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Original article

Negative Influence of femoral nerve block on quadriceps strength recovery following total knee replacement: A prospective randomized trial

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ABSTRACT

Background: Postoperative pain is a major concern after total knee replacement (TKR) and can be relieved using different methods, including femoral nerve block (FNB). Quadriceps strength recovery (QSR) is the most sensitive objective indicator of functional recovery after TKR. The goal of this study was to compare the QSR following TKR between three approaches to analgesia.
Hypothesis: FNB delays QSR at short- and mid-term follow-up.
Methods: In this prospective randomized trial, with single-blind assessment involving 135 patients admitted for TKR in an academic center, the three following groups included were: (A) Continuous FNB 48 h + PCA, (B) Single-shot FNB + PCA and (C) PCA alone. No intra-articular local anesthesia was carried out for all patients. Groups were comparable for demographic and surgical data. FNB was carried out and controlled (electric stimulation) by an expert anesthesiologist prior to the surgery. Follow-up was standardized in all groups using blinded assessors. Quadriceps strength was measured using a certified dynamometer at 6 weeks, 6 months and 12 months. Multivariate analysis (Kruskal-Wallis, Mann-Whitney) was used for the main outcome.
Results: A total of 135 patients were included. Two patients in group B were excluded due to a direct fall in the first postoperative week with extensor mechanism rupture and peri-prosthetic femoral fracture. QSR was significantly decreased in patients with FNB at all times (mean ± SD): 6 weeks (A: 51.3 ± 23.3%; B: 62.2 ± 21.9%; C: 77.4 ± 19.5%; $p < 0.01$), 6 months (A: 65.4 ± 22.9%; B: 82.1 ± 24.2%; C: 95.7 ± 20.7%; $p < 0.01$) and 12 months (A: 87.8 ± 17.6%; B: 97.8 ± 26.9%; C: 104.8 ± 25.2%; $p = 0.02$). No significant difference between continuous or single-shot FNB was observed.
Conclusion: FNB has a negative influence on QSR at short- and mid-term follow-up. FNB should not yet be recommended for analgesia after TKR.
Level evidence: I High-quality randomized controlled trial with statistically significant difference.

1. Introduction

Postoperative pain is a main concern after total knee replacement (TKR). Insufficient pain relief in the postoperative period negatively impacts the patient's rehabilitation. Thus, various pain control modalities have been developed following TKR, ranging from local anesthetic methods [1] to various nerve blocks [2,3].

Femoral nerve block (FNB) has demonstrated beneficial effects following TKR in terms of reduced opioid intake, reduced length of stay, and increased patient satisfaction [2]. The efficacy of FNB in reducing pain has not been associated with a negative impact on the active knee range of motion (ROM) [4].

Recent studies suggest that quadriceps strength is the best objective indicator for functional recovery following TKR [5,6]. Quadriceps electrical stimulation in the perioperative period has not yet demonstrated positive effects on quadriceps strength recovery (QSR) [7].

Obtaining optimal functional outcomes remains the main objective for patients following TKR. Therefore, it is of utmost importance

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to determine if FNB has any impact on QSR. The purpose of this study was to compare the QSR following TKR in patients with or without FNB. We hypothesized that FNB delays QSR at short- and mid-term follow-up.

2. Methods

2.1. Patients

All patients older than 18 admitted for a TKR were included in the study. Patients were excluded from the study if they had a previous surgery on the involved or contralateral knee, or if they present contra-indication to FNB. Subjects gave their written consent. The study received full approval by our institutional research ethics boards. The study is registered in ClinicalTrial.gov (NCT01111513). Fig. 1 illustrates the selection process in the study.

2.2. Study design

This study was a prospective, randomized trial. Subjects were randomized to one of three groups using sealed opaque envelopes: group A = FNB 48 hours + PCA, group B = FNB single-shot + PCA, group C = PCA (Patient controlled analgesia) alone (no sham block). Concealed randomization was obtained using the randomizer.org software. Envelopes were opened in the induction room. The evaluator was blinded to the type of analgesia until the end of the study.

2.3. Insertion of FNB

The FNB catheter was inserted under electric stimulation in the induction room prior to the surgery by an experienced anaesthesiologist trained in regional anaesthesia. The technique was standardized for all patients. Patients received either a single-shot (20 cc) of ropivacaine 0.05% and the catheter withdrawn, or a 20 cc bolus of ropivacaine 0.05% and the catheter kept in place for 48 hours with a 7 cc/h perfusion of ropivacaine 0.15%.

Immediately upon arrival in the recovery room, PCA was initiated in the three groups with a progressive loading dose (morphine 3 mg each 5 minutes until 15 mg) followed by an adjustable bolus dose of 1–1.5 mg morphine each 8 minutes until a maximum of 40 mg for 4 hours. Oral or rectal acetaminophen 1000 mg qid and naproxen 500 mg bid were delivered for 48 hours.

2.4. Surgical procedure

All procedures were carried out by general orthopedic surgeons. Most surgeries were conducted under general anesthesia. Antibiotic prophylaxis was given at induction and a tourniquet was positioned around the thigh on a supine patient. The TKR was undertaken using a medial parapatellar approach. The system used was the PFC-Sigma (Press-Fit Condylar system, Johnson and Johnson, Raynham, MA). Patella resurfacing was performed on surgeon's preference. The postoperative rehabilitation protocol was standardized for all patients.

2.5. Outcome measures

The primary outcome measure was QSR, calculated as the percentage of postoperative quadriceps strength value divided by the preoperative quadriceps' strength value. Quadriceps strength was measured at the preoperative visit (within two weeks prior to surgery) and at 6 weeks, 6 months, and 12 months following TKR. Quadriceps strength was determined with a specific certified dynamometer (Isoforce, MDS, Oberburg, Switzerland). All measures were carried out by the same blinded evaluator, specifically trained for the completion of this test. Three repeated measures were obtained with a one-minute interval, and the mean was calculated. Quadriceps strength was measured in closed and open (at sixty degrees) chain contractions.

Secondary outcome measures included knee pain (VAS), clinical and functional evaluations at 6 weeks, 6 months, and 12 months. Active knee ROM was determined using a goniometer. The diameter of the thigh was measured 15 cm above the upper pole of the patella with a metric band. Complementary functional evaluations were obtained using the WOMAC [8] and SF-36 v2 [9] scales.

During the first 48 hours, opioid consumption was calculated using the total PCA amount delivered adjusted to the subject's weight.

2.6. Statistical analysis

To obtain a power of 80%, a sample of 135 patients was calculated based on a significant 10% difference in QSR between groups [10] and including an a priori 15% of subjects lost at follow-up.

To determine the significance for the main outcome between the three groups, a three-way ANOVA test was performed with a Kruskal-Wallis test. When a significant difference was detected, a Mann-Whitney test was performed to rank the groups.

Data were analysed with the SPSS 19.1 software (IBM, Chicago, IL). All data were analysed using the intention to treat procedure. A p value ≤ 0.05 was considered significant.

3. Results

One hundred and thirty-five (135) patients were included. Table 1 describes the baseline characteristics of the subjects included in the study. The main exclusions are illustrated in Fig. 1 Two patients in group B presented a major complication during hospital stay related to a fall: a periprosthetic femoral fracture requiring fixation with a locking plate and an extensor mechanism rupture requiring suture and brace.

There was a significant reduction in QSR, more consistent in closed chain contractions, at all time points for patients with FNB (continuous or single-shot). Table 2 summarizes QSR for all treatment groups at all time points.

A progressive significant recovery of quadriceps strength was observed in all groups during the follow-up period, either for closed or open chain contractions. There was no significant difference in QSR between single-shot or continuous FNB at all time points. There was no correlation at any time point between QSR and surgical factors or patient characteristics.

Significantly higher ROM was obtained in subjects without FNB at all time points (Table 3).

No differences between groups for the VAS, the thigh diameter and all subscales of the SF-36 v2 scale. Patients without FNB performed best on the WOMAC score ($p < 0.05$) and a significant association with QSR was observed (rho 0.177, $p = 0.032$).

Table 4 summarizes opioid consumption and length of hospital stay.

4. Discussion

This study demonstrates a significant negative effect of FNB on QSR, mainly for closed chain contractions. A negative impact on QSR is strongly suggestive of a worse rehabilitation process. We believe that FNB may inhibit quadriceps motor units, thereby decreasing the real number of these units available for rehabilitation. This may explain the persistence of a difference in QSR up to one year after surgery and confirms the study hypothesis.

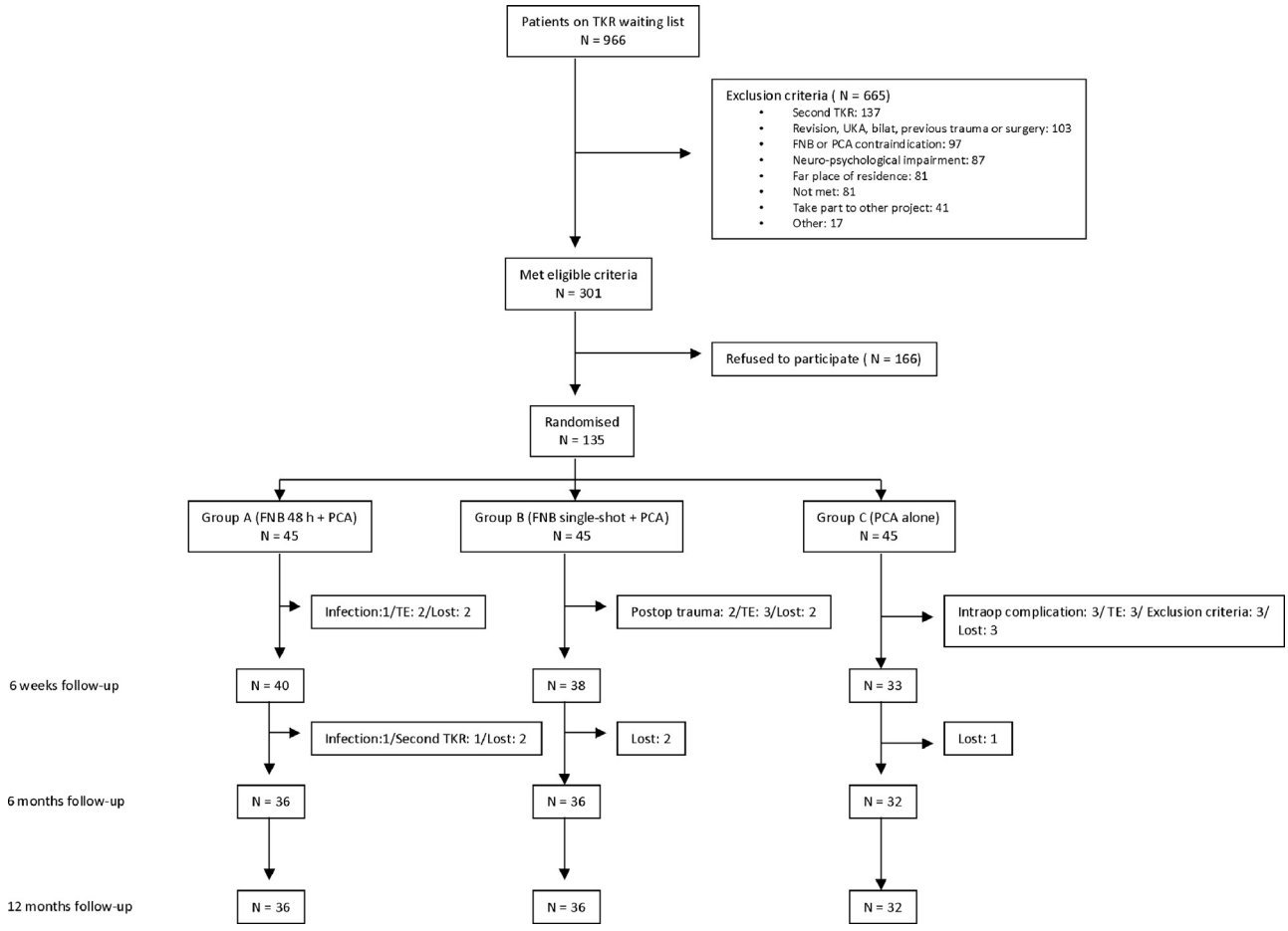

Figure 1. Flow diagram of the study.

Table 1
Baseline characteristics of the 135 subjects included in the study.

	Group AFNB 48 h + PCA($N = 45$)	Group BFNB single + PCA($N = 45$)	Group CPCA alone($N = 45$)
Age (yrs)[*]	66.6 (7.8)	69.4 (7.4)	67.0 (8.9)
Gender			
Male	20 (44.4%)	20 (44.4%)	25 (55.6%)
Female	25 (55.6%)	25 (55.6%)	20 (44.4%)
Body Mass Index (kg/m²)[*]	30.8 (8.3)	31.3 (5.6)	29.5 (6.6)
Diagnosis			
Osteoarthrosis	42 (93.4%)	44 (97.8%)	44 (97.8%)
Rheumatoid arthritis	2 (4.4%)	1 (2.2%)	1 (2.2%)
Other	1 (2.2%)	0 (0%)	0 (0%)
Type of TKR			
Cruciate-retaining	33 (73.3%)	31 (68.9%)	33 (73.3%)
Postero-stabilized	12 (26.7%)	14 (31.1%)	12 (26.7%)
Patella resurfacing	26 (57.8%)	21 (46.7%)	23 (51.1%)
Surgical time (min)[*]	86.6 (21.3)	89.3 (14.7)	85.7 (24.0)
Tourniquet time (min)[*]	67.8 (22.5)	73.4 (15.6)	69.5 (18.6)
Anaesthesia			
General	33 (73.3%)	30 (66.7%)	35 (77.8%)
Spinal	12 (26.7%)	15 (33.3%)	10 (22.2%)

[*]Results expressed as means (standard deviation) No significant differences between groups.

It is unclear if the inhibition of motor units is a direct consequence of the procedure or the anaesthetic drug [11]. All FNB procedures were performed under electric stimulation, but other studies demonstrated the same results when FNB was performed with ultrasound [12,13].

Many complications related to the reduced quadriceps strength after FNB were described, mainly fractures around the knee consecutive to a fall during the hospital stay [14,15]. We observed two cases in this study with these major complications. Some recent studies associated these complications with the motor block induced by FNB [16,17].

New analgesic modalities were developed to prevent these complications, and the periarticular injection (PAI) is the gold standard method to achieve a good analgesic effect with a rapid complete functional recovery [1,4,18–20]. PAI is more effective than FNB or adductor canal blocks for pain control and QSR [4,16,21].

Most studies describing the harmlessness of FNB after TKR used the ROM as a functional outcome measure and did not demonstrate

Table 2
Quadriceps strength recovery for each treatment group.

	Group AFNB 48h + PCA($N = 36$)	Group BFNB single + PCA($N = 36$)	Group CPCA alone($N = 32$)	p value
Closed chain contractions				
6 weeks	51.3% (23.3;44.1-58.5)	62.2% (21.8;55.2-69.2)	77.4% (19.5;70.7-84.1)	< 0.01*
6 months	65.4% (22.9;57.9-72.9)	82.1% (24.2;74.2-90)	95.7% (20.6;88.5-102.9)	< 0.01*
12 months	87.8% (17.6;82.1-93.5)	97.8% (26.9;89-106.6)	104.8% (25.2;96.1-113.5)	0.022*
Open chain contractions				
6 weeks	74.1% (28.1;65.4-82.8)	73.1% (28.4;64.1-82.1)	90.9% (26.8;81.8-100)	< 0.01*
6 months	106.7% (40.7;93.4-120)	98.7% (47,0;83.4-114)	119.3%(46,0;103.4-135.2)	0.146
12 months	130.1% (64.1;109.2-151)	107.5% (33.7;96.5-118.5)	131.5%(50,0;114.3-148.7)	0.132

Results expressed in percentages as means (SD; 95% confidence interval). *Significant p value.

Table 3
Knee range of motion for each treatment group.

	Group AFNB 48h + PCA($N = 36$)	Group BFNB single + PCA($N = 36$)	Group CPCA alone($N = 32$)	p value
6 weeks (°)	99.2 (14.7)	96.5 (13.8)	103.8 (10.1)	0.046*
6 months (°)	106.6 (12.0)	103.4 (12.0)	109 (9.9)	0.159
12 months (°)	104.6 (21.3)	104.8 (11.0)	111.5 (8.2)	0.026*

Results expressed as means (SD). *Significant p value.

Table 4
Morphine consumption (PCA) and hospital length of stay.

	Group AFNB 48h + PCA($N = 45$)	Group BFNB single + PCA($N = 45$)	Group CPCA alone($N = 45$)	p value
Morphine consumption (mg/kg)	0.45 (0.4)	0.48 (0.3)	0.56 (0.3)	0.14
24 hours				
48 hours	0.75 (0.6)	0.75 (0.4)	0.79 (0.5)	0.55
Hospital length of stay	6.2 (2.1)	6.5 (2.1)	6.1 (3.0)	0.30

Results expressed as means (SD).

differences between treatment groups [4]. This study demonstrates the absence of a relationship between QSR and ROM and suggests that ROM is not the best tool to assess functional outcome following TKR.

No differences in VAS values between the three groups during hospital stay or at follow-up visits were observed. This can be explained either by the bolus PCA each patient received at the recovery room or by the absence of efficacy of FNB on the posterior aspect of the knee. The beneficial aspect of adding a PAI is then easily understandable.

The main strength of this study is its design with a blinded evaluator. We acknowledge some limitations. The most important is a higher than expected number of patients lost to follow-up (22.3% vs. 15%). The patients with complications were excluded and no measure of quadriceps strength was performed, preventing to include these data in the final analysis.

5. Conclusion

FNB has a negative influence on QSR at short- and mid-term follow-up. FNB should not yet be recommended for analgesia after TKR.

Disclosure of interest

The authors declare that they have no competing interest.

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Contributions of the authors

Michèle Angers: Writing.
Étienne L. Belzile: Data gathering, writing.
Jessica Vachon: Writing.
Philippe Beauchamp-Chalifour: Writing.
Stéphane Pelet: Study design, statistical analysis, writing.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.03.002.

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