Adductor Canal versus Femoral Continuous Peripheral Nerve Blocks For Knee Arthroplasty: A One-Year Follow-Up Pilot Study of 2 Randomized, Controlled Clinical Trials

Running title: Adductor Canal vs. Femoral Continuous Nerve Blocks

Evan N. Davidson, BA[1]
Anthony T. Machi, MD [2]
Jacklynn F. Sztain, MD [3]
Nicholas J. Kormylo, MD [4]
Sarah J. Madison, MD [5]
Wendy B. Abramson, MD [6]
Amanda M. Monahan, MD [7]
Bahareh Khatibi, MD [8]
Scott T. Ball, MD [9]
Francis B. Gonzales, MD [10]
Daniel I. Sessler, MD [11]
Brian M. Ilfeld, MD, MS (Clinical Investigation) [12]

[1] Medical Student, School of Medicine
[2] Assistant Professor, Department of Anesthesiology
[3,5-8] Assistant Clinical Professor, Department of Anesthesiology
[4] Associate Clinical Professor, Department of Anesthesiology
[9] Associate Clinical Professor, Department of Orthopaedic Surgery
[10] Assistant Clinical Professor, Department of Orthopaedic Surgery
[11] Michael Cudahy Professor and Chair, Department of **O**UTCOMES **R**ESEARCH
[12] Professor, In Residence, Department of Anesthesiology

University of California San Diego, San Diego, California;[1,3-10,14] University of Texas Southwestern Medical Center, Dallas, Texas;[2] the Cleveland Clinic, Cleveland, Ohio;[11] and, the **O**UTCOMES **R**ESEARCH Consortium[11,12]

Address for correspondence: Brian M. Ilfeld, MD, MS, Department of Anesthesiology, 200 West Arbor Drive, MC 8770, San Diego, California, 92103-8770. Telephone (619) 543-8274; Fax: (858) 683-2003; bilfeld@ucsd.edu

Clinical Trials Registration Statement: found at clinicaltrials.gov, NCT01759277

Acknowledgements

Assistance: None

Financial Support: Funding for the original randomized, controlled trials provided by the University California Academic Senate (San Diego, California); Summit Medical (Sandy, Utah); and Teleflex Medical (Research Triangle Park, North Carolina). Teleflex Medical also provided the perineural catheters used in the investigations. Neither company had input into any aspect of study conceptualization, design, and implementation; data collection, analysis and interpretation; or manuscript preparation. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the funding entities.

Conflict of Interest: None of the authors has a personal financial interest in this research.

Presentation: None declared

ABSTRACT

Study Objective: For patients undergoing tricompartment or unicompartment knee arthroplasty, previous studies have shown that a continuous femoral block provides superior analgesia in various circumstances compared with a continuous adductor canal block during the local anesthetic infusion. However, the long-term outcomes of these two approaches remains unknown. We thus evaluated functional outcomes with each approach 1, 4, and 12 months after surgery.

Design: This is a retrospective one-year pilot study of two prospective, randomized, controlled clinical trials.

Setting: An academic medical center in Southern California.

Patients: Subjects undergoing unicompartment or tricompartmental knee arthroplasty.

Interventions: Subjects were randomized to receive either a continuous adductor canal (n=54) or femoral (n=56) nerve block for 48-72 postoperative hours.

Measurements: This follow up study measured passive range of motion of the surgically operated knee, assistive device use during ambulation, and pain scores collected at follow-up visits at 1, 4, and 12 months. These data were obtained via chart review.

Main Results: The underlying previous studies provided evidence that in some situations a continuous femoral block provided superior analgesia than the adductor counterpart, but that

ambulation and functional mobility were superior in subjects randomized to continuous adductor canal blocks. We now report that there were no statistically significant differences between the two treatments for pain scores, assistive device usage, or passive knee range-of-motion at 1, 4 and 12 months following surgery.

Conclusions: This 1-year follow-up pilot study of two previously-published randomized, controlled trials did not find evidence to support the theory that long-term outcomes differ when post-surgical analgesia is provided by either a femoral or adductor canal continuous nerve block in the immediate postoperative period.

Keywords: adductor canal block, femoral block, total knee arthroplasty

1.0 Introduction

Following knee arthroplasty, patients typically experience moderate to severe pain. Frequently, this pain is treated through oral and intravenous analgesics in combination with a continuous peripheral nerve block (CPNB), which involves infusing local anesthetic *via* a percutaneously-inserted perineural catheter. There are primarily two different anatomic locations to insert a perineural catheter to provide analgesia following knee arthroplasty: (1) at the level of the inguinal crease (a "femoral" catheter) or mid-thigh (an "adductor canal" catheter).[1,2]

While femoral CPNB has many benefits, one of the challenges of using this technique is a decrease in muscle strength. Both afferent (sensory and proprioception) and efferent (motor) nerve impulses exist at the level of the femoral crease where the catheter is inserted, and local anesthetics block both of these pathways.[3] Because decreased muscle strength and proprioception theoretically increase the risk of falling and limit postoperative rehabilitation, researchers and clinicians have sought an alternative whereby the positive sensory effects are attained without the concomitant motor and proprioception effects.

The adductor canal block is the primary alternative.[4,5] The adductor canal is an aponeurotic tunnel in the middle third of the thigh that runs from the apex of the femoral triangle to the opening in the adductor magnus.[6] It contains the saphenous nerve (the terminal branch of the femoral nerve), medial femoral cutaneous nerve, articular branches from the obturator nerve and the medial retinacular nerve as well as motor branch to the vastus medialis.[5] Because the only motor branch contained in the adductor canal is the branch to the vastus medialis, this block induces less quadriceps weakness and allows for a dramatic increase in ambulatory ability compared with a

femoral infusion following knee arthroplasty.[8,10,11] Unfortunately, there is also data suggesting that perineural adductor canal infusions provide inferior analgesia to their femoral counterparts, at least within the very early postoperative period.[10,11] The latter is of great importance because studies comparing continuous femoral nerve blocks with intravenous opioid analgesia reported not only improved analgesia with the former, but increased knee flexion both during and following the infusion itself for up to 12 weeks.[1, 12]

The first two randomized, controlled clinical trials comparing multi-day continuous femoral and adductor canal blocks following knee arthroplasty were recently published; but, reported outcomes only within the immediate postoperative period of one week.[10,11]We therefore performed this follow-up study of those two investigations to identify any long term benefits of one delivery method over the other at up to one year, including (1) passive range-of-motion; (2) persistent post-surgical pain; and, (3) use of assistive ambulatory devices.

2.0 Materials and Methods

2.1 Enrollment

The two previous clinical trials were prospectively registered at clinicaltrials.gov (NCT01759277), conducted within the ethical guidelines outlined in the Declaration of Helsinki, and followed Good Clinical Practice.[10,11] The local institutional review board (Director: Anthony Magit, University of California, 200 W. Arbor Drive, San Diego, CA 92103. Project 150696X, approved July 9, 2015) approved all study procedures, and written informed consent was provided by each subject.

In the original two studies, adults undergoing tricompartment or unicompartment knee arthroplasty were randomized to receive either a continuous femoral or an adductor canal block. Preoperatively, subjects had their perineural catheter inserted (FlexBlock, Teleflex Medical, Research Triangle Park, NC). Using a portable, programmable, electronic infusion pump (ambIT PreSet, Summit Medical Products, Inc. Salt Lake City, Utah), a ropivacaine 0.2% infusion was administered *via* the perineural catheter (initial basal rate 6 mL/h; 4 mL bolus; 30 minute lockout). Following joint closure, the surgeon infiltrated the joint using 30 mL of ropivacaine (0.5%), ketorolac (30 mg), epinephrine (5 g/ml), and tranexamic acid (2 g). Postoperatively, patients were placed on sustained release Oxycontin, celecoxib and acetaminophen. Breakthrough pain was treated with immediate release opioids. The perineural basal infusion rate was titrated to subject comfort (increased 2 mL/h for NRS > 4) up to twice daily (maximum = 12 mL/h).

The primary outcome measure was the time from the end of surgery until four criteria were fulfilled without reversion to unfulfilled status: (1) adequate analgesia (defined as NRS < 4 as recorded by nursing staff every 4 hours and at the time of analgesic request); (2) independence

from intravenous opioids for at least 12 hours; (3) ability to independently stand and sit down (evaluated with the Timed Up and Go test); and (4) unassisted ambulation of at least 30 meters (evaluated with the 6-minute walk test). Perineural catheters were removed the morning of postoperative day (POD) 2 or 3 for uni- and tri-compartment knee arthroplasty procedures, respectively.

Following discharge, patients returned for examination at approximately 1, 4, and 12 months following surgery. During these visits, information was collected regarding the current level of pain (charted using the Numeric Rating Scale for pain from 0-10 with lower values corresponding to lower levels of pain), passive range-of-motion capturing both extension and flexion with a standard goniometer, and use of assistive devices during ambulation. This data was charted in the medical record.

Subsequently, the local Institutional Review Board (University of California San Diego, San Diego, California) approved the current study, permitting the recovery of subject records solely for analysis purposes. A waiver of consent was granted for this specific portion of study and all data was de-identified.

2.2 Statistical Methods

Normality of data distribution was determined using the Shapiro-Wilk normality test (Prism 6, GraphPad, San Diego, California). Parametric and nonparametric data were tested using the t-test or Mann-Whitney test, respectively; and, presented as mean (SD) or median [interquartile], respectively. Nominal data was analyzed using the Pearson Chi-squared test. A $P<0.05$ was considered statistically significant.

3.0 Results

From March 2013 to July 2014, a total of 104 patients were randomized to either receive a continuous adductor canal (n=54) or femoral (n=56) nerve block (Figure 1) [10,11]. In brief, during the local anesthetic perineural infusion, regardless of surgical procedure (uni- vs tri-compartment knee arthroplasty) subjects with an adductor canal catheter could ambulate further than those with a femoral catheter ($P<0.001$). However, for subjects with a unicompartment knee arthroplasty, pain was reduced at both rest ($P<0.001$) and during physical therapy ($P=0.03$). Similarly, pain was reduced during physical therapy for subjects with a tricompartment procedure ($P=0.01$-0.02). Data for these endpoints was not reported for time points following catheter removal and infusion discontinuation.

For the current follow-up investigation, no statistically significant differences were found in the treatment groups for any of the examined end points at 1, 4, or 12 months following surgery (Table 1).

4.0 Discussion

This 1-year follow-up pilot study of two previously-published randomized, controlled trials did not find evidence to support the theory that long-term outcomes differ when post-surgical analgesia is provided by either a femoral or adductor canal continuous nerve block in the immediate postoperative period. This is in contrast with data from these same subjects during the infusions themselves (within the first 48-72 postoperative hours) in which distinct benefits were attributable to each of the two anatomic locations: improved physical therapy for adductor canal catheters versus improved analgesia for femoral infusions.

This pilot study was undertaken to investigate whether or not a future larger, randomized, controlled trial is warranted to compare these two modalities for long-term differences; and, to help power such a subsequent study if warranted. While the current study was not adequately powered to detect statistically significant differences between the two treatments at the 1-12 month time points investigated, this pilot study does not suggest that such an investigation is warranted. We conclude that while there are short-term benefits to both adductor canal and femoral continuous peripheral nerve blocks following knee arthroplasty during the infusions within the immediate postoperative period, there is no evidence that long-term differences in outcomes exists between these two techniques.

References

1. Singelyn, FJ, Deyaert M, 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.
2. Jenstrup MT, Jaeger P, Lund J, Fomsgaard, Bache S, Mathiesen O, Larsen TK, Dahl JB. Effects of Adductor-Canal-Blockade on pain and ambulation after total knee arthroplasty: a randomized study. *Acta Anaesth Scand* 2012; **56**:357-364.
3. Ilfeld BM, Loland VJ, Sandhu NS, Suresh PJ, Bishop MJ, Donohue MC, Ferguson EJ, Madison SJ. Continuous Femoral Nerve Blocks: The Impact of Catheter Tip Location Relative to the Femoral Nerve (Anterior Versus Posterior) on Quadriceps Weakness and Cutaneous Sensory Block. *Anesth-Analg* 2012; **115**:721-727
4. Manickam B, Perlas A, Duggan E, Brull R, Chan V, Ramlogan R. Feasibility and Efficacy of Ultrasound-Guided Block of the Saphenous Nerve in the Adductor Canal. *RAPM* 2009; **34**: 578-580.
5. Davis JJ, Bond TS, Swenson JD. Adductor Canal Block *More than Just the Saphenous Nerve*? *RAPM* 2009; **34**: 618-619.
6. Andersen HL, Gray AT. The Saphenous Nerve Block. *ASRA* News 2012; Feb: 10-12.
7. Jaeger P, Grevstad U, Henningsen MH, Gottschau B, Mathiesen O, Dahl JB. Effect of adductor-canal-blockade on established, sever post-operative pain after total knee arthroplasty: a randomized study. *Acta Anaesth Scand* 2012; **56**: 1013-1019.

8. Jaeger et al. Adductor Canal Block Versus Femoral Nerve Block for Analgesia After Total Knee Arthroplasty A Randomized, Double-blind Study. *Reg Anesth Pain Med* 2013; **38**: 526–532
9. Lund J, Jenstrup MT, Jaeger P, Sorenson AM, Dahl JB. Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results. *Acta Anaesth Scand* 2011; **55**:14-19
10. Machi AT, Sztain JF, Kormylo JN, Madison SJ, Abramson WB, Monahan AM, Khatibi B, Ball ST, Gonzales FB, Sessler DI, Mascha EJ, You J, Nakanote KA, Ilfeld BM. Discharge-readiness following tricompartment knee arthroplasty: Adductor canal versus femoral continuous nerve blocks; a dual-center, randomized trial. *Anesthesiology* 2015; **123**: 444-56 PMID: 26079800
11. Sztain, Jacklyn et al. Continuous Adductor Canal versus Continuous Femoral Nerve Blocks: Relative Effects on Discharge-Readiness following Unicompartment Knee Arthroplasty. *Reg Anesth Pain Med.* 2015 Sep-Oct; **40(5):**559-67
12. Capdevila et al. Effects of Perioperative Analgesic Technique. *Anesthesiology* 1999; **91**: 8

Table 1. Results

Postoperative Time Point		Adductor Canal	Femoral	P-Value
1 Month				
	Total (unicompartment)	54 (15)	56 (15)	
	Postoperative day visit	31 [29-34]	30 [28-34]	0.80
	Pain score (0-10)	2.0 [1.0-4.0]	2.5 [0.8-4.0]	0.80
	Reporting pain score = 0	20%	25%	0.40
	Passive extension ROM (degrees)	3 [0-5]	5 [2-5]	0.55
	Passive flexion ROM (degrees)	110 [100-120]	110 [105-120]	0.67
	Using ambulatory assist devices	47%	55%	0.26
4 Months				
	Total (unicompartment)	51 (15)	52 (15)	
	Postoperative day visit	122 [117-239]	121 [118-127]	0.80
	Pain score (0-10)	0 [0.0-3.0]	0.5 [0.0-2.0]	0.80
	Reporting pain score = 0	55%	50%	0.48
	Passive extension ROM (degrees)	0 [0-2]	0 [0-3]	0.45
	Passive flexion ROM (degrees)	110 [100-120]	110 [105-120]	0.67
	Using ambulatory assist devices	10%	10%	>0.99
12 Months				
	Total (unicompartment)	23 (7)	27 (8)	
	Postoperative day visit	367 [352-405]	382 [363-421]	0.28
	Pain score (0-10)	0.0 [0.0-3.0]	0.5 [0.0-2.0]	0.80
	Reporting pain score = 0	65%	68%	0.65
	Passive extension ROM (degrees)	0 [0-0]	0 [0-0]	0.58
	Passive flexion ROM (degrees)	125 [120-130]	125 [120-130]	0.33
	Using ambulatory assist devices	9%	4%	0.15

Data presented as median [interquartile], or otherwise indicated
ROM: range-of-motion

Figure Legend

Figure 1. CONSORT flow diagram.