

Continuous Suprainguinal Fascia Iliaca Block vs Epidural Analgesia for Pediatric Hip Surgery: A Retrospective Cohort Study

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Introduction: The primary aim of this study was to compare the continuous suprainguinal fascia iliaca block (CSFI) and continuous epidural analgesia (CEA) for procedures of the proximal femur and acetabulum in children. We hypothesized that CSFI would provide equivalent opioid requirements while both blocks were in place, reduced opioid requirements after epidural removal, earlier mobilization, and decreased length of stay compared to CEA.

Materials and Methods: We retrospectively examined all pediatric patients who underwent a procedure of the proximal femur or acetabulum between January 1, 2013, and December 31, 2023. Outcome measures included opioid usage, verbal pain scores (0-10), sedation scores, time to ambulation and length of hospital stay. The primary endpoint was daily opioid requirements.

Results: There were 82 patients in the cohort, 35 patients in the CEA group and 47 patients in the CSFI group. We found no evidence for differences in daily mean opioid requirements (parenteral and oral) for the two groups on the day of surgery (DOS) and POD 1 when both blocks were in place. CSFI was strongly associated with lower mean opioid requirements on POD 2 and POD 3 following removal of the epidural catheter, earlier time to ambulation, shorter length of stay and less sedation on the DOS, POD 1, and 2. Four patients reported persistent anterior thigh numbness 6 weeks after the procedure, all in the CSFI group. (8.5%).

Conclusion: CSFI was associated with similar parenteral and oral opioid requirements compared to CEA while both blocks were in place, earlier mobilization, reduced length of stay, less sedation and reduced opioid usage after epidural removal. CSFI appears to offer significant advantages over CEA for procedures of the proximal femur and acetabulum in pediatric patients, but persistent thigh numbness in the CSFI group warrants further investigation.

Keywords: fascia iliaca block, epidural anesthesia, hip surgery, regional anesthesia

Introduction

Effective postoperative pain management is essential for optimizing recovery in pediatric patients following surgery of the proximal femur and acetabulum. Continuous epidural analgesia (CEA) provides reliable pain control for these surgeries by anesthetizing the lumbar and sacral plexuses.^{1,2} However, motor blockade of the non-operative leg requires discontinuing CEA to facilitate recovery. Reported alternative methods of postoperative regional analgesia for these surgeries include the lumbar plexus block,³ quadratus lumborum block,⁴ erector spinae plane block⁵ and the single injection suprainguinal fascia iliaca compartment block.⁶ The single injection suprainguinal fascia iliaca block has been reported to provide analgesia for procedures of the hip and proximal femur in pediatric patients for 8–12 hours.⁷ Placement of a catheter into the fascia iliaca compartment for a continuous suprainguinal fascia iliaca block (CSFI) has the potential to provide analgesia beyond CEA by not requiring discontinuing the block for weakness of the non-operative leg. To our knowledge, no prior studies have directly compared CEA and CSFI for pediatric hip procedures. The primary objective of this study was to compare the efficacy of CSFI and CEA in children undergoing surgery of the proximal femur and acetabulum. The primary outcome was opioid

requirements in the two treatment groups. We hypothesized that CSFI would provide comparable opioid requirements while both blocks were active, decrease opioid requirements after epidural removal, allow earlier mobilization and a shorter hospital length of stay compared to CEA.

Materials and Methods

We conducted a retrospective cohort study of all pediatric patients who underwent surgery of the proximal femur or acetabulum between January 1, 2013, and December 31, 2023, at a pediatric orthopedic hospital. Approval was obtained for all parts of the study from the Washington Copernicus Group Institutional Review Board. Patients were divided into two groups based on the primary method of postoperative analgesia: CSFI or CEA. Patients were excluded if they had concomitant procedures beyond the acetabulum and femur, preexisting neurosensory deficit, inability to provide verbal pain scores or an alternative method of analgesia. Patients who had periacetabular osteotomy received CEA exclusively and were excluded. We collected demographic data for all participants to include age, gender, weight, body mass index, surgical procedure and preoperative diagnoses. All clinical outcome data (pain scores, sedation scores, opioid usage, nausea and pruritis) were extracted from the electronic medical record (EMR). We compared daily and total inpatient opioid usage through POD 3, when all CSFI patients had been discharged. We compared opioid usage with and without including epidural opioids. Postoperative opioid consumption was converted into oral morphine milliequivalent (OME) doses using standardized opioid conversion tables and presented as daily mean OME per weight in kilograms.⁸ Epidural hydromorphone and fentanyl usage was converted to OME using the conversion factor for intravenous dosing. We did not have access to patient opioid usage data after hospital discharge. We compared mean and maximum verbal pain scores (VPS, 0–10), mean Richmond sedation scores, time to ambulation, length of hospital stay, incidence of nausea, vomiting and pruritus. The frequency of pain score measurement was variable for each patient but a minimum of every four hours. Pain scores recorded as zero during sleep were not included. Postoperative nausea and vomiting and pruritis were inferred by multiple dosing with commonly used counteracting medications or when noted in the EMR. Clinic notes were followed for up to one year postoperatively to monitor potential complications related to the block. The primary endpoint of the study is daily opioid requirements. (parenteral and oral)

Protocol Description

In 2018 we transitioned to the CSFI from CEA for patients having procedures of the proximal femur and acetabulum. All surgical procedures were performed by one of three attending pediatric orthopedic surgeons. One of five pediatric anesthesiologists performed all peripheral nerve and epidural blockade using a standardized protocol. All patients had general anesthesia intraoperatively with propofol, sevoflurane, ketorolac, acetaminophen, dexamethasone, ondansetron and a laryngeal mask airway or endotracheal tube. Intraoperative analgesics were morphine or fentanyl. Intraoperative opioid dosing was at the discretion of the attending anesthesiologist. All study patients received the same multi-modal postoperative analgesia protocol in addition to their regional block, including scheduled acetaminophen (15 mg/kg), ibuprofen (10 mg/kg) and gabapentin (5mg/kg). All patients had intravenous (morphine) and oral (oxycodone) opioids available as needed for a pain score of four or greater. Hydromorphone and hydrocodone were available when these were not tolerated.

Continuous Suprainguinal Fascia Iliaca Block

All CSFI were performed under general anesthesia in the supine position. Using ultrasound guidance, (Logiq E, General Electric, Boston, MA) an echogenic 18 gauge, 4-inch Contiplex Tuohy stimulating needle (B. Braun, Meisungen, Germany) was inserted at the inguinal ligament and the fascia iliaca punctured at the junction of the internal oblique and sartorius muscles. (ie., bowtie sign) The deep circumflex iliac artery was identified when possible. The needle was advanced in a cephalad direction by hydrodissection to the circumflex iliac vessel. A total of 1 mL/kg of 0.2% ropivacaine (max 40 mL) with 1 mcg/kg of dexmedetomidine and 0.05 mg/kg of dexamethasone was injected through the needle. A catheter was then inserted 5 to 10 cm into the fascia iliaca compartment and position confirmed by visualization of injection. Postoperative inpatients received a continuous infusion of 0.2% ropivacaine at a rate of 0.1 mL/kg through the CSFI catheter for 48–72 hours. Patients were given the option to discharge home with the CSFI catheter.

Lumbar Epidural Block

Epidural catheters were placed under general anesthesia in the lateral decubitus position at the L2-3 or L3-4 interspace. Using a midline approach, an 18-gauge Touhy needle (B. Braun, Meisungen, Germany) was advanced through the ligament flavum by the loss of resistance technique. Following an epidural test dose with 1.5% lidocaine with epinephrine, an epidural catheter was threaded 3 to 5 cm into the epidural space. An epidural infusion of 0.1% ropivacaine with hydromorphone 5 mcg/mL or fentanyl 5 mcg/mL at 0.1 mL/kg/hr was initiated intraoperatively after a bolus of 0.1 mL/kg of 0.2% ropivacaine. The epidural infusion rate was adjusted as necessary for inadequate analgesia, excessive sedation or hypotension. Epidural infusions were discontinued at approximately 0500 on postoperative (POD) 2 to facilitate ambulation. All epidural patients had a foley catheter which was removed when the epidural infusion was discontinued.

Physical therapy notes were reviewed to determine when ambulation goals were achieved. Discharge criteria for all patients was independent sit to stand, ambulation 50 feet and negotiating five stairs with an assistive device. Per surgeon protocol, patients in the CEA group did not ambulate and physical therapy did not evaluate patients until the epidural was discontinued on POD 2 to avoid patient injury secondary to motor blockade of the non-operative leg. CSFI patients were allowed to ambulate and were evaluated by physical therapy on POD 1 because the non-operative leg was unaffected. We followed the patient's clinic notes for up to one year after the procedure for complications possibly associated with the block.

A formal sample size determination was not performed because all patient records meeting inclusion criteria during the study period were included in this retrospective analysis. To characterize the detection capability of this study, we conducted a sensitivity analysis using the pooled standard deviation estimated from the data (0.93 OME/kg). With 35 patients in the CEA group and 47 in the CSFI group, the study had 80% power to detect a difference of 0.59 OME/kg (approximately 29% reduction from the CEA mean) and 90% power to detect a difference of 0.67 OME/kg (33% reduction), at a two-tailed significance level of 0.05. The 95% confidence interval for the difference in total hospitalization opioid usage was [0.70, 1.60] OME/kg, with the entire interval exceeding a clinically meaningful threshold of 20% reduction (0.41 OME/kg). If a 20% reduction were considered the minimum clinically important difference for a future prospective study, approximately 83 patients per group would be required for 80% power.

Statistics

We used descriptive statistics to summarize patient demographics and clinical outcomes. Continuous variables were compared between the two groups using two-tailed t-tests, with a p-value < 0.05 considered statistically significant. Categorical variables were compared using the chi-square test with the Yates correction.

Results

A total of 82 patients were included in the study, 35 patients in the CEA group and 47 patients in the CSFI group. A comparison of the demographic data for both groups is presented in [Table 1](#). The average age in years was 14.6 in the CEA group and 12.7 in the CSFI group, which was statistically different but not felt to be clinically significant. Surgical data is presented in [Table 2](#). Over 90% of the patients in both treatment groups had surgery of the proximal femur, primarily femoral rotation for anteversion. All acetabular surgeries involved surgical dislocation of the hip, primarily for impingement syndrome. The mean inpatient duration of local anesthetic infusion for CEA was 45.4 (8.1) hours and CSFI 63.3 (12.1) hours ($p < 0.0001$). Twenty-six patients (57%) in the CSFI group elected to discharge home with an infusing fascia iliaca catheter.

For the primary outcome, we found no evidence for differences in mean parenteral and oral daily opioid requirements for the two groups on the day of surgery (DOS) and POD 1. CSFI was strongly associated with lower opioid requirements compared to the CEA group on POD 2 and POD 3 following the removal of the epidural catheter. ([Table 3](#), [Figures 1 and 2](#)) [Figure 2](#) shows the distribution of opioid usage for each patient per day. Note the few patients remaining in the CSFI group in [Figure 2](#) on POD 3, the remainder having been discharged to home. We found strong evidence that the CSFI group had significantly lower mean opioid usage for the entire hospitalization (CEA 2.04 (1.20) OME/kg vs CSFI 0.89 (0.66) OME/kg, $p < 0.0001$) When epidural opioids were included in the opioid usage calculations, opioid usage was significantly higher in the CEA group on DOS, POD 1, 2 and 3 ([Table 4](#)).

Table 1 Demographic Data in the Two Treatment Groups

Variable	CEA	CSFI	p value
Number patients	35	47	
Age Years (SD)	14.6 (3.2)	12.7 (3.9)	0.02*
Gender (F/M) (%F)	29/6 (82.9%)	31/16 (68.9%)	0.15
Weight (Kg) (SD)	62.1 (19.1)	54.5 (24.3)	0.13
BMI (SD)	23.7 (5.3)	22.3 (6.2)	0.30
ASA (1–4) (SD)	1.4 (0.5)	1.6 (0.5)	0.19

Note: *p<0.05.

Abbreviations: CEA, Continuous Epidural Analgesia; CSFI, Continuous Suprainguinal Fascia Iliaca Compartment Block; SD, Standard Deviation; BMI, Body Mass Index; ASA, American Society of Anesthesia Classification.

Table 2 Surgical Data

Procedure	CEA (n=35)	CSFI (n=47)	P value
Proximal femur	32 (91.4%)	43 (91.5%)	0.99
Femoral rotation	32 (91.4%)	36 (83.7%)	
Femoral Precise Nail	0	3 (7.0%)	
Internal Fixation Femur	0	4 (9.3%)	
Acetabulum	3 (8.6%)	4 (8.5%)	0.99
Hip Dislocation	3 (100%)	4 (100%)	
Surgical duration (hr/min) (SD)	2:08 (57)	2:03 (58)	0.34
Duration infusion (hr/min) (SD)	49.4 (8.1)	63.3 (12.1)	<0.0001

Abbreviations: CEA, Continuous Epidural Analgesia; CSFI, Continuous Suprainguinal Fascia Iliaca Block; hr/min, Hours/Minutes; SD, Standard deviation.

Table 3 Daily Opioid Usage (Parenteral and Oral) in the Two Treatment Groups, Epidural Opioids Excluded. (OME/Kg)

	CEA	CSFI	p values
DOS	0.50 (0.31)	0.58 (0.32)	0.30
POD 1	0.14 (0.22)	0.18 (0.24)	0.43
POD 2	0.69 (0.49)	0.23 (0.27)	<0.001*
POD 3	0.62 (0.43)	0.11 (0.17)	<0.005*

Note: *p<0.05.

Abbreviations: CEA, Continuous Epidural Analgesia; CSFI, Continuous Surpainguinal Fascia Iliaca Block; DOS, Day of surgery; POD, Postoperative day; OME, Oral Morphine Equivalents.

The CSFI group was strongly associated with significantly earlier time to ambulation (1.12 days (0.33) vs. 2.00 days (0.49), P<0.0001), shorter length of stay (1.64 days (0.76) vs. 3.29 days (0.79), P<0.0001) and less sedation with a significant difference in Richmond sedation scores on the DOS, POD 1, and 2. (DOS, -0.19 (0.19) vs. -0.64 (0.64),

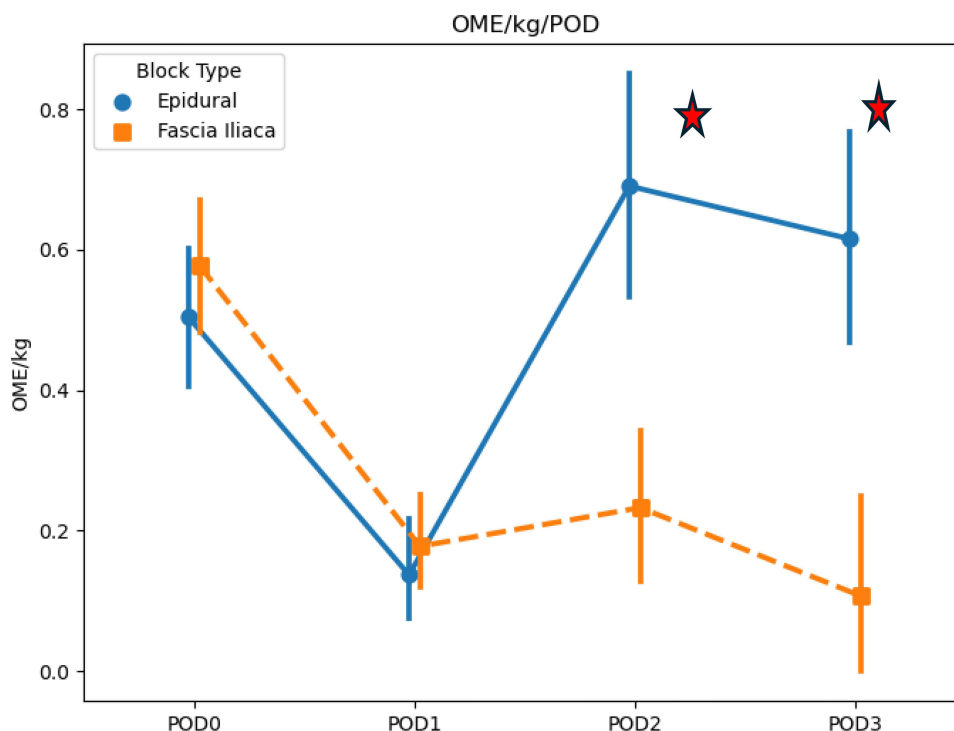


Figure 1 Daily opioid usage (parenteral and oral) in the two treatment groups while hospitalized. (OME/kg) Epidural discontinued on POD 2. Red star = $P < 0.05$. **Abbreviations:** CEA, Continuous Epidural Analgesia; CSFI, Continuous Suprainguinal Fascia Iliaca Block; POD, Postoperative day; OME/kg, Oral morphine equivalents/kg.

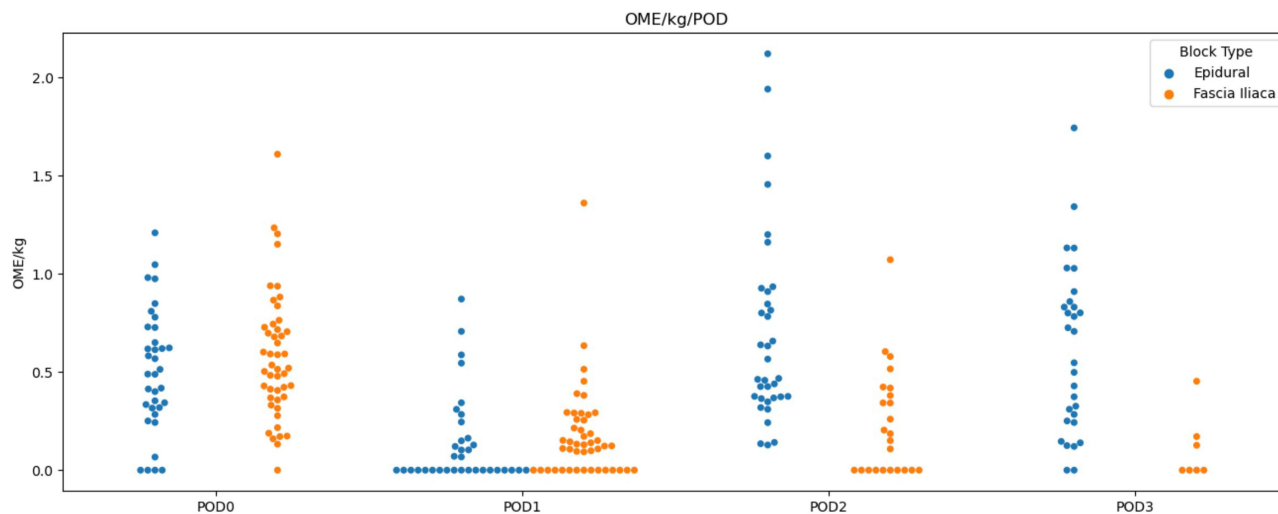


Figure 2 Opioid usage (oral and parenteral) per patient per day while hospitalized in the two treatment groups. **Abbreviations:** Blue dot, Epidural; Orange dot, Fascia iliaca; OME/kg, Oral morphine equivalents/kg.

$p < 0.0001$, POD 1, -0.06 (0.18) vs. -0.52 (0.50), $p < 0.0001$, and POD 2, -0.05 (0.37) vs. -0.49 (0.49), $p = 0.0005$. Average Richmond sedation scores were similar on POD 3. There was no evidence for significant differences between groups in the incidence of nausea, vomiting or pruritus, although the CSFI group trended lower in both (Table 5).

The CEA group was associated with lower mean and maximum pain scores on the DOS compared to CSFI. (Mean: CSFI 2.60 (2.13) vs. CEA 1.16 (1.80); $p = 0.002$, Max: 4.63 (3.07) vs. 2.46 (3.32); $p = 0.003$) On POD 2 the CSFI group had significantly lower maximum daily pain scores when compared to the CEA group. (Max: CSFI 3.09 (2.68) vs CEA 6.11 (1.95); $p < 0.0001$) There was no evidence for additional differences in pain scores on any day (Figure 3).

Table 4 Daily Opioid Usage in the Two Treatment Groups Including Epidural Opioids. (OME/Kg)

	CEA	CSFI	p values
DOS	1.13 (0.51)	0.58 (0.32)	<0.0001*
POD 1	1.36 (0.77)	0.18 (0.24)	<0.0001*
POD 2	1.29 (0.67)	0.23 (0.27)	<0.0001*
POD 3	0.62 (0.43)	0.11 (0.17)	<0.005*

Note: *p<0.05.

Abbreviations: CEA, Continuous Epidural Analgesia; CSFI, Continuous Surpainguinal Fascia Iliaca Block; DOS, Day of surgery; POD, Postoperative day; OME, Oral Morphine Equivalents.

Table 5 Incidence of Nausea and Vomiting and Pruritis in the Two Treatment Groups

Variable	CEAn (n=35)	CSFI (n=47)	p value
Nausea and Vomiting	8/35 (22.8%)	4/47 (8.5%)	0.11
Pruritis	4/35 (11.4%)	1/47 (2.1%)	0.07

Abbreviations: CEA, Continuous epidural analgesia; CSFI, Continuous suprainguinal fascia iliaca.

Four patients reported their chief complaint as persistent anterior thigh numbness at their first clinic visit six weeks after the procedure, all in the CSFI group. (8.5%) Two of these patients had concurrent numbness in the medial and posterior calf. Of these four patients, two patients experienced numbness for over six months. All cases resolved within one year.

Discussion

The primary finding of this study is CSFI was associated with similar oral and parenteral opioid requirements compared with CEA while both blocks were in place and significantly reduced opioid requirements and pain scores following epidural removal for procedures of the proximal femur and acetabulum in pediatric patients. CSFI was also associated with earlier mobilization, and a reduced length of hospital stay. Earlier ambulation postoperatively is associated with better functional recovery and a lower risk of postoperative complications.⁹ The shorter hospital stay we observed in the

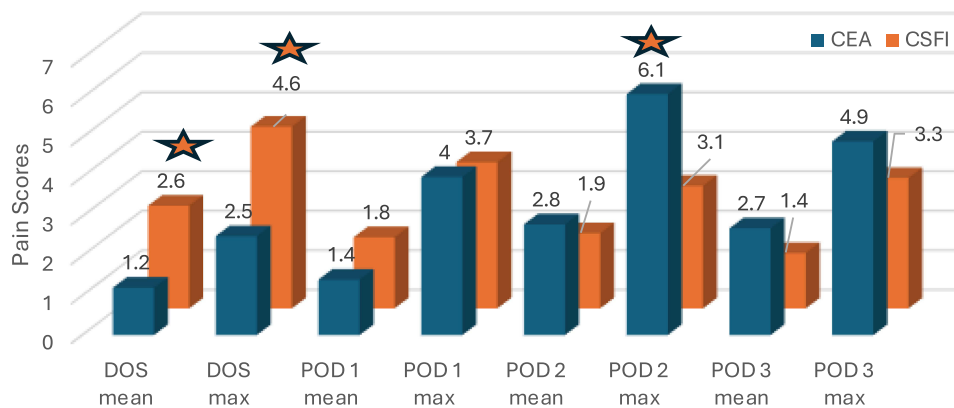


Figure 3 Average daily mean and maximum pain scores while hospitalized. Orange star = p<0.05.

Abbreviations: DOS, Day of surgery; POD, Postoperative day; CEA, Continuous epidural analgesia; CSFI, Continuous suprainguinal fascia iliaca block.

CSFI group suggests that CSFI may improve patient throughput and reduce healthcare costs without compromising pain management. The increased sedation scores seen with CEA, likely secondary to opioids included in the epidural infusion, may decrease active patient participation in rehabilitation and prolong the overall recovery experience.

We focused on oral and parenteral opioid comparisons because these are primarily responsible for the most concerning postoperative side-effects. (eg excessive sedation, respiratory depression). There is a lack of evidence-based guidelines in converting neuraxial opioids to oral morphine equivalent doses. Some authors suggest oral morphine conversion ratios of 100 mg IV, 10 mg epidural and 1 mg intrathecal; however, there is no credible scientific basis for these numbers, based on highly opioid tolerant adult patients converting from oral to neuraxial route.¹⁰ Should we apply the same ratio in reverse when converting from neuraxial to parenteral opioids in opioid naïve pediatric patients? In the case of epidural fentanyl, studies suggest that epidural and intravenous fentanyl, when given at the same dose, achieve similar plasma levels and analgesic effect.^{11,12} We chose to include epidural opioid calculations based on these studies, using the OME conversion factors for intravenous hydromorphone or fentanyl without the additional conversion factor (x10) for epidural opioids. When epidural opioids were included, opioid requirements were increased in the CEA group on all postoperative days.

Persistent thigh numbness reported in four patients, all in the CSFI group (8.5%), was an unexpected finding. There is only one previous report of persistent thigh numbness lasting eight days following a single injection fascia iliaca compartment block.¹³ The underlying cause of the numbness in these patients remains unclear. Two of the patients experiencing numbness had procedures of the proximal femur (proximal femoral derotational osteotomy for intoeing gait, proximal valgus producing osteotomy for coxa vera and developmental dysplasia of the hip) and two had surgeries of the acetabulum (hip dislocation and femoral neck cam plasty, hip dislocation and subtrochanteric derotation osteotomy, both for impingement syndrome). The differential diagnosis of postoperative neurologic symptoms (PONS) following peripheral nerve blockade includes effects of the surgical procedure, nerve block, patient positioning, tourniquet related ischemia, exacerbation of a preexisting neurological deficit, postoperative chronic regional pain syndrome (CRPS), postsurgical inflammatory neuropathy, central nervous system process (eg., cervical, lumbar spine injury) or a combination of these. In some cases, no explanation may be found. No patients in this cohort had a tourniquet. All patients were positioned supine. No patients had evidence of a preexisting neurologic deficit. There were no accompanying vasomotor symptoms consistent with CRPS. Nerve injury from the surgical incision, retraction and direct nerve injury during the procedure cannot be ruled out. However, all incisions were on the lateral aspect of the hip overlying the greater trochanter, making injury of the lateral femoral cutaneous nerve or anterior cutaneous nerve of the thigh unlikely. Direct nerve injury during block placement is unlikely as CSFI is a field block. Postsurgical inflammatory neuropathy (PIN) is a possible etiology but most often presents with acute pain and weakness¹⁴ and all patients who experienced postoperative numbness were in the CSFI group. The adjuvants dexmedetomidine and dexamethasone have both been implicated in postoperative numbness. A Cochrane review of dexamethasone as an adjuvant in peripheral nerve blockade found no evidence to support dexamethasone was a causative agent in block-related postoperative numbness.¹⁵ Dexmedetomidine as an adjuvant with ropivacaine in an adductor canal block has been associated with persistent thigh numbness in 8% of patients.¹⁶ In a rabbit model, dexmedetomidine has been shown to cause injury to the myelin surrounding the femoral nerve in a dose dependent manner when exposed to dexmedetomidine 3 mcg/mL and 0.25% ropivacaine for 48 hours.¹⁷ (Figure 4) Note vacuolization of the myelin sheath in the electron micrograph.

We suspect that postoperative numbness presenting at the postoperative orthopedic clinic visit may be underreported, attributed to the surgical procedure by the orthopedic clinic staff and not referred to the anesthesia department. None of the patients with numbness in this study were brought to the attention of the anesthesiologist. After making the surgeons aware of our findings, we were referred a patient who has persistent anterior thigh numbness 13 months following a single injection SFI block with ropivacaine, dexamethasone and dexmedetomidine for hardware removal from the proximal femur and is still ongoing.

This study has limitations inherent in a retrospective, non-randomized study design. There may have been other confounders between groups that could have affected the differences observed in opioid usage, pain scores and length of stay. The differences in time to ambulation were heavily influenced by the decision of our surgeons to not initiate physical therapy and ambulation until epidural removal. This limits the ability to draw unbiased conclusions about the effect of both blocks on time to ambulation. The majority of patients in both treatment groups had surgeries of the proximal femur, limiting conclusions on the effects of these blocks on procedures of the acetabulum. We did not make an attempt to decrease the

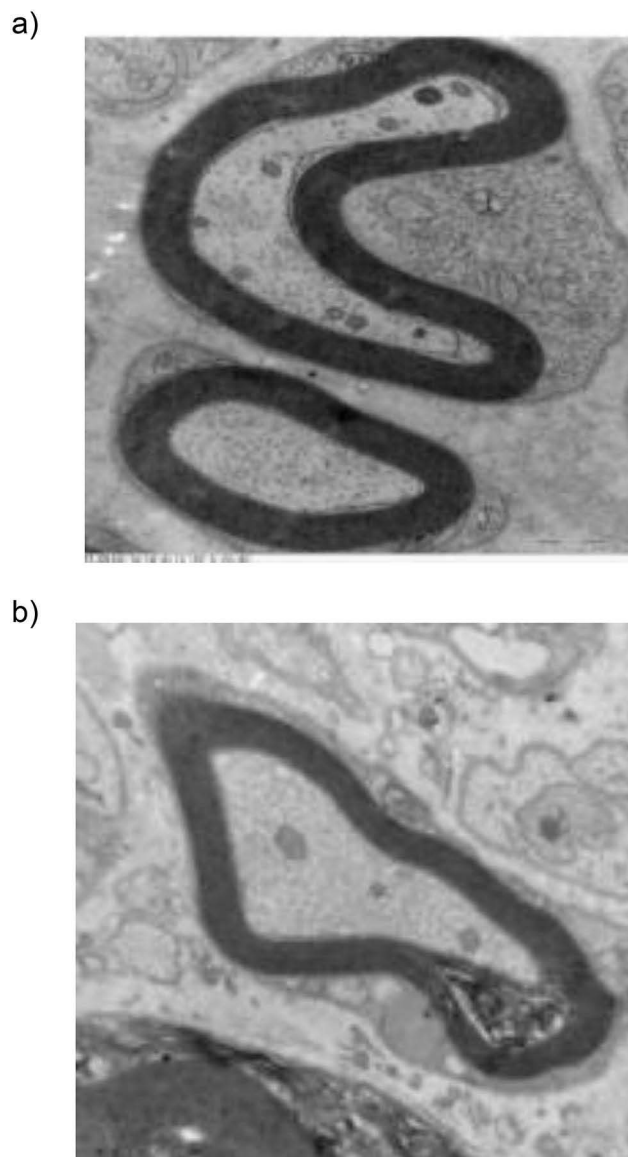


Figure 4 Electron microscopic exam demonstrating a) normal appearing myelin in a rabbit femoral nerve exposed to 0.25% ropivacaine for 48 hours and b) a vacuolated myelin injury in a femoral nerve exposed to 0.25% ropivacaine and 3 mcg/mL of dexmedetomidine for 48 hours.

epidural local anesthetic concentration to create a “walking epidural” or place the epidural higher (L1-2) in hopes of improving dermatomal analgesia. We lacked a control group that did not receive a block, making it impossible to make any conclusions on the effects of each block compared to a patient without regional anesthesia. This study was performed at a single center, requiring a careful comparison with your own situation. We did not have data on opioid usage after hospital discharge, the opioid requirements data on POD 3 reflect the minority of CSFI patients still hospitalized.

Conclusions

CSFI appears to offer substantial advantages over CEA for pediatric patients following procedures of the proximal femur and acetabulum by reducing length of stay while maintaining adequate pain control. However, persistent thigh numbness seen in our cohort highlights the need for further prospective studies to better understand the safety profile of dexmedetomidine and CSFI. Clinicians should weigh these benefits and risks when selecting a regional analgesia strategy for pediatric patients undergoing these procedures. Prospective, randomized, controlled trials are required to confirm these findings.

Data Sharing Statement

Data supporting the results reported in this manuscript are available upon request from the corresponding author.

Ethical Approval and Informed Consent

This manuscript adheres to the Declaration of Helsinki, which lays down ethical principles for medical research involving human subjects, including the importance of protecting dignity, autonomy, privacy and confidentiality of research subjects, and obtaining informed consent for using identifiable human biological material and data. On 5/17/24 WCG IRB approved a waiver of authorization of protocol SPO2401R for use and disclosure of protected health information under 45 CFR 164.501.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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