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Pain Management in Total Knee Arthroplasty: A Comparison of Periarticular Infiltration with Femoral and Sciatic Nerve Block

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Abstract

Background: The effect of periarticular infiltration (PAI) of Bupivacaine (Exparel®) with Marcaine® in the ipsilateral knee compared to femoral and sciatic nerve blocks (FSNB) in the contralateral knee in one-stage bilateral total knee arthroplasty (BTKA) has not yet been widely reported in the literature. This study compared the effect of PAI in the ipsilateral knee and FSNB in the contralateral knee on the postoperative pain and quadriceps function following a one-stage BTKA.

Methods: Fourteen patients who underwent one-stage BTKA for osteoarthritis were included in this prospective study. The surgical protocol was similar for all patients except for one randomized intervention: PAI in the ipsilateral knee (PAI knees) and FSNB in the contralateral knee (FSNB knees). The postoperative pain management protocol was the same for all patients. The postoperative pain was measured with the visual analogue scale (VAS) pain score on postoperative days (POD) 1, 2 and 3. The quadriceps power was clinically assessed in PAI and FSNB knees on POD 1, 2 and 3.

Results: On POD 1, 2 and 3, the VAS pain scores were comparable between the PAI knees and the FSNB knees (p value 0.61, 0.83 and 0.92 respectively). The quadriceps power was significantly lower in the FSNB knees compared to PAI knees on POD 1 (p = 0.012). No significant difference in the quadriceps power was noted between the PAI knees and the FSNB knees on POD 2 (p = 0.257) and POD 3 (p = 0.072).

Conclusion: During one-stage BTKA, administration of PAI for the ipsilateral knee and FSNB for the contralateral knee provides clinically similar postoperative pain relief on POD 1, 2 and 3. FSNB knees had significantly lower quadriceps power on POD1 compared to PAI knees. However, on POD2 and 3 no such significant difference in the quadriceps power was noted clinically between the PAI and FSNB knees.

Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Keywords: Periarticular injection; Bupivacaine; Femoral nerve block; Sciatic nerve block; Femoral and sciatic nerve block; Total knee arthroplasty; Postoperative pain; Quadriceps function

Introduction

The outcome of total knee arthroplasty (TKA) has improved in terms of the length of hospital stay from 23 days [1] reported in older literature to an average of 3 to 4 days [2] reported in the current literature which in part is due to improved perioperative pain management.

An ideal perioperative pain management after TKA should provide effective pain relief without sedation and facilitate early rehabilitation without affecting the muscle strength and facilitate early bed side mobilization and gait training. The adoption of multimodal pain management protocol after TKA is useful in achieving these goals [3]. Multimodal pain management protocol, including a variable combination of spinal anesthesia with or without continuous epidural analgesia, periarticular infiltration of drugs (PAI) during surgery [4], peripheral nerve blocks (femoral nerve or sciatic nerve) [5], continuous intraarticular infusion of anesthetics [6], and postoperative systematic and oral analgesics [7], is now the standard of care in managing pain after TKAs.

A periarticular injection (PAI) consists of a variable combination of drugs (and their doses) [4], including local anesthetics, nonsteroidal anti-inflammatory drugs, epinephrine and steroids. An extended release preparation of a local anesthetic, the liposomal Bupivacaine [8] with the trade name Exparel®, has become a recent addition to the list of drugs and their doses used for PAI.

The described techniques of peripheral nerve blocks for pain management after TKA are femoral nerve block (FNB), sciatic nerve

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block (SNB) and combined femoral and sciatic nerve blocks (FSNB). Both the FNB and the SNB may be effectively administered either as a single shot [9] of local anesthetic or as a continuous infusion [10] of local anesthetic via infusion catheter.

In spite of the availability of systemic and oral opioids, postoperative pain control with PAI and/or FSNB has a significant role in the management of pain after TKA. Opioid-related adverse drug events (ORADEs) [11], such as the sedation, respiratory depression, constipation, urinary retention and pruritus [12] have been shown to delay the rehabilitation, increase the hospital stay after TKA.

Though effective, the clinical safety of local anesthetics used for PAI and FSNB are still under investigation. A recent basic research study has shown the myotoxic effect of bupivacaine and ropivacaine on myotubes in primary mouse cell culture and an immortalized cell line [13]. Also, there is at least one recently published clinical research study that has shown a delayed return to sports with associated persistent isokinetic knee extension and flexion deficits even 6months following FNB [14].

Several randomized controlled trials (RCTs) compared the effect of PAI and FSNB on pain and function after unilateral TKAs [8,9,15-18]. However, there are no studies reporting the effect of ipsilateral PAI and contralateral FSNB on pain and function after a one-stage bilateral total knee arthroplasty (BTKA). The purpose of this study is to compare the effect of PAI and FSNB on the outcome of TKA on postoperative pain and clinically measured quadriceps muscle function.

Materials and Methods

This is a prospective comparative study involving two interventional cohorts performed at a tertiary level teaching hospital. All of the surgeries were performed by one senior author (FDC). After IRB approval to conduct the investigation, 14 consecutive patients who underwent one-stage BTKA for osteoarthritis between September 2013 and December 2014 were included in the study. Gender distribution among the 14 patients included in the study was equal with 7 male and 7 female patients.

The surgical protocol was the same for all patients except for one randomized intervention: PAI in the ipsilateral knee (PAI knee) and FSNB in the contralateral knee (FSNB knee). The allocation of which knee received PAI or FSNB was decided by stratified, simple randomization. The randomization process was stratified because each patient received PAI in one knee and FSNB in the other knee during a one-stage BTKA. The randomization process was simple (also called complete randomization) because each knee had an equal chance of receiving either PAI or FSNB in each patient.

In the FSNB knees, a single shot FNB and SNB was performed by the attending anesthetist before the surgery using ultrasound guidance and a nerve stimulator to locate the femoral nerve in the inguinal region and sciatic nerve in the gluteal region. The protocol was to inject a total of 20ml of 0.5% Bupivacaine with HCO3 and epinephrine 1: 200,000 which is equally divided into 10ml each for the FNB and SNB.

Smith and Nephew [Andover, MA] posterior stabilized implants were used in all patients. The instrumentation used for the surgery was identical on either side of the knee in any given patient. The one-stage BTKA surgeries were performed under spinal anesthesia without epidural analgesia and using a type 3 tourniquet technique i.e., inflation of the tourniquet before incision and deflation after complete closure of the surgical wound and application of a sterile compressive dressing. All the surgeries were performed on the left side first followed by the right side. While one assistant closed the left knee, the right knee's surgery was started, with the help of the other two assistants.

All patients received either an anteromedial or midvastus arthrotomy approach. The same approach was used in both knees for any single patient. The sequential surgical steps following the arthrotomy were: initial tibial preparation (resection of proximal surface), initial femoral resection (distal resection, sizing, AP cuts and chamfer cuts), working in-between tibia and femur (removal of medial and lateral menisci, removal of posterior condylar osteophytes, clearing the intercondylar notch of ACL and PCL), initial balancing (with spacer block and performing appropriate releases), final tibial preparation (ream and broach for the stem of tibial component), final femoral preparation (box cut for the posterior stabilized design), working in-between tibia and femur i.e., preparation of patella (sizing, reaming to appropriate depth, drilling lug holes), final balancing (with trial components), cementing of the final components (pulse lavage, tibial component implantation followed by femoral component and finally the patellar component).

The PAI was infiltrated into the tissues immediately prior to the implantation of the final components, and included 266mg of Exparel® and 30ml of 0.5% Marcaine with epinephrine®. The specific areas of infiltration were based on sensory innervation of the knee including the posterior capsule, the femoral attachment of the resected ACL and PCL ligaments, the resected medial and lateral meniscus-capsule junction, the anterior and inferior and posterior synovial folds of the medial and lateral femoral condyles, the supracondylar synovial fold, the medial and lateral tendinous quadriceps arthrotomy flaps along with the elevated part of the MCL and the medial skin flap, more thoroughly than the lateral skin flap [19]. The quadriceps muscle was not infiltrated to avoid the risk of myopathy. All knees were injected with a similar protocol that included 200 cc to the posterior capsule, 10cc around the periosteum and the remaining 20 cc in the subcutaneous tissue. The injections were administered with a 22 gauge needle and the goal was numerous small aliquots of injection to multiple sites rather than several large injection sites.

A 4 layer closure technique was followed in all cases. Starting at the center of the medial and lateral quadriceps flaps, the arthrotomy was closed continuously by knot less suturing with PDO size '0' bidirectional Quill™ device (Wyomissing, PA). Similarly, starting at the center of the medial and lateral skin flaps, the deep tissues were closed in one layer continuously by knot less suturing with PDO size '2-0' bidirectional Quill™ device. Again using the bidirectional Quill™ device, the subcuticular suturing was done with Monoderm™ size '3-0'. Finally, secure skin closure was obtained by Dermabond Prineo™ system (Cincinnati, OH).

The postoperative pain management protocol was the same in all of the studied patients and is primarily monitored by the pain

Table 1: Statistical analysis of postoperative pain in the PAI[@] knees and FSNB[#] knees.

Pain VAS score	PAI knees [Mean(SD, SE and 95% CI)]	FSNB knees [Mean(SD, SE and 95% CI)]	P value
Post-op day 1	5.3(2.6, 0.7, 3.9 to 6.7)	5.8(2.6, 0.7, 4.4 to 7.2)	0.61
Post-op day 2	4.7(2.5, 0.7, 3.3 to 6.1)	4.5(2.2, 0.6, 3.3 to 5.7)	0.83
Post-op day 3	3.5(1.9, 0.5, 2.5 to 4.5)	3.6(2.0, 1.0, 2.6 to 4.6)	0.93

[@]Periarticular Infiltration, [#]Femoral and sciatic nerve block.

management team. Postoperative pain was measured clinically using the VAS scale of 0 to 10, with 0 being no pain and 10 being the worst pain imaginable. Infusion of 1gm Acetaminophen IV every 8 hours for 3 doses was a standard. Patients were also routinely given 25mg Pregabalin PO three times a day. For moderate pain of 4 to 6 on a visual analog scoring (VAS) scale of 0-10, 5mg Oxycodone immediate release PO was administered every 4 hours PRN. For severe pain of 7 to 10 on a VAS scale of 0-10, 2-4mg Morphine IV was administered every 4 hours PRN. For those patients with a medical indication, 325 Aspirin PO was also restarted from the day of surgery.

All of the patients were mobilized by enhanced recovery after surgery (ERAS) protocol [20]. Physical therapy was instituted on POD 1 to facilitate motion and was progressively intensified from bed side mobilization to standing, to walking and to stairs. From POD1 onwards, the highest level of quadriceps function was assessed in terms of the ability to perform active straight leg raising (SLR) test with less than 10 degree quadriceps lag.

Two outcome measures that were specifically compared between the PAI and FSNB knees are the postoperative pain in terms of VAS score and the postoperative quadriceps function in terms of ability to perform active SLR.

The worst postoperative pain in PAI and FSNB knees was measured using VAS scale on POD 1, 2 and 3. The mean, standard deviation (SD), standard error (SE) and 95% confidence interval (CI) were calculated in PAI and FSNB knees and compared using two sample student t-tests to find if there is any statistically significant difference is present at $p < 0.05$.

Similarly, the best postoperative quadriceps function in PAI and FSNB knees was measured based on the ability to perform active SLR on POD1, 2 and 3. The proportion of cases which cleared active SLR test was calculated in the PAI and FSNB knees and compared using chi^2 test to find if there is any difference statistically significant difference is present at $p < 0.05$.

Results

The descriptive statistics of postoperative VAS pain scores in PAI and FSNB knees on POD 1, 2 and 3 are shown in Table I. The calculated p values of the two sample t-test performed comparing PAI and FSNB knees were 0.61, 0.83 and 0.92 on POD 1, 2 and 3 respectively, indicating that there was no statistically significant difference in the VAS pain scores on any of the first 3 postoperative days (Table 1).

The descriptive statistics of postoperative quadriceps function in terms of ability to perform active SLR in PAI and FSNB knees on POD 1, 2 and 3 are shown in Table 2. The calculated p values of the two chi^2 test performed comparing PAI and FSNB knees were 0.007, 0.19 and 0.14 on POD 1, 2 and 3 respectively, indicating that there was a significant difference in the quadriceps function on POD1 but not on POD 2 or 3 (Table 2).

Table 2: Statistical analysis of quadriceps function in terms of ability to perform active straight leg raising test (SLR) in the PAI[@] knees and FSNB[#] knees.

	Post-op day 1	Post-op day 2	Post-op day 3
Proportion of PAI knees that cleared active SLR test	11/14	12/14	14/14
Proportion of FSNB knees that cleared active SLR test	4/14	9/14	12/14
chi^2value	7.03	1.72	2.15
Degree of freedom	2	2	2
P value	0.007	0.19	0.14

[@]Periarticular Infiltration; [#]Femoral and sciatic nerve block.

Discussion

Unlike the previously conducted RCTs comparing the effect of PAI and FSNB in patients undergoing unilateral TKAs, this study compared the effect of PAI and FSNB in patients undergoing one-stage BTKA thus eliminating the confounding effects of systemic pain medications that could affect the VAS pain scores or subjective difference in the quadriceps function.

This study had several significant limitations. First, is the small sample size? Studies with small sample sizes are prone to type II statistical error. Further studies with larger sample sizes are needed to confirm or refute the finding that postoperative pain is comparable among the PAI and FSNB knees. Despite its small sample size, the study could still demonstrate a significant difference in the quadriceps function among the PAI and FSNB knees on POD 1. Further studies with larger sample sizes are needed to confirm or refute the finding that quadriceps function is in fact comparable among the PAI and FSNB knees from POD2 onwards.

Second, while designing this study we did not try to differentiate the postoperative pain at rest (PAR) from the movement-evoked pain (MEP) [21]. The severity of movement-evoked pain has shown to be 95-225% compared to severity of pain at rest i.e., an equivalent or more severe than pain at rest. Also, the effectiveness of various postoperative pain management modalities seem to be different on PAR compared to MEP. For example, opioids are less effective in managing movement-evoked pain compared to pain at rest. Therefore in future studies, standardizing the measurement of postoperative pain in terms of both PAR and MEP is recommended.

Postoperative pain following TKA and the effective management strategies are currently a focus of intense research for several reasons. One, Postoperative pain after a TKA has shown to be more severe compared to postoperative pain after a total hip arthroplasty [22]. Two, nearly 44-57% of patients who are status-postoperative TKA have severe enough pain to wake them up from sleep, pain at rest or stimulus independent pain during the first 3 postoperative days [23]. Three, severe postoperative TKA pain has been shown to be the most significant risk factor for developing persistent postsurgical pain [24]. Four, severe postoperative TKA pain is shown to be associated with poor functional outcome [25].

The use of periarticular injections instead of reliance on peripheral nerve blocks and opioids, which shifts some control over

pain management from the anesthesiologist and pain team to the orthopedic surgeon, represents a recent cultural change [26]. Unlike the opioids, PAI are not associated with opioid-related adverse drug events (ORADEs) [11], such as the sedation, respiratory depression, constipation, urinary retention and pruritus [12]. Among 1190 patients, Feibel et al reported an overall complication rate of 1.5%, with 0.7% at major risk of falling and requiring repeat surgical intervention [27]. Widmar et al found the incidence of neural complications was 1.94% out of 1802 patients [28]. Prolonged sensory dysfunction is a real and unique complication of FSNB in a subset of patients, especially those who are women, obese and older. Unlike the peripheral nerve blocks, PAI is not associated with quadriceps dysfunction hence facilitating early rehabilitation, decreased the length of hospital stay and ultimately affect the final clinical outcome positively after a TKA.

Taking further the concept of PAI in pain management following TKA, the efficacy of continuous intraarticular infusion is now being investigated [29,30]. If continuous intraarticular infusion is safe, effective and synergistic with PAI in controlling pain and restoring quadriceps function, evolution of TKA into outpatient surgery in the near future is possible.

Conclusion

During one-stage BTKA, administration of PAI for the ipsilateral knee and FSNB for the contralateral knee provides clinically similar postoperative pain relief on POD 1, 2 and 3. FSNB knees had significantly lower quadriceps power on POD1 compared to PAI knees. However, on POD2 and 3 no such significant difference in the quadriceps power was noted clinically between the PAI and FSNB knees.

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