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Comparison of 2 Analgesia Modalities in Total Knee Replacement Surgery: Is There an Effect on Knee Function Rehabilitation?

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Background: We compared the effects of continuous femoral nerve block (CFNB) and continuous intraarticular block (CIAB) on pain, functional recovery and adverse effects after total knee arthroplasty (TKA).

Material/Methods: We prospectively randomized 54 patients undergoing TKA into 2 groups: CFNB (Group F) and CIAB (Group I). Surgery was performed under spinal anesthesia. All patients received patient-controlled analgesia (PCA) with morphine, diclofenac, and acetaminophen for the first 72 h postoperatively. Pain was assessed with a visual analog scale (VAS), 48-h morphine consumption and 72-h local anesthetic dosage were recorded, motor blockade was assessed, maximum range of motion (ROM) was measured, and adverse effect profiles were recorded.

Results: There was no significant difference in postoperative pain at rest, in passive motion, active motion, or active movement (2-min walk test (2MWT)) between study groups. Group I had less opioid usage in the first 24 h postoperatively ($p<0.05$). No significant difference was found between the groups in the postoperative local anesthetic dosage ($p>0.05$). Significantly lower scores of Bromage scale in Group I in 72 h after surgery ($p<0.05$) were found. Group I had superior passive maximum ROM in 1 month after surgery and superior active maximum ROM on day 7 and at 1 month after surgery ($p<0.05$).

Conclusions: Both CFNB and CIAB are effective postoperative analgesia methods after TKA. CIAB leads to lower postoperative opioid usage in the first 24 h, lower motor blockade in the first 72 h, and better knee function on day 7 and at 1 month after surgery.

MeSH Keywords: Arthroplasty, Replacement, Knee • Injections, Intra-Articular • Nerve Block • Pain, Postoperative

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Background

Total knee arthroplasty (TKA) is a frequently performed major orthopedic operation, but pain management remains challenging in the postoperative period [1–11]. Inadequate postoperative analgesia leads to delayed functional recovery, worse rehabilitation, development of chronic postoperative pain, and delayed discharge from hospital [6–8,12]. These factors cause increased risk of complications such as deep venous thrombosis, pulmonary embolism, and pneumonia [7].

While there is no criterion standard for pain control after TKA, multimodal analgesia is widely used. The combination of opioid and nonopioid pharmacologic agents, epidural analgesia, peripheral neural blockade, and local (intraarticular) analgesia are used. Regional analgesia plays an important role in postoperative pain control after TKA.

The effect of continuous femoral nerve block (CFNB) is similar to epidural analgesia but has fewer adverse effects [13]. However, CFNB may result in femoral quadriceps muscle weakness, leading to increased risk of falling [3]. Continuous intraarticular block (CIAB) helps to preserve quadriceps muscle strength, but may be associated with higher risk of local infection [3,5].

The aim of our study was to compare CFNB and CIAB in terms of postoperative pain, knee functional recovery, and manifestation of adverse effects in the early postoperative period (in the first month) after total knee arthroplasty (TKA).

Material and Methods

The study was approved by the local ethics committee. All patients were informed about the study and written consent was obtained.

According to the inclusion criteria (Table 1), 54 patients undergoing unilateral TKA in the hospital of LSMU Kauno klinikos, Clinic of Orthopedics and Traumatology were enrolled in this study and prospectively randomized into 2 groups: Group F received CFNB and Group I received CIAB.

When standard monitoring tests were carried out in the operating room, all patients received NaCl 0.9% 500 ml, and spinal anesthesia was performed (levobupivacaine 0.5% 3 ml [15 mg] to the L3–L4 subarachnoid space). Fluid maintenance during surgery was performed with NaCl 0.9% 8–10 ml/kg/h. Sedation during surgery was performed using propofol 1% 1–2 mg/kg/h. TKA was performed according to the protocol approved by our hospital; based on it, no drains were used. At the end of the surgery, each patient received infiltration of bupivacaine 0.125% 40 ml (50 mg) and epinephrine 0.07 mg to the posterior capsule to avoid popliteal pain due to TKA.

A femoral nerve catheter was introduced for patients in Group F and 3-in-1 femoral nerve block (FNB) was performed: in the supine position with leg extended and turned outside (15° angle), the stimulating needle, connected to the nerve stimulator (1.0 mA) was inserted at a 45° angle 3 cm below the inguinal ligament and 1–1.5 cm lateral to the femoral artery. The nerve was also located with an ultrasonography using an out-of-plane technique. When the quadriceps muscle response was obtained, NaCl 0.9% 25–30 ml was injected and a nerve catheter with antibacterial filter was introduced for 5–7 cm. At the end of surgery, a bolus of levobupivacaine 0.25% 30 ml was administered, and infusion was started with levobupivacaine 0.125% 50 ml and fentanyl 5 µg/ml 7–12 ml/h and continued for 72 h after surgery.

Group I patients received knee tissue infiltration with a solution consisting of bupivacaine 150 mg (0.125% 120 ml) and epinephrine 0.2 mg. The solution was applied to the posterior capsule, the residual anterior capsule, quadriceps tendon, patellar ligament, and soft tissue surrounding the joint. At the end of the surgery, all patients in this group received a special intraarticular catheter with antibacterial filter placed to the knee joint (to the capsule, near quadriceps tendon, patellar ligament, and soft tissue). Continuous infusion with bupivacaine

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Agreement to participate in the study; • ASA I–II classes; • >18 years old patients undergoing unilateral TKA with a diagnosis of primary gonarthrosis.	• Disagreement to participate in the study; • ASA III–V classes; • Hepatic and renal insufficiency; • Morbid obesity (BMI >40 kg/m^2); • Neuropathic pain, stroke and neurological deficit, sensory and/or motoric disturbances of limbs; • Inability to walk unaided; • Allergic reactions to local anesthetics and other drugs used in this study; • Uncomprehending requirement of the study protocol (psychiatric disorder).

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Table 2. Patient characteristics.

		Group F, n=27	Group I, n=27	p
Sex	Male	11 (40.7%)	2 (7.4%)	0.004
	Female	16 (59.3%)	25 (92.6%)	
Age (years)		70.41±7.551	66.85±7.690	0.092
BMI (kg/m^2)		29.38±4.56	30±3.73	0.590

0.125% 50 ml and fentanyl 5 µg/ml at the rate of 7–12 ml/h was continued for 72 h after surgery using this catheter.

Both groups of patients were observed in the post-anesthesia care unit (PACU) for the first 24 h after surgery. Vital signs were monitored and infusion therapy was administered. All patients received thrombosis and stress ulcer prophylaxis. Antibiotic prophylaxis with cefazolin 1 g×3 was continued for 24 h. In case of postoperative nausea and vomiting, ondansetron 2–4 mg was administered i.v.

Postoperative pain was managed with patient-controlled analgesia (PCA) for 72 h using a morphine pump, delivering 1 mg dose of morphine with a 7-min lockout interval, and morphine usage was recorded. Also, all patients postoperatively received diclofenac 150 mg per day i.v. every 24 h for the first 72 h and acetaminophen 1 g i.v. every 6 h for the first 72 h.

We assessed pain at rest (preoperatively, at 3, 6, 24, 48, and 72 h after TKA, on day 7, and at 1 month after TKA), pain in passive motion (preoperatively, at 3, 6, 24, 48 and 72 h after TKA, on day 7 and in month 1 after TKA), pain in active motion (preoperatively, at 24, 48 and 72 h after TKA, on day 7, and at 1 month after TKA), and pain in active movement (2-min walk test (2MWT)) (preoperatively, at 24, 48 and 72 h after TKA, on day 7, and at 1 month after TKA) using a visual analog scale (VAS) (scores 0–10: 0=no pain, 1-2-3=mild pain, 4-5-6=moderate pain, 7-8-9=severe pain, 10=worst possible pain), recorded morphine consumption in the first 48 h, and local anesthetic dosage (at 3, 6, 24, 48, and 72 h after TKA). Motor blockade using the modified Bromage scale (scores 0–3: 0=no weakness, 1=inability to raise extended leg, 2=inability to flex knee, 3=inability to move any joint in the leg) (at 3, 6, 24, 48, and 72 h after TKA) was measured. Maximum range of motion (ROM) (preoperatively, on day 7, and at month 1 after TKA) using a goniometer was recorded, as were adverse effect profiles (depth of sedation using sedation scale (scores 0–4: 0=awake, 1=sleepy, 2=somnolent/sleeping, easily arousable with voice, 3=deep sleep, arousable only with physical stimulation, 4 = deep sleep, arousable with significant physical stimulation or unarousable), blood pressure, the incidence of nausea and vomiting (scores 0–2: 0=no nausea, 1=nausea, 2=nausea and vomiting)) (at 3, 6, 24, 48, and 72 h and on day 7).

Data were statistically analyzed using IBM SPSS 22.0 software. We used the χ^2 test, t test, Mann-Whitney U test, and Kruskal-Wallis test for comparisons. Significance was set at $p<0.05$.

Results

We studied a total of 54 patients, with 27 in each group. There were no differences in demographics between these 2 groups, except for a difference in sex distribution (Table 2).

There was no significant difference in preoperative pain in passive motion ($p>0.05$), active motion ($p>0.05$), or active movement (2MWT) ($p>0.05$) (Table 3). Postoperative pain showed no significant difference at rest ($p>0.05$), in passive motion ($p>0.05$), active motion ($p>0.05$), or active movement (2MWT) ($p>0.05$) (Table 3).

Group I had lower postoperative opioid usage in the first 24 h ($p<0.05$), but there was no significant difference between groups in the next 24 h ($p>0.05$) (Table 4). No significant difference was found between the groups on the postoperative local anesthetic dosage (Table 5).

Group I was found to have significantly lower Bromage scale scores than Group F in the first 72 h after surgery ($p<0.05$) (Table 6).

Group I had superior passive maximum ROM 1 month after surgery ($p<0,05$) and superior active maximum ROM 7 days after surgery ($p<0.05$) and 1 month after surgery ($p<0.05$) (Table 7).

The depth of sedation and blood pressure were not different between the study groups ($p>0.05$); the incidence of nausea and vomiting was lower in Group I at 6 h after TKA ($p=0.034$), but there was no significant difference between groups ($p>0.05$) later.

There were no wound-related complications, infections, or thromboembolic complications in either group in the postoperative period. Also, there was no local or systemic inflammatory responses in any of the patients.

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Table 3. Postoperative pain at rest, in passive motion, active motion and active movement using VAS (scores 0–10).

	Group F	Group I
At rest		
Preoperative	1.11±2.172*	0.15±0.602*
At 3 h	1.48±2.119	0.85±1.406
At 6 h	1.26±1.583	1.11±1.450
At 24 h	0.89±1.013	0.59±0.971
At 48 h	0.63±0.792	0.30±0.609
At 72 h	0.48±0.700	0.30±0.609
On day 7	0.44±0.577	0.15±0.362
In month 1	0.30±0.669	0.07±0.267
In passive motion		
Preoperative	2.85±2.461	2.33±2.746
At 3 h	2.46±2.874	1.56±1.761
At 6 h	2.54±2.064	1.93±1.900
At 24 h	1.50±1.208	1.26±1.196
At 48 h	1.12±0.909	1.04±1.255
At 72 h	1.23±0.951	0.78±0.847
On day 7	0.62±0.752	0.44±0.698
In month 1	0.62±1.203	0.56±1.121
In active motion		
Preoperative	4.42±3.022	4.04±3.019
At 24 h	2.38±1.602	2.15±1.406
At 48 h	1.92±1.197	1.81±1.442
At 72 h	2.04±1.076	1.78±1.086
On day 7	1.62±1.098	1.56±1.086
In month 1	1.08±1.383	1.07±1.412
In active movement (2MWT)		
Preoperative	5.46±2.302	4.85±2.032
At 24 h	2.46±1.772	2.07±1.357
At 48 h	1.81±0.981	1.78±1.423
At 72 h	2.00±1.166	1.74±1.059
On day 7	1.58±1.137	1.56±1.086
In month 1	1.08±1.383	1.07±1.412

* Statistically significant difference, p=0.032.

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Table 4. Postoperative morphine consumption.

	Group F (morphine, mg)	Group I (morphine, mg)	p
0–24 h	8.56±1.305	4.89±0.975	**0.033**
24–48 h	2.33±0.700	2.96±0.603	0.425

Table 5. Postoperative local anaesthetic dosage.

	Group F (ml/h)	Group I (ml/h)	p
3 h	8.07±1.466	8.22±1.281	0.611
6 h	7.78±1.761	8.04±1.315	0.564
24 h	5.30±1.815	6.30±1.660	0.059
48 h	4.11±1.625	4.81±1.570	0.090
72 h	2.63±1.822	2.85±2.349	0.559

Table 6. Motor blockage using Bromage scale (scores 0–3).

	Group F (N, %)				Group I (N, %)				p
	0	1	2	3	0	1	2	3	
3 h	8, 29.6%	9, 33.3%	6, 22.2%	4, 14.8%	17, 63.0%	7, 25.9%	3, 11.1%	–	**0.037**
6 h	11, 40.7%	13, 48.1%	3, 11.1%	–	21, 77.8%	6, 22.2%	–	–	**0.013**
24 h	9, 33.3%	16, 59.3%	2, 7.4%	–	27, 100.0%	–	–	–	**<0.005**
48 h	13, 48.1%	14, 51.9%	–	–	26, 96.3%	1, 3.7%	–	–	**<0.005**
72 h	20, 74.1%	7, 25.9%	–	–	27, 100.0%	–	–	–	**<0.005**

Table 7. Maximum range of motion (ROM).

	Passive maximum ROM (degrees)		p	Active maximum ROM (degrees)		p
	Group F	Group I		Group F	Group I	
Preoperative	111.78±11.015	116.96±10.357	0.081	117.93±11.142	124.41±9.005	**0.023**
Day 7 after TKA	92.74±6.478	96.07±6.038	0.056	95.56±7.282	99.22±5.989	**0.048**
Month 1 after TKA	110.41±13.910	117.89±10.308	**0.029**	114.15±14.365	122.93±11.479	**0.016**

Discussion

Adequate postoperative pain control after TKA leads to early functional recovery, earlier and better rehabilitation, and shorter in-hospital stay [6–8]. Early rehabilitation not only increases the satisfaction with treatment, but also decreases the risk of postoperative complications such as deep venous thrombosis, pulmonary embolism, pneumonia, and arthrofibrosis [7].

The results of studies on analgesia methods after TKA are still controversial. Recent studies comparing periarticular infiltration (PAI) method with FNB showed PAI to be superior [3,14], whereas FNB was shown to be the superior analgesia method in other studies [6,7]. According to some authors, FNB is an effective analgesia method after TKA only if used with infiltration to the posterior capsule of the knee joint [7,14–18]. In our study all patients in both groups received infiltration with local anesthetic solution to the posterior capsule. Local anesthetics are used for pain control, but they possess antimicrobial activity as well [19].

Our prospective randomized study was designed to compare the 2 most popular analgesia methods – continuous femoral nerve

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block (CFNB) and continuous intraarticular block (CIAB) – and to determine which of these methods better reduces postoperative pain and morphine consumption, improves knee functional recovery, and is associated with fewer adverse effects in the early postoperative period (in the first month) after TKA.

We showed that both CFNB and CIAB are equally effective methods to control postoperative pain, with similar VAS scores at rest, in passive motion, active motion, and active movement were estimated. However, morphine consumption in the first 24 h after TKA was lower in the CIAB group; it seems that the same analgesia was reached using more opioids. Patient-controlled analgesia for all patients with morphine pump was used, so there was no influence of medicine staff on the opioid usage. Moreover, there was no difference in the postoperative local anesthetic dosage in the 2 study groups. According to the protocol in our hospital, all patients received diclofenac 150 mg per day i.v. every 24 h for the first 72 h and acetaminophen 1 g i.v. every 6 h for the first 72 h postoperatively. The protocols using lornoxicam 8 mg i.v. bid and paracetamol are widely used, too. Similar results have been shown in a study by Toftdahl et al. [14], who reported lower pain and morphine consumption in the PAI group on the first day after surgery. In our randomized study, there was a significant difference in sex distribution between study groups, so we cannot dismiss the fact that sex can affect pain perception. In both groups there were more women than men, reflecting the fact that women more often experience osteoarthritis [20].

Assessing knee functional recovery, we found that CFNB was associated with loss of quadriceps motor control in the first 72 h after TKA; the CFNB group had significantly higher Bromage scale scores in the first 72 h in comparison to the CIAB group. Toftdahl et al. [14] and Chaumeron et al. [3] have shown the same results in their studies. The modern concept of Enhanced Recovery After Surgery (ERAS) is aimed not only to achieve excellent pain management but also to produce the best functional recovery and rehabilitation. One of the relevant factors is preserving the best possible quadriceps muscle function after TKA. Furthermore, the CIAB group had superior active maximum ROM on day 7 after surgery and superior passive and active maximum ROM at 1 month after surgery. These results show that CIAB is a better postoperative analgesia method than CFNB. These results bring significant clinical benefits: better knee functional recovery, earlier and easier rehabilitation, and shorter in-hospital stay, and can be useful for the ERAS protocols.

The incidence of adverse effects (depth of sedation, blood pressure, nausea and vomiting) is similar in both analgesia methods. No wound-related complications, infections, or thromboembolic complications were recorded in either group. There was no local or systemic inflammatory response in any of the patients.

Conclusions

Our prospective randomized study shows that both continuous femoral nerve block and continuous intraarticular block are effective postoperative analgesia methods for patients undergoing TKA. The continuous intraarticular block was associated with lower postoperative opioid usage and better knee functional recovery by preserving quadriceps muscle function and caused better passive and active maximum range of motion at 1 month after surgery. This brings significant clinical benefit and can be useful for the Enhanced Recovery After Surgery (ERAS) protocols in TKA.

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