctive intrathecal morphine.

In summary, there is inadequate evidence at this time to define the effect of adding SNB to FNB for postoperative analgesia following TKA. As a matter of course, the absence of evidence does not equate to evidence of absence, and as such, we must endeavor to rigorously investigate the analgesic benefits SNB for TKA in the setting of modern multimodal analgesia and accelerated clinical pathways to guide our best practice.

REFERENCES

1. Bonica J. Postoperative pain. In: Bonica J. *The Management of Pain*. 2nd ed. Malvern, PA: Lea & Febiger; 1990:461–480.
2. Allen HW, Liu SS, Ware PD, Nairn CS, Owens BD. Peripheral nerve blocks improve analgesia after total knee replacement surgery. *Anesth Analg*. 1998;87:93–97.
3. Cook P, Stevens J, Gaudron C. Comparing the effects of femoral nerve block versus femoral and sciatic nerve block on pain and opiate consumption after total knee arthroplasty. *J Arthroplasty.* 2003;18:583–586.
4. Weber A, Fournier R, Van Gessel E, Gamulin Z. Sciatic nerve block and the improvement of femoral nerve block analgesia after total knee replacement. *Eur J Anaesthesiol*. 2002;19:834–836.
5. 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;98:747–749.
6. Hebl J, Dilger J, Byer D, et al. A pre-emptive multimodal pathway featuring peripheral nerve block improves perioperative outcomes after major orthopedic surgery. *Reg Anesth Pain Med*. 2008;33:510–517.
7. Hebl J, Kopp S, Ali M, et al. A comprehensive anesthesia protocol that emphasizes peripheral nerve blockade for total knee and total hip arthroplasty. *J Bone Joint Surg Am*. 2005;87(suppl 2):63–70.
8. Horlocker T, Kopp S, Pagnano M, Hebl J. Analgesia for total hip and knee arthroplasty: a multimodal pathway featuring peripheral nerve block. *J Am Acad Orthop Surg*. 2006;14:126–135.
9. Williams BA, Kentor ML, Vogt MT, et al. Femoral-sciatic nerve blocks for complex outpatient knee surgery are associated with less postoperative pain before same-day discharge: a review of 1,200 consecutive cases from the period 1996-1999. *Anesthesiology.* 2003;98:1206–1213.
10. Mahomed N, Barrett J, Katz J, Baron J, Wright J, Losina E. Epidemiology of total knee replacement in the United States Medicare population. *J Bone Joint Surg Am*. 2005;87:1222–1228.
11. Bouaziz H, Mercier FJ, Narchi P, Poupard M, Auroy Y, Benhamou D. Survey of regional anesthetic practice among French residents at time of certification. *Reg Anesth*. 1997;22:218–222.
12. Hadzić A, Vloka JD, Kuroda MM, Koorn R, Birnbach DJ. The practice of peripheral nerve blocks in the United States: a national survey [p2e comments]. *Reg Anesth Pain Med*. 1998;23:241–246.
13. Smith MP, Sprung J, Zura A, Mascha E, Tetzlaff JE. A survey of exposure to regional anesthesia techniques in American anesthesia residency training programs. *Reg Anesth Pain Med*. 1999;24:11–16.
14. Asp JP, Rand JA. Peroneal nerve palsy after total knee arthroplasty. *Clin Orthop*. 1990;233–237.
15. Bromage PR. Masked mischief. *Reg Anesth*. 1993;18:143–144.
16. Rose HA, Hood RW, Otis JC, Ranawat CS, Insall JN. Peroneal-nerve palsy following total knee arthroplasty. A review of the Hospital for Special Surgery experience. *J Bone Joint Surg Am*. 1982;64:347–351.
17. Schinsky MF, Macaulay W, Parks ML, Kiernan H, Nercessian OA. Nerve injury after primary total knee arthroplasty. *J Arthroplasty.* 2001;16:1048–1054.
18. Todkar M. Sciatic nerve block causing heel ulcer after total knee replacement in 36 patients. *Acta Orthop Belg*. 2005;71:724–725.
19. Fischer HBJ, Simanski CJP, Sharp C, et al. A procedure-specific systematic review and consensus recommendations for postoperative analgesia following total knee arthroplasty. *Anaesthesia*. 2008;63:1105–1123.
20. Paul J, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Anesthesiology.* 2010;113:1144–1162.
21. Ben-David B, Salinas FV. Pro/con: is continuous sciatic nerve block routinely needed in addition to a continuous femoral nerve block following total knee arthroplasty? *ASRA News*. 2007;3:6–9.
22. Fowler SJ, Symons J, Sabato S, Myles PS. Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. *Br J Anaesth*. 2008;100:154–164.
23. Zugliani A, Verosa N, Amaral JLGd, Barrucand L, Salgado C, Karam MBH. Control of postoperative pain following total knee arthroplasty: is it necessary to associate sciatic nerve block to femoral nerve block? [in Portuguese]. *Rev Bras Anestesiol*. 2007;57:514–524.
24. Rajeev S, Batra Y, Panda N, Kumar M, Nagi O. Combined continuous "3-in-1" and sciatic nerve blocks provide improved postoperative analgesia with no correlation to catheter tip location after unilateral total knee arthroplasty. *J Arthroplasty.* 2007;22:1181–1186.
25. Naux E, Pham-Dang C, Petitfaux F, et al. Sciatic nerve block: an new lateral mediofemoral approach. The value of its combination with a "3 in 1" block for invasive surgery of the knee [in French]. *Ann Fr Anesth Reanim*. 2000;19:9–15.
26. Liu SS, Warren DT, Wu CL, et al. A lovely idea: forming an ASRA Acute Postoperative Pain (AcutePOP) Database. *Reg Anesth Pain Med*. 2006;31:291–293.
27. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*. 1996;17:1–12.
28. OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence. Oxford, UK: Oxford Centre for Evidence-Based Medicine. Available at: http://www.cebm.net/index.aspx?o=1025. Accessed May 21, 2011.
29. Hunt K, Bourne M, Mariani EM. Single-injection femoral and sciatic nerve blocks for pain control after total knee arthroplasty. *J Arthroplasty.* 2009;24:533–538.
30. Morin A, Kratz C, Eberhart LHJ, 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;30:434–445.
31. Pham Dang C, Gautheron E, Guilley J, et al. The value of adding sciatic block to continuous femoral block for analgesia after total knee replacement. *Reg Anesth Pain Med*. 2005;30:128–133.
32. Abrahams MS, Aziz MF, Fu RF, Horn J. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: a systematic review and meta-analysis of randomized controlled trials. *Br J Anaesth*. 2009;102:408–417.

The Sciatic Nerve and Knee Arthroplasty

To Block, or Not to Block—That Is the Question

Brian M. Ilfeld, MD, MS and Sarah J. Madison, MD

Tricompartment (total) knee arthroplasty (TKA) consistently results in severe postoperative pain. Although providing a femoral nerve block dramatically improves analgesia,[1] 80% to 90% of patients still experience pain requiring treatment with intravenous opioids in the immediate postoperative period.[2,3] This pain is usually attributed to the sciatic and obturator nerves that contribute innervation to the knee joint, albeit less extensively than the femoral nerve. Although a lumbar epidural infusion will affect all 3 nerves, multiple investigations suggest that a continuous femoral nerve block offers similar analgesia with a more favorable adverse effect profile[4–7] and is thus often cited as the "gold standard" following TKA.[8] However, little consensus has emerged regarding the routine addition of a single-injection or continuous sciatic nerve block.[1,9] This question is of great interest to health care providers considering the frequency that TKA is performed: more than 500,000 cases annually in the United States alone, with this number growing to 3.5 million in fewer than 20 years.[10]

BENEFITS

Two previously published randomized controlled trials provide evidence that the addition of a continuous sciatic to a continuous femoral nerve block reduces pain,[11] supplemental opioid requirements,[11,12] and opioid-related adverse effects.[11] However, neither of these studies included a treatment group receiving a single-injection sciatic nerve block. The study by Wegener and colleagues[13] in this month's issue of *Regional Anesthesia and Pain Medicine* provides additional important, clinically relevant information on this topic. In brief, patients undergoing TKA all received a continuous femoral nerve block and were then randomized into 3 treatment groups: no sciatic nerve block/catheter, a single-injection sciatic nerve block, or a continuous sciatic nerve block. All single-injection blocks were performed with 0.375% levobupivacaine, and all infusions included levobupivacaine 0.125%. Although time until discharge readiness—the primary end point—did not differ among groups, pain scores and supplemental opioid use were dramatically higher the day of surgery in the group without any form of sciatic nerve block. Furthermore, during the day after surgery, both resting and dynamic pain scores remained lower exclusively in subjects with a continuous sciatic nerve block.

However, before routinely providing dual femoral/sciatic continuous nerve blocks for all TKA patients, there are multiple caveats to consider. Intraoperative and postoperative supplemental analgesic delivery regimen certainly influences analgesic quality, and these vary dramatically among centers. Wegener and colleagues[13] acknowledge that the extraordinarily high median recovery room pain score of 7 of 10 found in their subjects without a sciatic nerve block is likely due to the fact that "patients received only short- and ultrashort-acting opioids before and during the surgery." In addition, both this study and a previous investigation reporting similar inferior recovery room analgesia without a sciatic nerve block provided intravenous morphine exclusively for a pain score greater than 4 (scale: 0–10; 0 = no pain).[11] In contrast, more aggressive titration of longer-acting intravenous analgesics provides far-improved analgesia to patients lacking a sciatic nerve block (with the disadvantage of possible increased opioid-related adverse effects),[14] although what constitutes an "acceptable" level of pain remains in dispute.[15–17]

Similarly, the 2 studies demonstrating lower pain scores in patients with a continuous sciatic nerve block both treated breakthrough pain on the ward/floor with subcutaneous,[11] oral,[13] and/or nurse-administered intravenous analgesics.[13] For subjects of these studies, treating pain required

From the Department of Anesthesiology, University of California San Diego, San Diego, CA.
Accepted for publication June 12, 2011.
Address correspondence to: Brian M. Ilfeld, MD, MS, Department of Anesthesiology, 200 W Arbor Dr, MC 8770, San Diego, CA 92103 (e-mail: bilfeld@ucsd.edu).
Funding for this project provided by the University of California San Diego (San Diego, California), Department of Anesthesiology.
There authors report no conflicts of interest.
The contents of this editorial are solely the responsibility of the authors and do not necessarily represent the official views of this entity.

ISSN: 1098-7339
DOI: 10.1097/AAP.0b013e31822940d2

contacting the nurse (presumably frequently unavailable caring for multiple other patients), waiting for analgesic delivery, and then enduring continuing discomfort until analgesic onset. This routine had to be repeated until adequate analgesia was attained. In contrast, using a patient-controlled pump to provide intravenous opioids allows timely titration of analgesics to an acceptably low level of pain. Not surprisingly, the one study that used this latter analgesic delivery method found no differences in pain scores for subjects provided both continuous femoral and sciatic blocks and those receiving solely femoral perineural infusion.[12] Of note, unlike continuous femoral nerve blocks, there is currently no evidence that the addition of a sciatic perineural infusion accelerates resumption of passive knee flexion, decreases time until discharge readiness, or shortens rehabilitation duration.[18] Therefore, when using an efficient supplemental analgesic regimen considered standard of care (at least in the United States), the only consistently demonstrated benefit of adding a continuous sciatic nerve block to a femoral perineural infusion following TKA is decreased supplemental opioid consumption (and probably the incidence of opioid-related adverse effects, although the data are somewhat conflicting).[11,13]

DRAWBACKS

Every medical procedure has inherent risks, and invasive procedures are therefore usually applied only when the potential benefits outweigh the potential risks. Single-injection and continuous sciatic nerve blocks have similar complication rates as their counterparts in other anatomic locations, with permanent injury an exceptionally rare occurrence.[18,19] However, there are additional factors specific to anesthetizing the sciatic nerve for TKA that must be considered. First, because the TKA-related incidence of sciatic nerve palsy is as high as 2.4% (without a peripheral nerve block),[20] many surgeons require an unanesthetized sciatic nerve following general anesthetic emergence or spinal resolution to identify an intraoperative injury.[15] In these cases, a sciatic nerve block may be provided following recovery room evaluation, although postoperative block placement may be more challenging for both the patient (postoperative pain and positioning) and provider (availability; postblock narcotized patient). For practices in which the incidence of "unacceptable" sciatic-derived pain is very low, this may be the optimal approach.[15] Conversely, this arrangement may be suboptimal in practices with a large percentage of patients experiencing "unacceptable" pain (eg, prioritizing opioid-avoidance; opioid-tolerant patient population).[17]

In addition, post-TKA physical therapy expectations are of concern. The combination of single-injection femoral and sciatic nerve blocks renders patients unable to actively participate in most rehabilitation maneuvers.[21] With the widespread trend among orthopedic surgeons to ambulate post-TKA patients as early as possible—often the afternoon of surgery—the intense motor effects of dual single-injection nerve blocks[11,12] are frequently considered unacceptable.[12] Although a knee immobilizer may neutralize femoral block–induced quadriceps weakness,[7,21] it is less effective when the sciatic nerve is simultaneously anesthetized with a resulting foot drop.[21]

For continuous blocks, the choice of local anesthetic, dose, and delivery method greatly influence infusion effects.[18] In one study that injected a 20-mg ropivacaine bolus every 12 hours via a sciatic catheter, the majority of subjects could not complete motion against resistance—let alone support their body weight (no mention made of this effect on physical therapy).[11] In the study by Wegener and colleagues[13] in this issue of the *Journal*, a 10-mL/hr perineural sciatic infusion with 0.125% levobupivacaine resulted in a complete motor block in 37% of subjects the day following surgery. The investigators decreased the rate to 6 mL/hr and stated that "none of the patients had a motor block" the following day (measurement technique not described)—but, the catheters were removed at 6:00 the following morning, and motor strength evaluation did not occur until 4 hours later. Similarly, although active knee flexion could have provided an indication of hamstring muscle strength, only measurements following catheter removal are reported. While using a lower initial dose would certainly result in a lower incidence of motor block,[17] it remains unknown whether this lower dose would result in the analgesic and opioid-sparing benefits originally detected at the higher dose.[22] Finally, whereas sensory block in the sciatic nerve distribution was not formally evaluated or reported, the 37% incidence of complete motor block suggests that a similarly high percentage experienced a concurrent insensate extremity. Many investigators consider an insensate extremity a risk factor for injury, and precisely titrating a perineural infusion to provide adequate analgesia yet not result in a significant sensory block is often challenging.[23]

LOGISTICAL FACTORS

Adding a sciatic block requires additional time, regardless of operator skill or insertion technique.[24] The study by Wegener and colleagues[13] reported a median sciatic catheter insertion time of 5 minutes, but the range was up to 15 minutes. Furthermore, their calculation did not include time to position the patient, evaluate external landmarks, sterilely prepare the site and catheter insertion kit, or administer cutaneous anesthesia. Two similar investigations reported an increase from 4 to 17 and 10 to 30 minutes when adding a sciatic catheter to a femoral catheter insertion.[11,12] Whereas some practice models allow for similar durations—such as those with a regional anesthesia induction area and available providers—many others allow for only a fraction of this time between cases, and yet others lack the infrastructure to provide subsequent infusion management. Also requiring consideration is the additional cost of a second catheter insertion set, infusion pump, local anesthetic, and follow-up.

CONCLUSIONS

The myriad of institution-specific characteristics precludes the determination of a single, optimal analgesic technique following TKA. Some practices will find the benefits of adding a single-injection and/or continuous sciatic nerve block to a femoral perineural infusion outweigh the potential risks and drawbacks, whereas others will conclude the opposite. Certainly, additional research will be greatly helpful in better defining the risks and benefits of the various analgesic modality combinations, as well as optimizing single-injection and continuous blocks by altering local anesthetic type, dose, and adjuvants; block and catheter insertion techniques; and infusion management.[18] Perhaps future data and/or pharmacologic/technological developments will produce a dramatic shift in the risk-benefit ratio or logistical issues,[25] but until then, the current lack of consensus will most likely continue unabated.

REFERENCES

1. Paul JE, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Anesthesiology.* 2010;113:1144–1162.
2. Ilfeld BM, Le LT, Meyer RS, et al. Ambulatory continuous femoral nerve blocks decrease time to discharge readiness after tricompartment total knee arthroplasty: a randomized, triple-masked, placebo-controlled study. *Anesthesiology.* 2008;108:703–713.

3. Ilfeld BM, Mariano ER, Girard PJ, et al. A multicenter, randomized, triple-masked, placebo-controlled trial of the effect of ambulatory continuous femoral nerve blocks on discharge-readiness following total knee arthroplasty in patients on general orthopaedic wards. *Pain*. 2010;150:477–484.
4. Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology.* 1999;91:8–15.
5. Singelyn FJ, Deyaert M, Joris D, Pendeville E, Gouverneur JM. 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.
6. Dauri M, Polzoni M, Fabbi E, et al. Comparison of epidural, continuous femoral block and intraarticular analgesia after anterior cruciate ligament reconstruction. *Acta Anaesthesiol Scand*. 2003;47:20–25.
7. Long WT, Ward SR, Dorr LD, Raya J, Boutary M, Sirianni LE. Postoperative pain management following total knee arthroplasty: a randomized comparison of continuous epidural versus femoral nerve infusion. *J Knee Surg*. 2006;19:137–143.
8. Hadzic A, Houle TT, Capdevila X, Ilfeld BM. Femoral nerve block for analgesia in patients having knee arthroplasty. *Anesthesiology.* 2010;113:1014–1015.
9. Fischer HB, Simanski CJ, Sharp C, et al. A procedure-specific systematic review and consensus recommendations for postoperative analgesia following total knee arthroplasty. *Anaesthesia*. 2008;63: 1105–1123.
10. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am*. 2007;89:780–785.
11. Pham Dang C, Gautheron E, Guilley J, et al. The value of adding sciatic block to continuous femoral block for analgesia after total knee replacement. *Reg Anesth Pain Med*. 2005;30:128–133.
12. 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: 434–445.
13. Wegener JT, Dijk NV, Hollmann MW, Preckel B, Stevens MF. Value of single-injection or continuous sciatic nerve block in addition to a continuous femoral nerve block in patients undergoing total knee arthroplasty: a prospective, randomized, controlled trial. *Reg Anesth Pain Med*. 2011;36:481–488.
14. Allen HW, Liu SS, Ware PD, Nairn CS, Owens BD. Peripheral nerve blocks improve analgesia after total knee replacement surgery. *Anesth Analg*. 1998;87:93–97.
15. Levesque S, Delbos A. Sciatic nerve block for total-knee replacement: is it really necessary in all patients? *Reg Anesth Pain Med*. 2005;30: 410–411.
16. Sciard D, Lam N, Hussain M. Continuous sciatic nerve block and total-knee arthroplasty. *Reg Anesth Pain Med*. 2005;30:411–412.
17. 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;98:747–749.
18. Ilfeld BM. Continuous peripheral nerve blocks: a review of the published evidence. [published online ahead of print August 4, 2011]. *Anesth Analg*.
19. Brull R, McCartney CJ, Chan VW, El Beheiry H. Neurological complications after regional anesthesia: contemporary estimates of risk. *Anesth Analg*. 2007;104:965–974.
20. Horlocker TT, Cabanela ME, Wedel DJ. Does postoperative epidural analgesia increase the risk of peroneal nerve palsy after total knee arthroplasty? *Anesth Analg*. 1994;79:495–500.
21. Muraskin SI, Conrad B, Zheng N, Morey TE, Enneking FK. Falls associated with lower-extremity-nerve blocks: a pilot investigation of mechanisms. *Reg Anesth Pain Med*. 2007;32:67–72.
22. Charous MT, Suresh PJ, Sandhu NS, et al. Continuous femoral nerve blocks: varying local anesthetic delivery method (bolus vs. basal) to minimize quadriceps motor block while maintaining sensory block [published online ahead of print June 17, 2011]. *Anesthesiology.*
23. Ilfeld BM, Loland VJ, Gerancher JC, et al. The effects of varying local anesthetic concentration and volume on continuous popliteal sciatic nerve blocks: a dual-center, randomized, controlled study. *Anesth Analg*. 2008;107:701–707.
24. Mariano ER, Cheng GS, Choy LP, et al. Electrical stimulation versus ultrasound guidance for popliteal-sciatic perineural catheter insertion: a randomized controlled trial. *Reg Anesth Pain Med*. 2009;34:480–485.
25. Ilfeld BM, Yaksh TL. The end of postoperative pain–a fast-approaching possibility? And, if so, will we be ready? *Reg Anesth Pain Med*. 2009;34:85–87.

Does Continuous Sciatic Nerve Block Improve Postoperative Analgesia and Early Rehabilitation After Total Knee Arthroplasty?

A Prospective, Randomized, Double-Blinded Study

Gianluca Cappelleri, MD, Daniela Ghisi, MD,† Andrea Fanelli, MD,† Andrea Albertin, MD,‡ Francesco Somalvico, Ph,§ and Giorgio Aldegheri, MD§*

Introduction: The aim of this prospective, randomized, double-blind study was to evaluate whether continuous sciatic nerve block can improve postoperative pain relief and early rehabilitation compared with single-injection sciatic nerve block in patients undergoing total knee arthroplasty (TKA) and lumbar plexus block.

Methods: After ethical committee approval and written informed consent, 38 patients with ASA physical status I to II were enrolled. The first group received continuous sciatic and continuous lumbar plexus blocks (group regional or R, n = 19), whereas the second group received a single sciatic nerve block followed by saline infusion through the sciatic catheter and continuous lumbar plexus block (group control or C, n = 19). We assessed morphine consumption, scores for visual analog scale for pain at rest (VASr), and during continuous passive motion (VASi during CPM) for 48 hours postoperatively. Effectiveness of early ambulation was also evaluated.

Results: Scores for VASr and VASi during CPM, as well as morphine consumption, were significantly higher in group C than in group R ($P < 0.01$). Moreover, patients in group R showed earlier rehabilitation with more effective ambulation ($P < 0.05$).

Conclusions: Continuous sciatic nerve block improves analgesia, decreases morphine request, and improves early rehabilitation compared with single-injection sciatic nerve block in patients undergoing TKA and lumbar plexus block.

(*Reg Anesth Pain Med* 2011;36: 489–492)

Postoperative pain after total knee arthroplasty (TKA) represents a continued challenge for physicians. It is severe in 60% of cases and represents a limiting factor for early postoperative knee rehabilitation.[1,2] The superiority of regional techniques over systemic opioid analgesia is well established in the literature.[2–4] A recent review showed better dynamic pain scores with lumbar epidural continuous infusion than with systemic opioids after TKA, but no difference was reported in terms of adverse effects.[3]

When compared with epidural infusion or systemic opioids, peripheral nerve blocks can offer some advantages in orthopedic patients: they reduce postoperative pain, improve rehabilitation, and shorten length of hospital stay.[4–6] Femoral nerve block alone has been shown to achieve comparable analgesia quality to epidural infusion after TKA with fewer adverse effects.[7,8] Moreover, the risk for epidural hematoma in patients receiving thromboprophylaxis represents a significant concern in this population.[7,8]

Although the knee is supplied from both lumbar and sacral plexi, the role of continuous sciatic nerve (SN) block for pain relief after TKA is controversial.[9] Some clinical trials suggest that adding SN block in patients undergoing TKA could improve postoperative analgesia.[10–13] Nevertheless, recent systematic reviews failed to demonstrate a clear advantage in terms of pain relief when either single-injection or continuous SN block is added to continuous femoral nerve block.[7,8]

We conducted this prospective, randomized, double-blind study to evaluate whether continuous SN block added to continuous lumbar plexus (LP) block can improve postoperative pain relief and early rehabilitation compared with single-injection SN block added to continuous LP block in patients undergoing TKA.

METHODS

After approval from the local ethics committee (IRCCS Multimedica, Milan) and written informed consent, 38 patients with ASA physical status I to II undergoing unilateral primary tricompartmental cemented TKA were enrolled. Patients with clinically significant coagulopathy (hemophilia, von Willebrand disease), infection at the injection site, allergy to local anesthetics, severe cardiopulmonary disease (New York Heart Association classification ≥ III or severe chronic obstructive pulmonary disease), diabetes, or other neuropathies as well as patients receiving major opioids for chronic analgesic therapy were excluded. Following European guidelines, all patients received thromboprophylaxis with 4000 IU of enoxaparin once daily.

Standard monitoring was applied throughout the procedure, including noninvasive arterial blood pressure, electrocardiography (lead II), heart rate, and pulse oximetry. After an 18-gauge intravenous (i.v.) catheter was placed at the opposite forearm, all patients received i.v. premedication with midazolam (0.05 mg/kg). Continuous nerve blocks were performed by 1 of 2 experienced anesthesiologists skilled in regional anesthesia techniques.

All patients received continuous LP and continuous SN blocks in the lateral decubitus position, with the surgical limb uppermost. The surface landmarks for the posterior approach to the LP were individualized in all patients: a vertical line was drawn at the level of the superior border of the posterior iliac crests (intercristal line) and another horizontal line was drawn through the spinous processes. After lidocaine infiltration, an insulated, 18-gauge, 10-cm Tuohy needle (PlexoLong; Pajunk,

From the *Azienda Ospedaliera Istituto Ortopedico Gaetano Pini; †Azienda Ospedaliera di Cremona; ‡Ospedale San Giuseppe – Milano; and §IRCCS Multimedica, Milan, Italy.
Accepted for publication June 4, 2011.
Address correspondence to: Gianluca Cappelleri, MD, Azienda Ospedaliera Istituto Ortopedico Gaetano Pini. Piazza cardinal Ferrari 1, 20122 Milano (e-mail: kappe@hotmail.com).
The authors have no conflicts of interest.

ISSN: 1098-7339
DOI: 10.1097/AAP.0b013e3182286a2b

Geisingen, Germany) was inserted perpendicular to the plane of the skin with the bevel oriented cranially, 4 cm laterally to the spinous process on the intercristal line, aiming at the L3 or L4 transverse process. A combination of loss of resistance and nerve stimulation techniques (Stimuplex [Pajunk]; 2 Hz, 0.1 millisecond, 1 mA) was applied to localize the psoas compartment and the LP. The needle was advanced until quadriceps contraction was elicited or bony contact was encountered. In the latter case, the needle was withdrawn and redirected caudally to walk off the transverse process and advanced until quadriceps contraction was elicited with 0.4 mA current or less.

A nonstimulating catheter was then introduced through the needle and advanced 3 cm beyond the needle tip. The Tuohy needle was removed, and the catheter was secured in place with a locking system (Lockit; Portex, Milan, Italy) and covered with transparent dressing (Tegaderm; 3M, Milan, Italy) allowing for direct visualization of both the insertion site and the catheter. At this point, after negative aspiration for blood or cerebrospinal fluid, 20 mL of 0.75% levobupivacaine was progressively injected.

The SN catheter was placed using the subgluteal approach described by Di Benedetto.[14]

With an insulated 18-gauge, 10-cm, Tuohy needle (Pajunk), after common peroneal or tibial motor responses were elicited with the aid of a nerve stimulator, a stimulating catheter (StimuLong; Pajunk) was inserted 4 to 5 cm over the needle tip and the Tuohy needle removed. The catheter was then connected to the same nerve stimulator (2 Hz, 0.1 millisecond,1 mA), and the stimulating current was progressively decreased to verify its correct placement. If a correct response was not elicited at 0.5 mA, the catheter was slowly withdrawn until the proper twitch was obtained. The catheter was secured in place with a locking system (Lockit; Portex), covered with transparent dressing (Tegaderm; 3M) and its depth was recorded. No local anesthetic was injected until normal SN function was assessed and documented at the end of surgery.

General anesthesia was induced with 1 to 2 μg/kg of fentanyl, 2 mg/kg of propofol, and 0.5 mg/kg of atracurium to facilitate orotracheal intubation and maintained with sevoflurane.

Once patients recovered from general anesthesia, each stimulating sciatic catheter was tested to exclude surgical SN damage or unintentional intraoperative catheter dislodgement. If unable to elicit the proper sciatic motor response with a stimulating current of 0.6 mA, the catheter was replaced immediately after surgery. After confirmation of the correct catheter placement and normal nerve function, 20 mL of 0.37% levobupivacaine was injected through the catheter in both groups. Sensory function was assessed with pinprick test in both femoral and sciatic territories of distribution. Also, the time to achieve a score for visual analog scale (VAS) less than 40 mm after sciatic injection of local anesthetic was registered.

At this point, using a computer-generated sequence of random numbers and a sealed envelope technique, patients were randomly allocated to 1 of 2 groups: the first group received a continuous infusion of 0.1 mL/kg of 0.06% levobupivacaine (group regional or R = 19 patients), whereas the second group received a continuous infusion of 0.1 mL/kg of 0.9% saline solution (group control or C = 19 patients) through the sciatic catheter. All patients also received a continuous infusion of 8 mL h of 0.125% levobupivacaine through the LP catheter. All investigators, patients, nurses, and physiotherapists remained blinded to the patients' randomization until study enrollment was completed. The study solutions (7 syringes containing 50-mL solutions) were prepared in advance by one of the authors not taking any further part in patients' care.

Postoperative analgesia was implemented with 30 mg of i.v. ketorolac every 8 hours and i.v. patient-controlled morphine analgesia (PCA, bolus dose = 1 mg; lockout = 15 minutes; maximum dose/hour = 4 mg). During the preoperative anesthesia visit, patients were instructed to use the PCA postoperatively in case of an unacceptable level of pain localized in the surgical knee.

Postoperative assessments were made blindly every 6 hours after the beginning of surgery and until the completion of the first 48 hours postoperatively. Postoperative registered parameters included total volume of morphine used through the PCA pump, VAS scores at rest (VASr) from 0 (no pain) to 10 (worst imaginable pain) as well as the incidence of adverse effects such as nausea, vomiting, and pruritus. We also assessed patients' VAS scores during early rehabilitation (VASi), which consisted of knee continuous passive motion (CPM) at 8, 26, 32, and 48 hours postoperatively (2-hour session at each time point).

During CPM, patients underwent 4 incremental angles of knee passive flexion using a motorized variable amplitude splint (Kinetec, Tournes, France). The CPM was maintained 2 hours for each of the 4 incremental steps (30, 40, and 50 degrees of passive flexion of the knee, then followed by 2 hours at the maximum range of motion reached with no pain or tolerable pain). If the patient was not able to complete rehabilitation because of pain, CPM was stopped ahead of time and the episode recorded. At the end of the study protocol (48 hours after the beginning of surgery), both lumbar and sciatic infusions were stopped and removed independently from timing for thromboprophylaxis. Four hours later, with the aid of a walker, patients were asked to walk with the physiotherapist's assistance, considering a 40-m distance walked without pain as the ideal target. The maximum walking distance was measured and recorded in both groups.

Statistical Analysis

The primary end point of the study was morphine consumption used by patients in the 2 study groups through the PCA pump. Secondary end points were VAS scores both for pain at rest and during physiotherapy and distance of unassisted walk.

Power calculation was based on the mean and SD of the consumption of morphine during the 48 hours after total knee replacement when a single-injection SN block, added to the obturator nerve block and 3-in-1 femoral nerve block, was performed.[15] We considered a reduction of 50% morphine consumption by adding a continuous SN block to be clinically meaningful.

Based on a previous investigation,[15] a minimum of 14 patients per group was required to detect this difference, accepting a 2-tailed α error of 5% and a β error of 0.8. Qualitative data were presented as numbers (%) and analyzed by χ^2 or Fisher exact test. Quantitative and continuous data were presented as mean (SD) and analyzed by nonparametric tests.

The statistical evaluation was performed adopting SPSS Statistical Package Version 18, Statistica StatSoft, and NQUERY Advisor for sample size calculation. $P \leq 0.05$ was considered significant.

RESULTS

Thirty-eight patients were enrolled in the study protocol. After surgery, sciatic catheters resulted in correctly placed (tibial or peroneal motor response evocated at a stimulating current 0.6 mA) in 37 cases. In 1 patient, the stimulating sciatic catheter became dislodged after being tested at the end of the procedure. The catheter was then repositioned immediately after surgery, and the patient was kept in the study protocol.

TABLE 1. Anthropometric Characteristics and Duration of Surgery

	Control Group	Regional Group
Age, y	67 (10)	69 (8)
Body mass index, kg/m^2	28 (4)	29 (5)
Height, cm	168 (9)	165 (10)
Sex (male/female)	8/11	6/13
Duration of surgery, min	83 (13)	88 (13)
Time from LA sciatic injection to VAS < 40 mm, min	18 (7)	20 (4)

One patient in the control group was excluded from the study because his sciatic catheter was unintentionally removed before the end of the 48-hour observation period. Therefore, 37 patients were evaluated in the study analysis (18 in group C and 19 in group R). All patients in both groups completed the 48-hour observation period.

No difference in anthropometric data, time of surgery, and time to a VAS score less than 40 mm after local anesthetic injection through the sciatic catheter were found between the 2 groups (Table 1). After recovery from general anesthesia, all the patients showed a negative pinprick test in the femoral region.

Total consumption of morphine was 12 (9) mg in group C and 3 (4) mg in group R ($P < 0.01$). Morphine consumption was statistically higher at 30, 42, and 48 hours postoperatively in group C than in group R (Fig. 1). Also, mean VASr scores were higher in group C compared with group R, reaching a statistically significant difference at 30 and 42 hours postoperatively ($P < 0.01$) (Fig. 2).

Postoperative data are shown in Table 2. Scores for VASi during CPM were lower in group R than group C, being statistically different at the second and third steps of passive knee flexion (40 and 50 degrees, respectively) ($P < 0.01$), whereas no difference was found at the first step (30 degrees) between groups. At 48 hours after surgery, patients in group R reached a range of motion with no pain statistically different compared with group C ($P < 0.01$) (Table 2).

At the end of the observation period, patients who received continuous SN block were able to walk for a mean distance of 31 (9) m compared with 22 (12) m in patients receiving single-injection SN blocks ($P < 0.05$).

DISCUSSION

The results of this prospective, randomized, double-blind study show that continuous SN block added to continuous LP block decreases morphine administration and improves postoperative pain relief and early rehabilitation compared with single-injection SN block added to LP block after TKA.

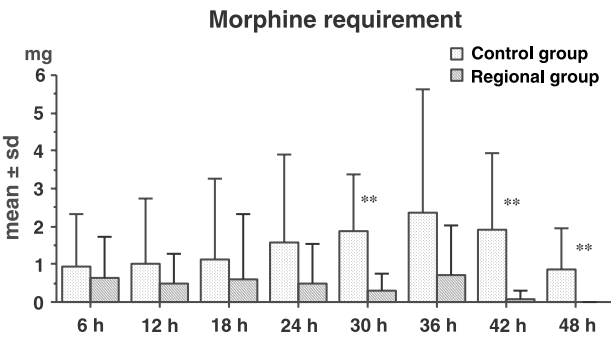

FIGURE 1. Morphine consumption in the 2 studied groups. Values are shown as mean (SD). $^{**}P < 0.01$.

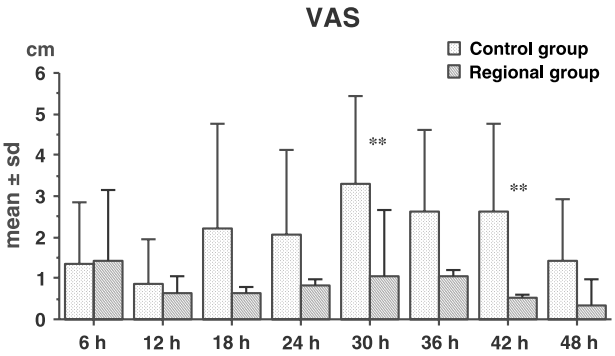

FIGURE 2. Scores for VASr (0 cm = no pain, 100 mm = worst imaginable pain). Values are shown as mean (SD). $^{**}P < 0.01$.

Few studies compare both femoral/LP block alone with a combination of femoral/LP block and single-injection or continuous SN block after total joint arthroplasty.[10–13] Pham et al[12] reported significantly higher pain scores and 80% higher morphine consumption in the first 36 hours after surgery in patients receiving continuous femoral nerve blocks than in patients receiving both femoral and sciatic continuous blocks after total knee replacement.

Because of single-injection SN block, our patients did not show any difference in morphine consumption within the first 24 hours postoperatively. Afterward, patients who received single-injection SN blocks showed a higher consumption of morphine by 72% compared with those receiving continuous SN infusion. The lower efficacy of pain therapy in the control group might have compromised patients' ambulation 48 hours after surgery. In fact, patients receiving continuous SN block showed prompter knee rehabilitation and walked significantly longer distances 48 hours after surgery than patients receiving single-shot SN blocks.

Two systematic reviews have recently demonstrated that analgesia provided by continuous femoral nerve block alone is comparable with epidural analgesia, with fewer adverse effects.[7,8] Paul et al[8] showed that both single-shot (SSFNB) and continuous femoral nerve blocks (CFNB) plus PCA are superior to PCA alone or epidural infusion for postoperative analgesia in TKA. Nevertheless, in contrast with our results, there seems to be a lack of evidence that SN block or CFNB provide additional analgesia or any recovery benefits.[8] Unfortunately, of the 23 studies

TABLE 2. Postoperative Data: VASi Scores (mm) During CPM, Maximum Distance Walked With Walker 48 Hours After Surgery

	Control Group	Regional Group	*P*
VASi 30 degrees (H8), mean (SD)	10 (12)	10 (12)	NS
VASi 40 degrees (H26), mean (SD)	29 (26)	10 (11)	<0.05
VASi 50 degrees (H32), mean (SD)	38 (30)	7 (14)	<0.01
Maximum knee flexion after 48 h, mean (SD), degrees	60 (12)	102 (10)	<0.01
Ambulation, mean (SD), m	21 (12)	31 (9)	<0.05
Nausea, n (%)	12 (63)	3 (15)	<0.01
Vomiting, n (%)	7 (36)	1 (5)	<0.05

(1016 patients) included in the meta-analysis by Paul et al, only 1 study specifically addresses the direct comparison of SSFNB versus SSFNB plus SN block (36 patients).[13] The paucity of randomized control trials directly investigating the SN block contribution to pain relief and physiotherapy after knee surgery could have affected the authors' conclusions.

In the cited systematic reviews, femoral nerve block was performed with the 3-in-1 technique. Previous investigations have shown the relevance of the obturator nerve block after TKA.[15] Unfortunately, the 3-in-1 technique does not seem to provide a reliable obturator nerve block,[15–18] and we therefore decided to perform a continuous LP block instead of continuous femoral nerve block, despite its deeper location and common fear for complications.[19,20] In the present investigation, 31% of patients of group R were entirely free from pain and did not require any i.v. morphine within the first 48 hours after TKA versus only 5% of patients in group C.

The study presents some limitations. First, adding a third group with saline single-injection sciatic and placebo catheter infusion could have eventually addressed the question whether or not a SN block is beneficial in TKA. Second, this trial was not performed to value the benefit of continuous SN block in long-term outcomes and length of hospital stay. Further studies are advocated to address this issue. Moreover, to comply with surgeon request, to assess potential surgical SN injury,[21] the SN catheter was injected at the end of surgery, after normal nerve function was confirmed. Immediately after recovery from general anesthesia, most patients complained of pain in the posterior region of the knee or calf. Local anesthetic was administered as soon as possible through the sciatic catheter; nevertheless, given the pathophysiology of pain, the elapsed time interval could represent a study limit.

Differences in VASr scores were statistically significant but not clinically meaningful between the 2 groups. Nevertheless, our results about pain scores during movement, morphine requirements, and patients' ambulation suggest a clinical advantage in adding a continuous sciatic infusion after TKA.

In conclusion, this prospective, randomized, double-blind study shows that continuous SN block reduces morphine consumption and improves postoperative analgesia during the first 48 hours after TKA and LP block, if compared with single-injection sciatic. Moreover, the best analgesic profile provided by the combination of continuous SN block and continuous LP block allowed a better postoperative rehabilitation in the early period after TKA. Further studies are needed to investigate benefits of the studied intervention on postoperative outcomes and length of hospital stay.

REFERENCES

1. Singelyn FJ, Deyaert M, Joris D, et al. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg*. 1998;87:88–92.
2. Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, D'athis F. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology.* 1999;91:918–915.
3. Choi PT, Bhandari M, scott J, Douketis J. Epidural analgesia for pain relief following hip or knee replacement. *Cochrane Database Syst Rev.* 2003;CD003071.
4. Allen HW, Liu SS, Ware PD, Nirn CS, Owens BD. Peripheral nerve blocks improve analgesia after total knee replacement surgery. *Anesth Analg*. 1998;87:93–97.
5. Brull R, McCartney Cj, Chan VW, El-Beheiry H. Neurological complications after regional anesthesia: contemporary estimates of risk. *Anesth Analg*. 2007;104:965–974.
6. Barrington MJ, Olive D, low K, Scott DA, Brittain J, Choong P. Continuous femoral nerve blockade or epidural analgesia after total knee replacement: a prospective randomized controlled trial. *Anesth Analg*. 2005;101:1824–1829.
7. Fowler SJ, Symons J, Sabato S, Myles PS. Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. *Br J Anaesth*. 2008;100:154–164.
8. Paul JE, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Anesthesiology.* 2010;113: 1144–1162.
9. Berry M, Bannister LH, Standring SM. Lumbar plexus. In: William PI, ed. *Gray's Anatomy: Nervous System*. 38th ed. New York, NY: Churchill Livingstone;1995:1277–1282.
10. Morin AM, Kratz CD, Eberhart LHJ, 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; 30:434–445.
11. Ben-David B, Schmalenberger K, Chelly J. Analgesia after total knee arthroplasty: is continuous sciatic blockade needed in addition to continuous femoral blockade? *Anesth Analg*. 2004;98:747–749.
12. Pham D, Gautheron E, Guilley G, et al. The value of adding sciatic block to continuous femoral block for analgesia after total knee replacement. *Reg Anesth Pain Med*. 2005;30:128–133.
13. Cook P, Stevens J, Gaudron C. Comparing the effects of femoral nerve block versus femoral and sciatic nerve block on pain and opiate consumption after total knee arthroplasty. *J Arthroplasty.* 2003;18:583–586.
14. Di Benedetto P, Casati A, Bertini L, et al. Posterior subgluteal approach to block the sciatic nerve: description of the technique and initial clinical experiences. *Eur J Anaesthesiol*. 2002;19: 682–686.
15. Macalou D, Trueck S, Meuret M, et al. Postoperative analgesia after total knee replacement: the effect of an obturator nerve block added to the femoral 3-in-1 nerve block. *Anesth Analg*. 2004;99:251–254.
16. McNamee DA, Parks L, Milligan KR. Post-operative analgesia following total knee replacement: an evaluation of the addition of an obturator nerve block to combined femoral and sciatic nerve block. *Acta Anaesthesiol Scand*. 2002;46:95–99.
17. Marhofer P, Nagel C, Sitzwohl C, Kapral S. Magnetic resonance imaging of the distribution of local anesthetic during the three-in-one block. *Anesth Analg*. 2000;90:119–124.
18. Cappelleri G, Aldegheri G, Ruggieri F, et al. Effects of using the posterior or anterior approaches to the lumbar plexus on the minimum effective anesthetic concentration (MAEC) of mepivacaine required the femoral nerve: a prospective, randomized, up and down study. *Reg Anesth Pain Med*. 2008;33:10–16.
19. Litz RJ, Vincent O, Wiessner W, Heller A. Misplacement of a psoas compartment catheter in the subarachnoid space. *Reg Anesth Pain Med*. 2004;1:60–64.
20. Posman RM, Masoor Z, Sciard D, et al. Total spinal anesthetic after continuous posterior lumbar plexus block. *Anesthesiology.* 2003;98:1281–1282.
21. Nercessian OA, Ugwonali OFC, Park S. Peroneal nerve palsy after total knee arthroplasty. *J Arthroplasty.* 2005;20:1068–1073.

Value of Single-Injection or Continuous Sciatic Nerve Block in Addition to a Continuous Femoral Nerve Block in Patients Undergoing Total Knee Arthroplasty

A Prospective, Randomized, Controlled Trial

Jessica T. Wegener, MD, Bas van Ooij, MD,†‡ C. Niek van Dijk, MD, PhD,†‡*
Markus W. Hollmann, MD, PhD, Benedikt Preckel, MD, MA,* and Markus F. Stevens, MD, PhD**

Background and Objectives: Continuous femoral nerve block in patients undergoing total knee arthroplasty (TKA) improves and shortens postoperative rehabilitation. The primary aim of this study was to investigate whether the addition of sciatic nerve block to continuous femoral nerve block will shorten the time-to-discharge readiness.

Methods: Ninety patients undergoing TKA were prospectively randomized to 1 of 3 groups: patient-controlled analgesia via femoral nerve catheter alone (F group) or combined with a single-injection (Fs group) or continuous sciatic nerve block (FCS group) until the second postoperative day. Discharge readiness was defined as the ability to walk and climb stairs independently, average pain on a numerical rating scale at rest lower than 4, and no complications. In addition, knee function, pain, supplemental morphine requirement, local anesthetic consumption, and postoperative nausea and vomiting (PONV) were evaluated.

Results: Median time-to-discharge readiness was similar: F group, 4 days (range, 2–16 days); Fs group, 4 days (range, 2–7 days); and FCS group, 4 days (range, 2–9 days; $P = 0.631$). No significant differences were found regarding knee function, local anesthetic consumption, or postoperative nausea and vomiting. During the day of surgery, pain was moderate to severe in the F group, whereas Fs and FCS groups experienced minimal pain ($P < 0.01$). Patients in the F group required significantly more supplemental morphine on the day of surgery and the first postoperative day. Until the second postoperative day, pain was significantly less in the FCS group ($P < 0.01$).

Conclusions: A single-injection or continuous sciatic nerve block in addition to a femoral nerve block did not influence time-to-discharge readiness. A single-injection sciatic nerve block can reduce severe pain on the day of the surgery, whereas a continuous sciatic nerve block reduces moderate pain during mobilization on the first 2 postoperative days.

(*Reg Anesth Pain Med* 2011;36: 481–488)

Total knee arthroplasty (TKA) reduces pain and improves function resulting in a higher quality of life for patients with knee osteoarthritis.[1] These patients can suffer from considerable postoperative pain, which is known to impair early intensive physical therapy and rehabilitation. Good postoperative pain control is probably the most important factor to accelerate knee rehabilitation.[2–4] Meanwhile, hospital stay after TKA has been shortened by the introduction of clinical pathways including standardized pain therapy allowing accelerated mobilization: good postoperative pain management should allow intensive physical therapy and early discharge.

With patient-controlled intravenous (IV) opioids alone, moderate to severe pain can persist, especially during mobilization.[2,5,6] Continuous epidural analgesia and continuous peripheral nerve blocks provide improved analgesia and a significantly shortened rehabilitation time when compared with pure opioid therapy.[3] In a risk-benefit analysis, peripheral nerve blocks offer more site-specific analgesia with a lower incidence of adverse effects compared with epidural analgesia.[7–9] For balancing adequate analgesia with limited quadriceps motor impairment, patient-controlled femoral nerve block can be used.[10] Although a recent meta-analysis could not find any advantage of a continuous femoral nerve block in comparison to a single injection,[11] in most institutions, it is considered standard for TKA.[12] However, continuous femoral nerve block might lead to insufficient pain relief in the posterior region of the operated knee.[13,14] Yet, the discussion continues whether a supplemental sciatic nerve block plus analgesia via a femoral nerve catheter is beneficial in these patients.[14–17] Pham et al[18] demonstrated better pain relief at rest and decreased morphine consumption when combining continuous femoral and sciatic nerve blockade. Unfortunately, in this study, data from patients with continuous and single-injection sciatic block were not analyzed separately. Morin et al[19] reported improved analgesia in patients undergoing TKA with combined continuous femoral and sciatic nerve block for a median of 3 days but also reported more problems while performing active exercises and more insecure walking in patients with an additional sciatic nerve block. Therefore, we shortened the time of nerve blocks to not interfere with early ambulation. Finally, a recent meta-analysis concluded that further studies are needed to evaluate the value of adding sciatic nerve block to femoral nerve block in patients undergoing TKA.[11]

We hypothesize that addition of sciatic nerve block (single-injection or continuously) to a patient-controlled femoral nerve blockade will shorten time-to-discharge readiness and improve postoperative knee mobilization and pain relief after TKA.

METHODS

This trial was designed as a single-center, prospective, randomized, controlled study. Approval of the study was obtained by the Medical Ethics Committee of the Academic Medical Centre of Amsterdam (07/321 MEC), and it was registered in the national trial register (NTR2207). Progress of the study and adverse event rates were annually reviewed by the hospital ethics committee.

From the Departments of *Anesthesiology and †Orthopedic Surgery, Academic Medical Center, University of Amsterdam; and ‡Orthopedic Research Center Amsterdam, The Netherlands.
Accepted for publication May 11, 2011.
Address correspondence to: Benedikt Preckel, MD, MA, Department of Anesthesiology, Academic Medical Center, Meibergdreef 9, 1100DD Amsterdam, The Netherlands (e-mail: b.preckel@amc.uva.nl).
This study was support was provided solely from institutional sources.

ISSN: 1098-7339
DOI: 10.1097/AAP.0b013e318228c33a

TABLE 1. Scale of Sensory and Motor Function

S1	Normal sensation
S2	Touch sensation, no pain
S3	No sensation
M1	Full power
M2	Decreased power
M3	No power

Examination of sensory and motor block based on a 3-point scale and tested every 5 minutes during the first 45 minutes after femoral and sciatic nerve blocking.

Study Participants

All eligible patients scheduled for total knee replacement arthroplasty (TKA) in a clinical pathway were enrolled 1 week before knee surgery. After being provided with written and verbal information, the subject's written informed consent was obtained on admission. Inclusion criteria consisted of age older than 18 years and American Society of Anesthesiologists classification I to III. Exclusion criteria were infection near the insertion site of any catheter, coagulation disorders, allergy to local anesthetics, prior surgery near the site of nerve block, inability to use the patient-controlled analgesia device, pregnancy or lactation, known hepatic or renal insufficiency, and preexisting neurologic deficit of the operated leg. Normal motor and sensory function of the operated leg was evaluated before randomization. The study period included the time from admission for TKA until hospital discharge.

Randomization

Eligible patients were randomized into 3 groups using opaque-sealed envelopes containing the treatment assignment. Thus, 90 patients were randomly allocated to 1 of 3 equally sized groups:

F: Patients receiving patient-controlled femoral nerve block only.

Fs: Like the F group combined with a single-injection sciatic nerve block.

FCS: Like the F group combined with a continuous sciatic nerve block.

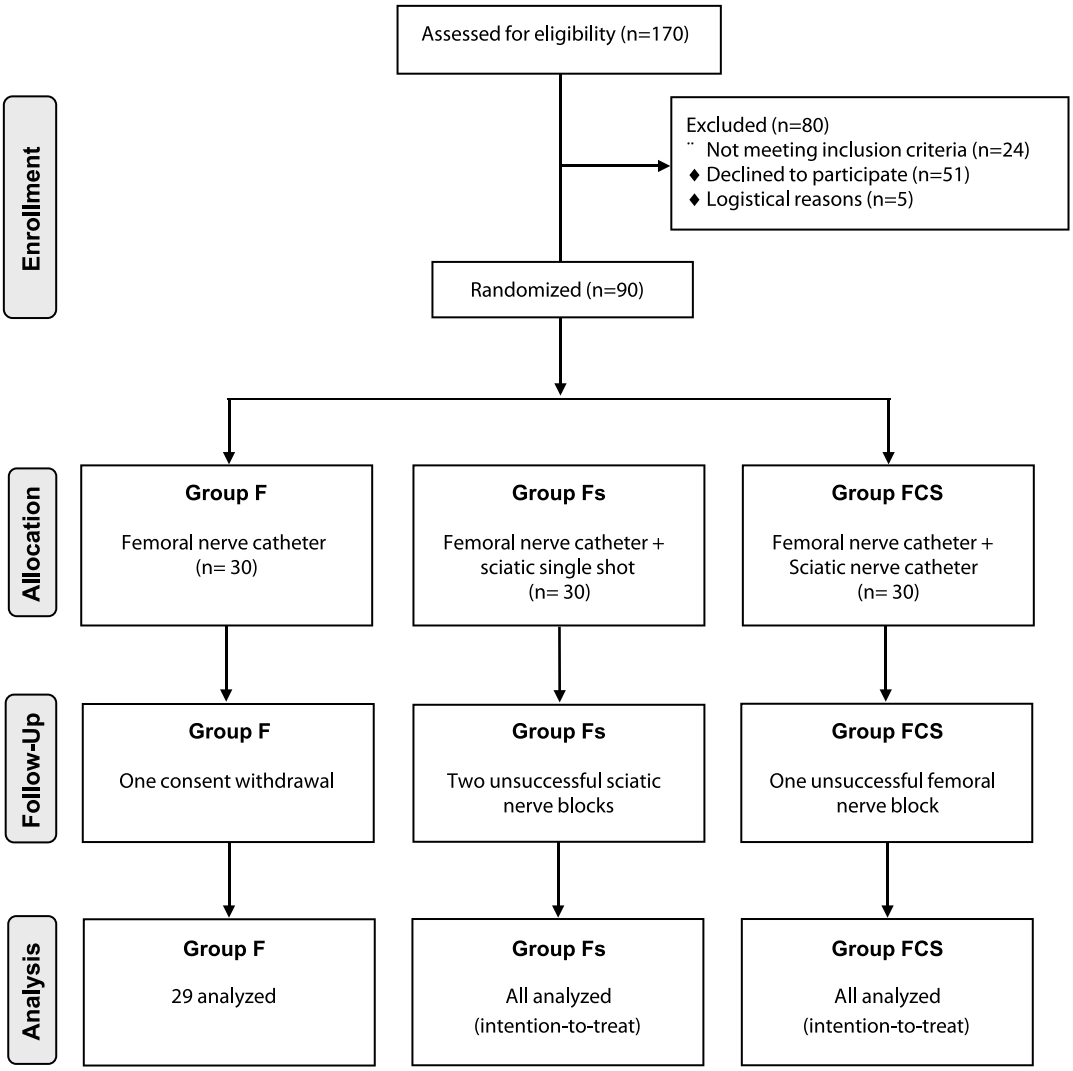

FIGURE 1. CONSORT diagram showing flow of patients for TKA through the study.

TABLE 2. Demographic Data

	F Group (n = 29)	Fs Group (n = 30)	FCS Group (n = 30)
Age, y	62 (50–79)	65 (43–81)	66 (43–83)
Sex (M/F)	11/18	9/21	8/22
Height, cm	174 (158–188)	171 (150–187)	173 (159–188)
Weight, kg	84 (72–116)	82 (62–125)	89 (68–118)
BMI, kg/m^2	30.3 (23.2–39.7)	28.6 (21.0–48.8)	27.8 (22.1–39.6)
ASA I/II/III	13/13/3	13/17/2	9/16/5
NRS preoperatively	5.4 (3.0–7.5)	6.5 (2.0–10)	6.3 (0–10)
AROM, degrees	120 (70–130)	110 (60–135)	110 (80–135)

Patient characteristics presented as median (range) or absolute number as appropriate. There were no significant demographic differences between the 3 groups ($P > 0.05$).

AROM indicates active range of motion of the knee; ASA, American Society of Anesthesiologists status; BMI, body mass index; NRS, pain score as numeric rating scale.

Preoperative Knee Function and Pain Assessment

Preoperative functional capacity of the knee was assessed by active range of motion, measuring knee flexion with a goniometer. Ratings were documented of preoperative knee pain on a numeric rating scale (NRS; range, 0–10; 0 = no pain, 10 = most imaginable pain) during movement.

Nerve Block Techniques

After establishing venous access and standard hemodynamic monitoring (electrocardiogram, pulse oximetry, noninvasive blood pressure measurement), peripheral nerve blocks were placed under aseptic conditions in the preoperative holding area by 1 of 3 anesthesiologists with extensive experience in ultrasound-guided nerve block procedures. All patients received a stimulation femoral nerve catheter (Stimucath continuous nerve block set with a 18-gauge Tuohy needle and 20-gauge catheter; Arrow International, Inc, Reading, Pa), inserted via an ultrasound-guided inguinal in-plane approach in supine position. The needle tip was positioned dorsomedial to the femoral nerve under ultrasound guidance (HFL 38 probe connected to MicroMaxx; SonoSite, Inc, Bothell, Wash) and nerve stimulation (Stimuplex HSN 12 [B Braun, Melsungen, Germany]; pulse width, 0.1 millisecond; frequency, 2 Hz). The stimulating catheter was advanced or repositioned aiming for stimulation current less than 0.6 mA. Ultrasound identification of the catheters was difficult in patients with a body mass index greater than 30 kg/m^2. The lowest current inducing muscle contractions via the catheter was registered. After negative aspiration, a loading dose of 20 mL of levobupivacaine 0.375% was administered slowly in fractions of 5 mL.

For patients from the Fs and FCS groups, before placement of the femoral nerve catheter, a sciatic nerve block was established via a parasacral approach, as described by Mansour,[20] in the lateral decubitus position with guidance of a nerve stimulator. In the Fs group, a stimulating needle (15-cm 20-gauge needle; Stimuplex A [B Braun]) was used, and in the FCS group, a stimulating needle with a catheter set was used (15-cm 18-gauge needle, 100-cm 20-gauge catheter; Contiplex Tuohy [B Braun]). After eliciting dorsal or plantar flexion of the foot with a current preferably below 0.6 mA, a loading dose of 20 mL of levobupivacaine 0.375% was injected intermittently after negative aspiration. In the FCS group, the catheter was inserted 5 cm beyond the needle tip. Nerve catheters were secured to the skin with a catheter stabilization device (Statlock, for winged catheters; Bard, Inc, Covington, Ga) and covered with a transparent dressing (Tegaderm; 3M, St Paul, Minn).

Time needed for establishing the nerve block from first needle penetration to withdrawal of the needle (for single-injection blocks) and catheter fixation (for continuous techniques) was registered. All electrical stimulation thresholds were noted.

After injection of local anesthetics, sensory and motor block was examined based on a 3-point scale every 5 minutes

TABLE 3. Characteristics of Block and Surgical Performance per Group

Variables	F Group (n = 29)	Fs Group (n = 30)	FCS Group (n = 30)
Alfentanil, μg	500 (250–1000)	1000 (0–1750)	1000 (250–2000)
Propofol, mg	0 (0–40)	0 (0–50)	0 (0–100)
Femoral catheter placing duration, min:s	5:56 (2:30–21:00)	7:41 (2:20–26:00)	6:40 (3:20–24:12)
Femoral catheter threshold, mA	0.44 (0.20–0.80)	0.40 (0.20–0.90)	0.35 (0.1–0.6)
Sciatic injection duration, min:s		3:49 (1:10–22:00)	
Sciatic threshold, mA		0.38 (0.2–0.9)	
Sciatic catheter placing duration, min:s			4:46 (2:00–15:15)
Sciatic catheter threshold, mA			0.30 (0.1–0.60)
Length of surgery, min	93 (51–150)	87 (53–178)	93 (69–134)
Tourniquet time, min	88 (33–152)	75 (14–158)	69 (15–109)

Data are given as median (range). There were no statistical significant differences between groups ($P > 0.05$).

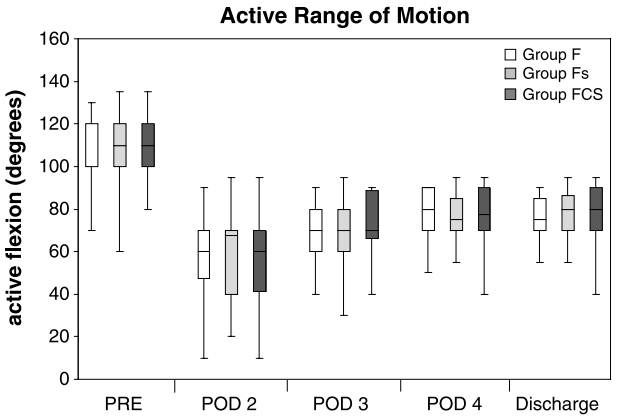

FIGURE 2. The range of motion of the different treatment groups over time. Box plots representing the degree of active knee flexion per group and per day. The white boxes represent the F group (only femoral catheter), light gray boxes represent the Fs group (femoral catheter and sciatic single injection), and dark gray boxes represent the FCS group (femoral and sciatic catheter). There were no significant differences between groups at any time.

during the first 45 minutes (Table 1).[21] Femoral sensory function was tested by pinprick 10 cm proximal of the patella and femoral nerve motor function by knee extension. Sciatic motor function was tested by foot plantar/dorsal extension and sensory function by pinprick sensation at the lateral calf and the dorsum of the foot.

During the Surgery

Patients received lorazepam 1 mg 2 hours and acetaminophen 2 g 1 hour before surgery. At 45 minutes after application of the initial bolus at the femoral nerve site, a continuous infusion of levobupivacaine 0.125% 10 mL/h was started via the femoral nerve catheter in all groups. In the FCS group, a second continuous infusion of levobupivacaine 0.125% 10 mL/h was started via the sciatic catheter 45 minutes after catheter placement.

General anesthesia was induced with propofol target-controlled infusion set to 3 to 5 μg/mL and remifentanil 0.5 μg/kg per minute and maintained with 2 to 3 μg/mL and 0.1 to 0.25 μg/kg per minute, respectively. Infusion rates were adjusted as required, and patients were ventilated via a laryngeal mask.

A pneumatic tourniquet was placed on the thigh before surgery and inflated to 300 mm Hg during surgery. Total needs of propofol and remifentanil, duration of surgery, and time of tourniquet were recorded.

Postoperatively on Postanesthesia Care Unit

Postoperatively, the continuous femoral nerve infusion was changed to patient-controlled femoral nerve infusion (5-mL bolus, 30-minute lockout; basal rate, 6 mL/h [Perfusor fm; B Braun]) in all groups. In the FCS group, the additional continuous sciatic infusion was maintained during the postoperative period (10 mL/h).

Supplemental morphine IV was administered for pain control if pain score on an NRS was higher than 4. Consumption of morphine and NRS at 1, 2, and 3 hours postoperatively were noted. The extent of postoperative nausea and vomiting (PONV) was graded as none = 0, mild = 1, and severe = 2. Patients with PONV received ondansetron 4 mg IV and, when the symptoms persisted, droperidol 0.625 mg IV was added.

Postoperatively on Surgical Ward

All patients received standardized postoperative analgesia with acetaminophen 1 g 4 times daily. In the absence of any contraindications, diclofenac 50 mg was added 3 times daily, combined with esomeprazol 20 mg once daily for gastric protection. Alternatively, tramadol was started 50 mg 3 times daily. An extra dose of tramadol (100 mg) was administered before removal of nerve catheters. If NRS remained high despite these treatments, morphine was administered for pain relief as required. Perineural infusions were continued for 36 hours, and catheters were removed on the morning of the second postoperative day (POD 2). Deep vein thrombosis prophylaxis was provided with fondaparinux 2.5 mg/0.5 mL subcutaneously daily, starting the evening on the day of surgery and continued for 4 weeks.

Physical therapy started on POD 1 until discharge. Functional capacity was assessed daily and recorded with the Medical Research Council scale for muscle strength of the quadriceps (MRC-Q) and active range of motion of the knee with a goniometer by the physical therapist.

Readiness to Discharge and Functional Outcome

The primary end point was time-to-discharge readiness. Criteria were as follows:

1. Ability to walk 25 m or more with walking aids and to climb a flight of stairs. This end point was checked daily at 10 AM and 2 PM by a physical therapist.
2. A pain score below 4 on an NRS as taken by nurses educated in pain measurement and therapy.
3. Absence of serious complication as examined by an orthopedic surgeon on a daily basis.

These discharge criteria were checked daily by an investigator. Furthermore, short-term functional capacity was determined by MRC-Q and active flexion of the knee daily by a physical therapist. Duration of actual admission was also noted.

Secondary end points were pain scores measured on an NRS at rest and during movement, supplemental consumption of morphine, local anesthetic consumption, and grade of PONV. These variables were noted daily at 8 AM and 6 PM on the ward starting the day of surgery until the third postoperative day. Patients were assessed daily by the surgeon for complications during admission, as well as 6 weeks postoperatively.

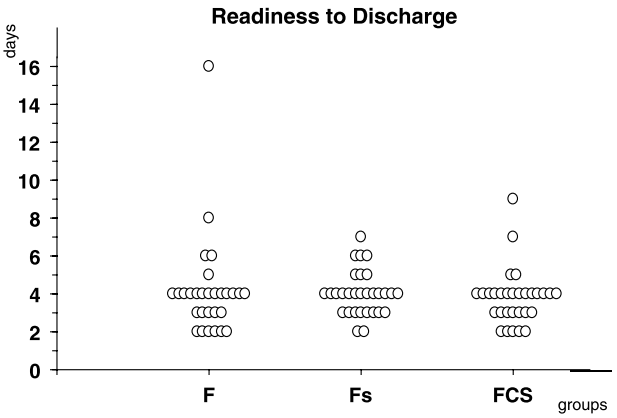

FIGURE 3. Time points when each of 89 patients reached discharge criteria for each treatment group. There were no statistical significant differences between groups ($P = 0.631$).

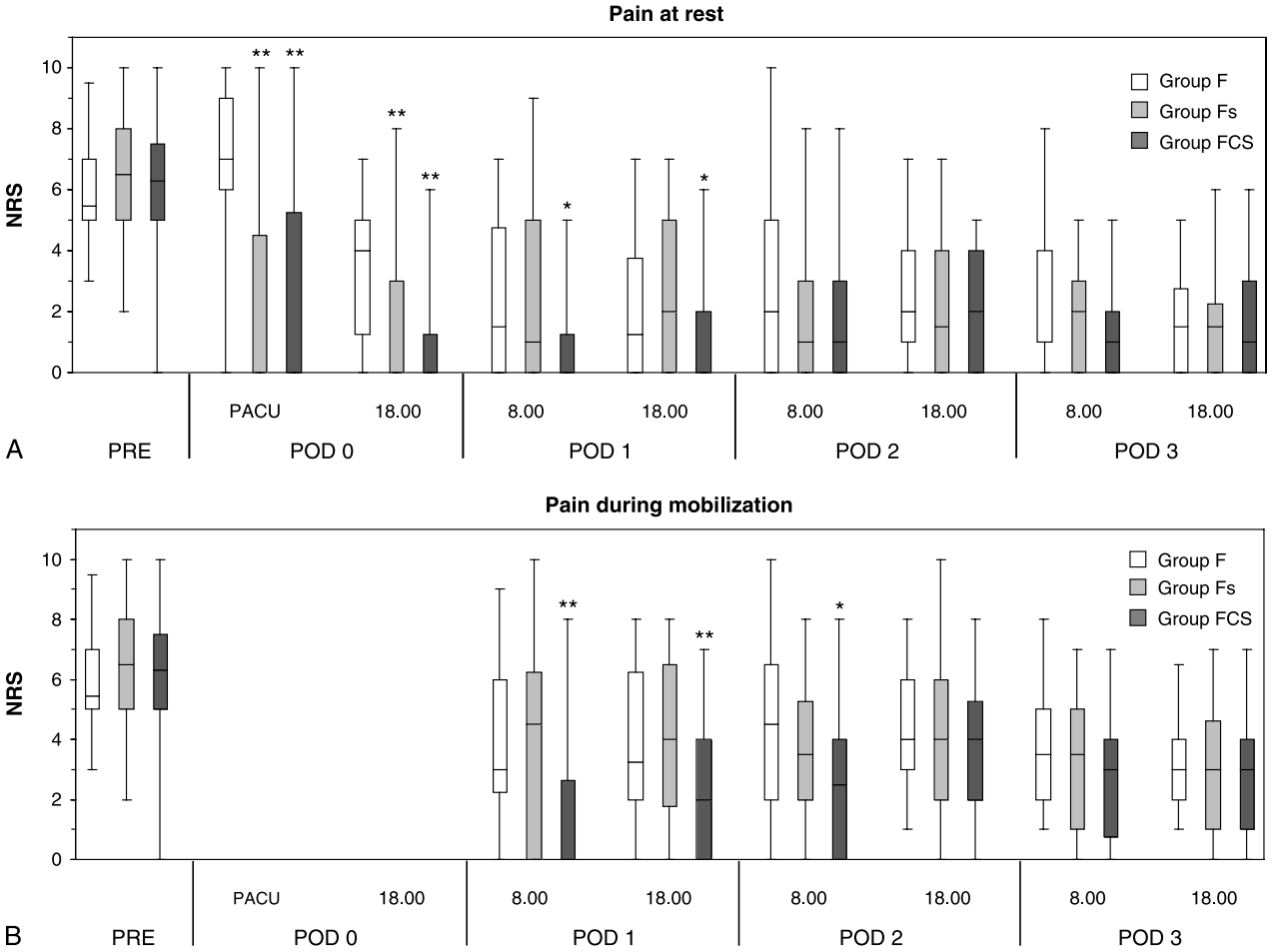

FIGURE 4. Pain at rest (A) and during mobilization (B) over time per group. The white boxes represent the F group (only femoral catheter), light gray boxes represent the Fs group (femoral catheter and sciatic single injection), and dark gray boxes represent the FCS group (femoral and sciatic catheter). For each patient, POD 2 pain score measurements (NRS, numeric rating scale) are performed at 8:00 AM (left) and 6:00 PM (right). All patients who received a sciatic block had significant lower pain scores at rest on POD 0 (postanesthesia care unit and 6:00 PM) ($P < 0.01$), whereas only the patients with a sciatic nerve catheter had significantly less pain on POD 1 ($P < 0.05$). Although the differences were clinically relevant on day 0 according to International Association for the Study of Pain (IASP) definition (ΔNRS >2), they were not clinically relevant on day 1. The patients with a continuous sciatic nerve catheter had statistically significant pain reduction during mobilization on POD 1 and 2; however, postoperative pain during mobilization was always below preoperative values in all groups. *$P < 0.05$. **$P < 0.01$.

Statistical Analysis

We considered a 25% reduction in discharge readiness to be clinically relevant (normal length of stay 4 days). On the basis of previous data, we assumed a standard deviation of 1 day. Sample size analysis indicated that a group size of 30 patients will allow to show a 25% difference between groups at a 90% power and at a 2-tailed alpha level of 0.05 (after Bonferroni correction for multiple comparisons). Intention-to-treat analysis was conducted.

Comparisons between groups were made by Kruskal-Wallis test and, if significant, by unpaired 2-sided Mann-Whitney *U* test. Dichotomous variables were compared on contingency

TABLE 4. Postoperative Morphine Consumption

Morphine (mg/24 h)	F Group (n = 29)	Fs Group (n = 30)	FCS Group (n = 30)	*P*
POD 0	16 (0–42) 27/29	2 (0–22) 16/30	0 (0–16) 11/30	0.000
POD 1	0 (0–48) 5/29	0 (0–5) 1/30	0 (0–0) 0/30	0.006
POD 2	0 (0–48) 7/29	0 (0–8) 3/30	0 (0–0) 0/30	0.011
POD 3	0 (0–40) 3/29	0 (0–13) 1/30	0 (0–0) 0/30	0.149

A significant difference was found between the F group and the other 2 groups on POD 0 and 1 but only between the F group and the FCS group on POD 2. After the day of surgery (POD 1-3), median (range) morphine consumption was 0 mg for all groups. When morphine was administered orally the equipotent dose was calculated (oral/IV; 3:1) and added to the total morphine requirement. The number of patients per group who required morphine is given below.

TABLE 5. Bolus Doses of Levobupivacaine 0.125% per Group

		F Group (n = 29)	Fs Group (n = 30)	FCS Group (n = 30)
POD 1	8 AM	25 (0–119)	6 (0–163)	6 (0–144)
	6 PM	13 (0–94)	3 (0–106)	0 (0–75)
POD 2	8 AM	6 (0–44)	0 (0–56)	0 (0–25)

Levobupivacaine (mg/12 h) delivered as bolus via patient-controlled femoral nerve block (basic infusion rate of levobupivacaine 0.125%, 6 mL/h). There were no statistically significant differences between groups.

table by Fisher exact test. A value of $P < 0.05$ was considered significant. The P values of the primary end points (readiness to discharge) were corrected by Bonferroni-Holmes adjustment for multiple comparisons.

RESULTS

Patients were included between February 2008 and April 2010. A CONSORT flow diagram of eligible and participating patients is demonstrated in Figure 1. Four patients had a staged bilateral TKA. One patient (F group) withdrew consent after randomization and refused to give NRS scores or other data. Therefore, no data from this patient could be analyzed. Patients with primary failed blocks (1 femoral in the FCS group, 2 sciatic blocks in the Fs group) were included in an intention-to-treat analysis.

Demographic data and values for required sedation, block performance, and tourniquet as well as surgery duration are shown in Tables 2 and 3 per group. There were no significant demographic differences between the 3 groups.

Three patients had no signs of nerve block within 40 minutes. The other 86 patients developed signs of motor and sensory block within 15 minutes, whereas complete block took up to 40 minutes. There were no significant differences between groups regarding onset times of blocks.

Readiness to Discharge and Functional Outcome

Median time-to-discharge readiness was similar for all 3 groups: F group, 4.0 days (range, 2.0–16.0 days); Fs group, 4.0 days (range, 2.0–7.0 days); and FCS group, 4.0 days (range, 2.0–9.0 days) (Fig. 2). The actual median length of hospital stay was equal to the time-to-discharge readiness and did not differ between groups: F group, 4 days (range, 3–16 days); Fs group, 4 days (range, 4–10 days); and FCS group, 4 days (range, 4–10 days).

Similarly, no significant differences were found in active knee flexion at the time-to-discharge readiness (F group, 75 degrees [range, 55–90 degrees]; Fs group, 80 degrees [range, 55–95 degrees]; and FCS group, 80 degrees [range, 40–95 degrees]) or in MRC-Q (F group, 3 [range, 3–4]; Fs group, 3 [range, 2–4]; and FCS group, 3 [range, 2–5]). Likewise, there were no significant differences in active flexion (Fig. 3) or MRC-Q between all groups at POD 2, 3, and 4 or at discharge.

Postoperative Pain and Analgesic Consumption

Patients in the F group had significantly more postoperative pain at the day of TKA compared with those in the Fs and FCS groups (Fig. 4). During the first postoperative hours in the postanesthesia care unit, patients of the F group experienced moderate to severe pain with a median pain score of 7 (range, 0–10), whereas patients of the Fs and FCS groups had a median pain score of 0 (range, 0–10; $P < 0.01$). Patients in the F group needed 16 mg (range, 0–42 mg) of morphine IV in contrast to the Fs (2 mg [range, 0–22 mg]) and FCS groups (0 mg [range, 0–12 mg], $P < 0.01$; Table 4). When patients still experienced pain scores higher than 4 after morphine 15 to 20 mg IV, supplemental medication like *S*-ketamine 5 to 10 mg IV and clonidine 75 to 150 μg were administered (9 patients in the F group, 1 patient in the Fs group, and 1 patient in the FCS group, $P < 0.01$). Nevertheless, patients in the F group still had more pain at the end of the day (NRS POD 0, at 6 PM in the F group, 4 [range, 0–7]; Fs group, 0 [range, 0–8]; and FCS group, 0 [range, 0–6]; $P < 0.01$). Until POD 2, pain at rest and during mobilization was significantly less in the FCS group. However, pain during mobilization was moderate in the F and Fs groups (median NRS ≤5; Fig. 4B) and mild at rest in all groups. Rescue medication with morphine was increased in the F group on POD 0 to 2 (Table 4). Incidence of postoperative nausea and vomiting was 6.7% without significant difference between groups.

No significant difference for delivered boluses of levobupivacaine 0.125% applied via the patient-controlled femoral nerve block was found between groups (Table 5).

Complications

Twelve patients did not have mobilization according to the schedule because of hematoma, swelling, or wound leakage (4 patients in the F group, 5 patients in the Fs group, and 3 patients in the FCS group). One patient (F group) required surgical drainage on POD 3. The number of patients with delayed mobilization included 3 of the total 4 patients (3 patients in the Fs group and 1 patient in the FCS group), who had fallen because of unaccompanied mobilization on POD 2.

After diagnosis of a full motor block of the foot in 11 patients from the FCS group on POD 1, infusion of continuous sciatic nerve block was interrupted temporarily until motor function was restored and then infusion of levobupivacaine was continued at a lower infusion rate (6 mL/h) and motor block did not reappear in any of these patients.

DISCUSSION

Addition of a single-injection or continuous sciatic nerve block to a continuous femoral nerve block for postoperative pain treatment after TKA did not improve time-to-discharge readiness or knee function in this randomized controlled trial. However, early postoperative pain relief was much better controlled at rest and during mobilization, whereas opioid requirements were reduced in patients with a sciatic nerve block. The group receiving a continuous sciatic catheter had significantly less pain during mobilization.

Patients with continuous femoral nerve block alone experienced severe postoperative pain on the day of TKA, whereas the addition of a sciatic block provided complete pain relief. Thus, sciatic nerve block combined with a continuous femoral nerve block improved the quality of early postoperative analgesia significantly and in a clinically relevant manner. The difference in median pain score between groups was 7 on an NRS from 0 to 10 and are in line with observational studies[22,23] and 2 other randomized trials.[24,25] The high pain scores in the F group are concerning and may be explained by the fact that our patients received only short-acting and ultra short-acting opioids before and during the surgery. However, the use of longer-acting opioids might be insufficient for those patients requiring up to 42 mg of morphine and who still had moderate

to severe pain scores during the early postoperative period. Even the addition of *S*-ketamine and clonidine as nonopioid rescue analgesics was needed frequently in the F group to achieve sufficient pain control.

One may argue that patient-controlled systemic analgesia would have reduced the maximum pain scores and might have been a better indicator for a good postoperative pain therapy. However, it is difficult to include an additional patient-controlled infusion pump and handling 2 patient-controlled systems in elderly patients shortly after a major surgery under general anesthesia.

Because median pain scores at rest were 2.0 or lower in all groups from POD 1 on, we could not demonstrate any advantage of a sciatic nerve block for pain relief at rest from that time on. However, addition of a continuous sciatic nerve block controls pain significantly better during mobilization. Although the pain reduction is according to International Association for the Study of Pain (IASP) definitions clinically relevant, the median pain scores during mobilization were moderate in patients receiving a femoral nerve block with or without single-injection sciatic nerve block.

Readiness to discharge was not affected when combining a sciatic nerve block to a continuous femoral nerve block in our study. While Ilfeld et al[26,27] demonstrated in 2 multicenter studies a difference in time to reach discharge criteria when pain was better controlled with an extended continuous femoral nerve block during 4 days compared with a continuous femoral nerve block overnight, addition of a sciatic nerve block did not affect readiness to discharge in our study. However, because discharge criteria, patient population, clinical pathway, and systemic analgesic management were different between the cited study and the present investigation, it is difficult to draw conclusions from comparisons of these 2 studies.[26,27]

A sciatic nerve block, specially a continuous block, might impair motor function and thereby might have a negative effect on active knee movement, thereby delaying hospital discharge. Of the patients in the FCS group, 36.7% had a motor block on POD 1. Subsequently, the infusion was stopped and later restarted at a lower rate. Thus, none of the patients had a motor block on POD 2; furthermore, all regional anesthesia was stopped at 6 AM on POD 2. No patient of any group reached discharge criteria on POD 1. Therefore, it is unlikely that the high incidence of motor block in the FCS group had influenced the discharge criteria.

One may also argue that the addition of a sciatic nerve block requires more patient preparation time. Establishing sciatic nerve block took, on average, less than 5 minutes and, therefore, had little impact on the clinical pathway. However, in institutions with less experience in regional techniques, this time might be longer and more relevant.

In patients having considerable more pain (like those in the F group), one should expect an increased demand and delivery of levobupivacaine 0.125%. However, no differences were found between groups in total bolus dose via patient-controlled femoral block.

Worrisome are the 4 falls during mobilization at the beginning of the study period. Falls occurred in 3 patients of the Fs group and 1 patient of the FCS group on POD 2. In all cases our safety instructions for mobilization were violated. We repeated education to nurses and patients about nerve block induced motor weakness and risks of falling and observed no further falls thereafter. Our study is underpowered to draw conclusions on the influence of blocks on fall incidents. Previously, worries about the risk of falling when using a femoral block in patients undergoing TKA have been expressed.[28,29] The incidence of falls reported by these authors is lower than the incidence we determined, probably due to underreporting in these retrospective studies. Recently, Ilfeld et al[30] reanalyzed the risk of falling in their prospective randomized studies in patients undergoing TKA with or without continuous femoral nerve block. The authors observed significantly more fall incidents in the groups with continuous femoral nerve block, although none of the falls led to a change in treatment or delay of hospital discharge. Incidents of falls were moderately higher than the incidents we observed. As shown recently, effective fall prevention is much more than providing an information folder or to just advice the patient that he/she should not ambulate on his own.[31]

A limitation of the study is the absence of blinding of patients.

In conclusion, combining sciatic nerve block to femoral nerve catheter did not influence readiness to discharge or short-term knee function. A single-injection sciatic nerve block can reduce severe pain on the day of surgery, whereas a continuous sciatic nerve block reduces moderate pain during mobilization on the first 2 postoperative days. Therefore, improved pain therapy cannot simply be translated into reduced hospital stay and improved short-term rehabilitation.

REFERENCES

1. Losina E, Walensky RP, Kessler CL, et al. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. *Arch Intern Med*. 2009;169:1113–1121.
2. Singelyn FJ, Deyaert M, Joris D, Pendeville E, Gouverneur JM. 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.
3. Capdevila X, Barthelet Y, Biboulet P, et al. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology.* 1999; 91:8–15.
4. Horlocker TT, Kopp SL, Pagnano MW, Hebl JR. Analgesia for total hip and knee arthroplasty: a multimodal pathway featuring peripheral nerve block. *J Am Acad Orthop Surg*. 2006;14:126–135.
5. Ganapathy S, Wasserman RA, Watson JT, et al. Modified continuous femoral three-in-one block for postoperative pain after total knee arthroplasty. *Anesth Analg*. 1999;89:1197–1202.
6. McNamee DA, Convery PN, Milligan KR. Total knee replacement: a comparison of ropivacaine and bupivacaine in combined femoral and sciatic block. *Acta Anaesthesiol Scand*. 2001;45:477–481.
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;16:436–445.
8. Sites BD, Beach M, Gallagher JD, et al. A single injection ultrasound-assisted femoral nerve block provides side effect–sparing analgesia when compared with intrathecal morphine in patients undergoing total knee arthroplasty. *Anesth Analg*. 2004;99: 1539–1543.
9. Fowler SJ, Symons J, Sabato S, Myles PS. Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. *Br J Anaesth*. 2008;100:154–164.
10. Morfey DH, Brull R. Target driven analgesia for total knee arthroplasty. *Anaesthesia*. 2009;64:332–333.
11. Paul JE, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Anesthesiology.* 2010;113:1144–1162.

12. Hadzic A, Houle TT, Capdevila X, Ilfeld BM. Femoral nerve block for analgesia in patients having knee arthroplasty. *Anesthesiology*. 2010;113:1014–1015.
13. Macalou D, Trueck S, Meuret P, et al. Postoperative analgesia after total knee replacement: the effect of an obturator nerve block added to the femoral 3-in-1 nerve block. *Anesth Analg*. 2004;99:251–254.
14. Boezaart AP. Perineural infusion of local anesthetics. *Anesthesiology*. 2006;104:872–880.
15. Chelly JE, Casati A. Perineural infusion of local anesthetics: more to the review. *Anesthesiology*. 2007;106:191–192.
16. Levesque S. Sciatic nerve block for total-knee replacement: is it really necessary in all patients? *Reg Anesth Pain Med*. 2005;30:410–411.
17. Sciard D, Lam N, Hussain M. Continuous sciatic nerve block and total-knee arthroplasty. *Reg Anesth Pain Med*. 2005;30:411–412.
18. Pham DC, Guilley J, Dernis L, et al. Is there any need for expanding the perineural space before catheter placement in continuous femoral nerve blocks? *Reg Anesth Pain Med*. 2006;31:393–400.
19. 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;30:434–445.
20. Mansour NY. Reevaluating the sciatic nerve block: another landmark for consideration. *Reg Anesth*. 1993;18:322–323.
21. Neal JM. Assessment of lower extremity nerve block: reprise of the four P's acronym. *Reg Anesth Pain Med*. 2002;27:618–620.
22. 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;98:747–749, table of contents.
23. Aguirre J, Neudoerfer C, Ekatodramis G, Borgeat A. The sciatic nerve should be blocked to optimize postoperative analgesia after knee arthroplasty. *Eur J Anaesthesiol*. 2009;26:439–440.
24. Pham DC, Gautheron E, Guilley J, et al. The value of adding sciatic block to continuous femoral block for analgesia after total knee replacement. *Reg Anesth Pain Med*. 2005;30:128–133.
25. Cook P, Stevens J, Gaudron C. Comparing the effects of femoral nerve block versus femoral and sciatic nerve block on pain and opiate consumption after total knee arthroplasty. *J Arthroplasty*. 2003;18:583–586.
26. Ilfeld BM, Mariano ER, Girard PJ, et al. A multicenter, randomized, triple-masked, placebo-controlled trial of the effect of ambulatory continuous femoral nerve blocks on discharge-readiness following total knee arthroplasty in patients on general orthopaedic wards. *Pain*. 2010;150:477–484.
27. Ilfeld BM, Meyer RS, Le LT, et al. Health-related quality of life after tricompartment knee arthroplasty with and without an extended-duration continuous femoral nerve block: a prospective, 1-year follow-up of a randomized, triple-masked, placebo-controlled study. *Anesth Analg*. 2009;108:1320–1325.
28. Kandasami M, Kinninmonth AW, Sarungi M, Baines J, Scott NB. Femoral nerve block for total knee replacement—a word of caution. *Knee*. 2009;16:98–100.
29. Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. *Clin Orthop Relat Res*. 2010;468:135–140.
30. Ilfeld BM, Duke KB, Donohue MC. The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. *Anesth Analg*. 2010;111:1552–1554.
31. Dykes PC, Carroll DL, Hurley A, et al. Fall prevention in acute care hospitals: a randomized trial. *JAMA*. 2010;304:1912–1918.