ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2015;49(3):260–266
doi: 10.3944/AOTT.2015.14.0263

A comparison of continuous femoral nerve block and periarticular local infiltration analgesia in the management of early period pain developing after total knee arthroplasty

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Objective: This study aimed to compare the effects of 24-h continuous femoral nerve block (CFNB) and periarticular infiltration analgesia (PIA) on postoperative pain and functional results in the first 6 weeks after total knee arthroplasty (TKA).

Methods: Sixty patients who underwent unilateral TKA were included in this study. The patients were divided into two groups: Group A received CFNB and Group B received PIA. Each patient received 0.25% levobupivacaine and 1:100,000 epinephrine as infiltration to the posterior capsule. A patient-controlled analgesia (PCA) device was used for all patients, and 24-h tramadol usage by patients was recorded. We measured maximum range of motion (ROM), pain using a visual analog scale (VAS), 2-min walk test (2MWT), and the scores of Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Knee Society Score (KSS).

Results: Compared with Group B, Group A had lower postoperative opioid usage ($p<0.05$), less pain at rest ($p<0.05$), less pain with passive motion ($p<0.05$), less pain with movement and after active movement ($p<0.05$), and superior passive and active ROM ($p<0.05$). Group A also had better 2MWT results at 24 and 48 h after surgery ($p<0.05$), and superior WOMAC and KSS results at 6 weeks after surgery.

Conclusion: As long as it is applied with infiltration analgesia to the posterior capsule, CFNB is an effective and safe analgesia method resulting in better postoperative patient comfort and greater ROM. Furthermore, it produces better results in the early postoperative period with a favorable side effect profile.

Keywords: Femoral nerve block; knee arthroplasty; multimodal analgesia; periarticular infiltration.

Total knee arthroplasty (TKA) is one of the most frequently performed major orthopedic operations, and postoperative pain is the most common adverse effect.[1–3] Postoperative pain is a primary concern for patients and can directly affect their functional recovery.[4–6] With sufficient pain control in the postoperative period, patient

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Submitted: July 21, 2014 **Accepted:** December 12, 2014

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2015.14.0263
QR (Quick Response) Code

satisfaction increases, rehabilitation becomes easier, and length of hospital stay shortens.[3–5] In addition, early rehabilitation can decrease risk of complications such as deep venous thrombosis, pulmonary embolism, pneumonia, and urinary retention. Furthermore, arthrofibrosis development can be prevented if the maximum range of motion (ROM) is recovered in the early postoperative period.[7,8]

Analgesia administered after TKA is usually multimodal and includes various methods such as intravenous (IV) opioids, peripheral nerve block, epidural analgesia, intraarticular or intrasynovial opioids, oral analgesics, and local anesthetics.[2,5] Multimodal therapy is achieved by the simultaneous use of analgesic agents acting on different pain pathways.[9]

The aim of this prospective randomized study was to compare the effects of 24-h continuous femoral nerve block (CFNB) with posterior capsular infiltration versus periarticular infiltration analgesia (PIA) on postoperative pain, and the manifestation of these effects on functional results in the early postoperative period after TKA.

Patients and methods

The study was approved by the local ethics committee (decision no: 41; June.1.2012). Prior to surgery, patients were informed about the surgical anesthetic method they would receive and about the study and postoperative processes and written consent was obtained. The study could not be blinded because of the catheter placement.

Patients were included if they underwent unilateral TKA with a diagnosis of primary gonarthrosis and agreed to participate in the study and comply with all study-related procedures. Patients were excluded from participating if they had American Society of Anesthesiologists (ASA) grades IV/V, hepatic dysfunction, liver disease, kidney disease, severe heart failure, morbid obesity (body mass index [BMI] >40 kg/m^2), neuropathic pain, allergies to local anesthetics, or were unable to walk unaided.

A total of 60 patients were enrolled. These patients were divided into to two study groups: Group A received CFNB and Group B received PIA. Randomization was carried out by the patient choosing an envelope containing the name of the group to which they would be assigned.

Patients were taken to the operating room without premedication. Spinal anesthesia was performed after standard monitoring tests were carried out. Intraoperative fluid maintenance was provided at a rate of 6–8 mL/kg/h with 0.9% NaCl. All patients were given an antibiotic prophylaxis comprising of one injection of 1 g Cefozine administered 1 h before surgery.

All operations were performed under pneumatic tourniquet by the same surgical team, using the standard anterior median longitudinal skin incision and medial parapatellar approach. The same prosthesis (Vanguard® Complete Knee System-Cruciate Retaining; Biomet® Orthopedics, Inc., USA) was used in all patients.

A patellar implant was not used in any patient. In order to create similar groups in terms of popliteal pain, the patients received 0.25% levobupivacaine and 20 mL of a solution containing epinephrine (1:100,000) as infiltration to the posterior capsule immediately before the implants were placed. Before closure, bleeding control was performed and an aspiration drain was placed.

A femoral nerve catheter was placed in each Group A patient before spinal anesthesia was administered. Under aseptic conditions, the nerve was located using an out-of-plane technique with a linear probe (10–18 MHz) under ultrasonography (My Lab-5TM; E-Saote, Italy) guidance. Once motor motion (0.5 mA, 0.1 ms) was observed in the quadriceps with a neurostimulator (Stimuplex® HNS 11; Braun, Germany), nerve circumference was extended with 10 mL of 0.9% NaCl, and a nerve catheter (Contiplex® D; Braun, Germany) was placed at 5-cm depth. At the end of surgery, a loading dose of 10 mL of 0.25% levobupivacaine was administered, and infusion was started with 0.1% levobupivacaine at a rate of 8 mL/ h and continued for 24 h after surgery.

In Group B patients, a total of 75 mL of 0.25% levobupivacaine with a 1:100,000 solution of epinephrine was applied to the medial and lateral capsule, medial and lateral meniscal rims, deep portion of the medial ligament, medial and lateral synovial recesses, patellar ligament, and quadriceps tendon, in three equal doses.

In the recovery room, all patients received 50 mg IV dexketoprofen. A patient-controlled analgesia (PCA) device was used for 24 h (settings: 5 mg/h tramadol IV infusion, 5 mg bolus dose, lock-out 10 min, and 4-h tramadol limit of 100 mg), and 24-h tramadol use was recorded. Antibiotic prophylaxis was continued for 24 h with 3×1 g of cefozine. Patients were given dexketoprofen every 12 h and 1 g of paracetamol tablets every 8 h until discharge. In case of nausea and vomiting, 20 mg of IV metoclopramide was given.

Preoperative quadriceps muscle strength was assessed by manual muscle testing, and ROM was mea-

sured using a long-arm goniometer with the patient in the supine position. Patients were not allowed to exercise actively until postoperative day 1 (12.00–15.00 h). ROM and pain (visual analog scale; VAS) were evaluated with active flexion on postoperative days 1 and 2 at 12.00 h. Pain at rest and pain and ROM with passive flexion were recorded using VAS at 22.00 h on the operation day, and at 08.00 and 22.00 h on postoperative days 1 and 2. On the latter 2 days, patients exercised under the supervision of the same physiotherapist. The exercises focused on quadriceps and hamstring muscle strength, and consisted of quad sets, straight leg raise, ankle pumps, heel slides, terminal knee extensions, and bedside flexes. Pain occurring with maximum knee motion and immediately after exercise was recorded using VAS.

Two-min walking tests (2MWTs) were performed and recorded before surgery, and at 24 h, 48 h, and at 6 weeks after surgery. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC;[10] pain, stiffness and function subscales) and Knee Society Score (KSS;[11] pain and function subscales) were completed in person by patients, with the assistance of a resident, and recorded before surgery and at 6 weeks after surgery.

Data were statistically analyzed using SPSS software (v. 10.0; SPSS Inc. Chicago, IL, USA). Student's t test, Mann–Whitney U test, and χ^2 test were used for comparisons. Significance was set at $p<0.05$.

Results

When demographic characteristics of patients in both groups were statistically compared, there were no significant differences in age, ASA scores, or operated side ($p>0.05$) (Table 1).

There were no significant differences between the groups in surgery time, tourniquet time and pressure, amount of bleeding and IV fluid given during surgery, mobilization time, or length of hospital stay ($p>0.05$) (Table 1). There were no significant differences between the groups in preoperative ROM ($p>0.05$) (Table 3) or quadriceps muscle strength (5/5 in both). When preoperative pain at rest was evaluated with VAS, average pain score was significantly higher ($p<0.05$) in Group A (9.61) than in Group B (8.61) (Table 2). No significant difference was found between the groups on the 2MWT before surgery ($p>0.05$) (Table 4). There were no significant differences in preoperative KSS or WOMAC scores between the groups ($p>0.05$) (Table 5).

Table 1. Patient characteristics and clinical data.

	Group A			Group B			p
	n	%	Mean±SD	n	%	Mean±SD	
Age (Years)			69.50±5.28			66.93±7.44	.125*
Weight (kg)			94.63±11.77			90.36±12.79	.184*
Height (cm)			160.34±3.82			162.93±5.91	**.046***
Body mass index			36.741±3.675			33.961±3.853	**.006***
Sex (Male/female)	2/30			4/24			.301#
ASA							
I	5	15.6		3	10.7		
II	24	75.0		20	71.4		
III	3	9.3		5	17.9		.576#
Side							
Left	15	46.9		14	50.0		
Right	17	53.1		14	50.0		.809#
Operation time (min)			97.53±7.10			98.82±8.68	.529*
Tourniquet time (min)			88.19±6.52			90.04±7.61	.315*
Tourniquet pressure (mmHg)			288.44±14.62			294.64±14.27	.103*
Intraoperative bleeding (ml)			225.63±31.72			223.93±28.46	.829*
Intraoperative fluid (ml)			1421.88±361.66			1482.14±419.04	.585*
Postoperative eating time (h)			5.09±0.73			5.18±0.82	.674*
Mobilization time (h)			26.69±4.67			27.86±6.01	.401*
Hospitalization time (days)			4.81±0.69			4.61±0.74	.271*
Residual narcotics (ml)			77.26±4.15			61.21±9.24	**.000***

*Student's t-test; #Chi-square test; $p<0.05$ is statistically significant; ASA: American Society of Anesthesiologists.

After surgery, PCA-administered opioid use, measured by the residual volume of the PCA narcotics, was significantly lower in Group A ($p<0.05$) (Table 1). Patients in Group A experienced less pain with passive motion until 22.00 h on day 1 ($p<0.05$) (Table 2) and had superior postoperative pain control at rest until 22:00 h on day 2 ($p<0.05$) (Table 2). In this group, pain with active motion was significantly less on day 1, while pain after active motion was less on both days 1 and 2 compared with Group B ($p<0.05$) (Table 2). Passive and active ROM was superior in Group A at all times after surgery ($p<0.05$) (Table 3). Group A also demonstrated better 2MWT results at 24 and 48 h after surgery; however, this difference disappeared by 6 weeks after surgery (Table 4). WOMAC and KSS scores were superior at 6 weeks after surgery in Group A ($p<0.05$) (Table 5).

In the postoperative period, no wound or deep infection developed in any of the patients. There was also no systemic or local complication due to CFNB or PIA.

Discussion

Postoperative pain is primary concern for patients after TKA.[4–6] Pain with motion has been shown to be great-

Table 2. Postoperative pain at rest, with passive motion and with active motion (VAS).

	Group A	Group B	p*
Preoperative	**9.16±1.02**	8.61±0.83	**.005**
At rest			
At 22:00	2.34±1.96	**4.39±2.02**	**.000**
Day I at 08:00	1.88±1.41	**3.25±1.96**	**.002**
Day I at 22:00	0.81±1.35	**2.07±1.39**	**.000**
Day II at 08:00	0.38±0.66	**1.46±1.26**	**.001**
Day II at 22:00	0.28±0.46	0.67±0.88	.094
With passive motion			
At 22:00	4.53±2.08	**6.32±1.89**	**.001**
Day I at 08:00	4.56±1.37	**5.14±1.21**	**.046**
Day I at 22:00	4.06±1.19	4.21±1.50	.113
Day II at 08:00	3.53±1.05	3.86±1.30	.058
Day II at 22:00	3.47±1.34	3.19±1.24	.295
With active motion			
Day I	4.50±1.19	**5.64±1.50**	**.002**
Day II	4.28±1.11	4.46±1.26	**.640**
After active motion			
Day I	1.56±1.81	**3.18±1.61**	**.001**
Day II	.97±1.03	**1.82±1.36**	**.014**

*Mann–Whitney U test; $p<0.05$ is statistically significant.

Table 3. Passive and active flexion range of motion (degrees).

	Group A	Group B	p*
Preoperative flexion	96.78±7.84	96.07±7.92	.729
Passive flexion			
At 22:00	**90.63±10.14**	77.14±15.36	**.000**
Day I at 08:00	**96.56±11.53**	82.32±12.43	**.000**
Day I at 22:00	**98.44±10.19**	88.21±10.20	**.000**
Day II at 08:00	**97.81±6.59**	89.82±9.67	**.000**
Day II at 22:00	**101.25±6.60**	92.04±6.24	**.000**
Active flexion			
Day I	**97.19±10.23**	85.89±11.14	**.000**
Day II	**99.38±7.59**	91.25±10.68	**.001**

*Student's t-test; $p<0.05$ is statistically significant.

Table 4. Preoperative and postoperative 2MWT.

	Group A	Group B	p*
Preoperative	63.38±18.35	68.14±21.16	.354
Postoperative 24 h	**20.06±5.80**	15.71±7.85	**.017**
Postoperative 48 h	**29.13±6.12**	24.71±9.57	**.035**
6 weeks after surgery	57.19±13.81	53.57±13.92	.317

*Student's t-test; p<0.05 is statistically significant.

Table 5. WOMAC and KSS scores before surgery and 6 weeks after surgery.

WOMAC	Group A	Group B	p*
Preoperative	33.75±3.49	34.19±2.87	.600
6 weeks after surgery	**47.10±3.42**	44.36±4.59	**.011**
KSS			
Preoperative	37.41±3.96	38.57±4.45	.288
6 weeks after surgery	**56.47±7.41**	49.18±4.86	**.000**

*Student's t-test; p<0.05 is statistically significant.

er than pain at rest after TKA.[4] There have been many studies on multimodal analgesia after TKA, but results have been conflicting.[9–14] PIA has been shown to be superior in some studies, whereas FNB with or without patient-controlled epidural analgesia has been shown to be superior in others.[3,9–14] Usually, differences in pain between the groups disappeared 1 day after surgery.[3,9–13] One study showed that application of analgesic infiltration to the posterior capsule in both PIA and FNB groups resulted in lower narcotic usage and the prolongation of analgesic effect by a day in the FNB group.[14] Femoral block alone without infiltration analgesia in the posterior capsule of the knee joint does not provide sufficient analgesia to the posterior capsule.[12,13,15] A combined sciatic–femoral nerve block provides better analgesia than femoral block alone,[6,16,17] but causes motor block of the hamstring and quadriceps muscles, which increases fall risk.[6] Additionally, sciatic-nerve block delays patient mobilization.[12] Posterior capsule infiltration is considered superior to sciatic-nerve block because it demonstrates similar postoperative pain relief, but is easier to apply and has a decreased risk of morbidity.[17] In the present study and that of Carli et al.,[14] analgesic infiltration was applied to the posterior capsule in both groups to eliminate pain in the capsule, thus homogenizing groups. With similar comparison groups in both of these studies, patients who received a femoral catheter had better pain control at rest after surgery.

Similarly, studies comparing FNB and PIA showed that patients administered FNB without analgesic infiltration to the posterior capsule experienced greater pain with movement.[13] In the present study, no differences in pain were found for passive movement at night on day 1 and 2 after surgery or for active movement performed on day 2 after surgery. Thus, our study provides similar results to those of Meftah et al. and Toftdahl et al., who also reported that group differences disappeared by day 2 after surgery.[9,12] However, in the present study, Group A had statistically less pain immediately after exercise than Group B. This is likely to encourage patients to exercise following surgery. No similar assessment or analysis has been performed in previous studies.

In a previous study conducted to assess the effectiveness of posterior capsule injection, it was reported that pain was less and movement was easier in the first 12 h after surgery in the group that received posterior capsule injection than in the group that received CFNB only.[16] In the present study, total opioid usage was significantly lower in patients who were administered CFNB.

In the present study, ROM during active and passive flexion on days 1 and 2 after surgery was statistically better in patients administered CFNB than in patients administered PIA. In a previous study in which posterior capsular infiltration was not performed, ROM was greater in the PIA group.[3] Another study found that when CFNB was compared with continuous epidural analgesia, the patients who received CFNB had less pain during rehabilitation, indicating that CFNB controls pain better and speeds up knee rehabilitation.[18] Less pain after exercise increases patient comfort and encourages the patient to exercise.[3–5] Taking the results of the present study and those of previous studies together, ef-

fective analgesia appears to affect ROM directly during the early postoperative period.

In our study, both the CFNB and the PIA groups had better KSS and WOMAC scores at 6 weeks after surgery than those before surgery. Similarly, in the study of Carli et al.,[14] patients given CFNB had better results at 6 weeks after surgery than patients given PIA. As there are no other similar comparison studies in the literature, we were unable to compare our results with more studies. However, we agree with Carli et al.,[14] that results at 6 weeks after surgery are not directly dependent on postoperative analgesics, but are more likely to be a result of the general positive effects of postoperative analgesia.

In the current study, we observed that patients who received CFNB had better walking distances at 24 and 48 h after surgery, and they experienced less pain at rest, during active and passive movement, and after exercise. However, the difference in preoperative walking distance between the groups was not statistically significant. In addition, neither group was able to reach the walking distances they had achieved prior to surgery. By contrast, Carli et al. showed that 6-min-walk test increased significantly in patients who received CFNB at 6 weeks after surgery,[14] and it was also observed that the walking distance had increased in both groups compared with preoperative values.[14] As there is no other similar study in the literature comparing the walking distances at 6 weeks after surgery, it is not possible for us to make further comparisons. Comparing these two studies, a possible explanation for the discrepancy between the results is that the BMI of our patients was higher than that of the patients in the Carli et al. study;[14] this might have made walking more difficult for our patients and decreased their 2 MWT results. In other studies that have evaluated BMI and functional results, it was reported that obesity negatively affected functional results after arthroplasty.[19,20]

In the current prospective study, we compared patients administered CFNB or PIA, two methods that provide pain control through different mechanisms. We ensured homogenization of the groups by performing infiltration analgesia to the posterior capsule, and observed that patients who were administered CFNB experienced less pain at rest and during movement postoperatively needed less PCA and had higher ROM than patients administered PIA. We believe that the lower pain experienced after exercise was an important factor that directly affected rehabilitation. At follow-up at 6 weeks after surgery, KSS and WOMAC scores of the patients receiving CFNB were better than those of patients receiving PIA; however, there was no difference in 2MWT results between the groups at this time point.

There are some limitations to our study. The nonblinded design of the study could be disadvantageous in the interpretation of outcomes in comparison with a blinded study; however, blinding was not possible because of catheter placement. The simplicity of the randomization procedure could also be a disadvantage compared with a block design. We did not measure the preoperative and postoperative quadriceps muscle strength with a specialized instrument; if we had, this would have provided an objective outcome for the femoral block. We assessed 2MWT before and after surgery, but walking represents only one type of activity performed on a daily basis. A community Health Activities Model Program for Seniors (CHAMPS)[21] questionnaire could be useful to estimate physical activities.

In conclusion, CFNB, as long as it is administered with infiltration analgesia to the posterior capsule, is an effective and safe analgesia method. It results in better postoperative patient comfort and higher ROM, and it produces better results in the early postoperative period with a favorable side effect profile.

Conflics of Interest: No conflicts declared.

References

1. Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS. Multimodal pain management after total hip and knee arthroplasty at the Ranawat Orthopaedic Center. Clin Orthop Relat Res 2009;467:1418–23. CrossRef
2. Kazak Bengisun Z, Aysu Salviz E, Darcin K, Suer H, Ates Y. Intraarticular levobupivacaine or bupivacaine administration decreases pain scores and provides a better recovery after total knee arthroplasty. J Anesth 2010;24:694–9. CrossRef
3. Parvataneni HK, Shah VP, Howard H, Cole N, Ranawat AS, Ranawat CS. Controlling pain after total hip and knee arthroplasty using a multimodal protocol with local periarticular injections: a prospective randomized study. J Arthroplasty 2007;22(6 Suppl 2):33,8.
4. Ng FY, Ng JK, Chiu KY, Yan CH, Chan CW. Multimodal periarticular injection vs continuous femoral nerve block after total knee arthroplasty: a prospective, crossover, randomized clinical trial. J Arthroplasty 2012;27:1234–8.
5. Gómez-Cardero P, Rodríguez-Merchán EC. Postoperative analgesia in TKA: ropivacaine continuous intraarticular infusion. Clin Orthop Relat Res 2010;468:1242–7. CrossRef
6. Kadic L, Boonstra MC, DE Waal Malefijt MC, Lako SJ, VAN Egmond J, Driessen JJ. Continuous femoral nerve block after total knee arthroplasty? Acta Anaesthesiol Scand 2009;53:914–20. CrossRef
7. Dobrydnjov I, Anderberg C, Olsson C, Shapurova O,

Angel K, Bergman S. Intraarticular vs. extraarticular ropivacaine infusion following high-dose local infiltration analgesia after total knee arthroplasty: a randomized double-blind study. Acta Orthop 2011;82:692–8. CrossRef

8. Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. Clin Orthop Relat Res 2010;468:135–40.
9. Meftah M, Wong AC, Nawabi DH, Yun RJ, Ranawat AS, Ranawat CS. Pain management after total knee arthroplasty using a multimodal approach. Orthopedics 2012;35:660–4. CrossRef
10. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)-development of a self-administered outcome measure. J Orthop Sports Phys Ther 1998;28:88–96. CrossRef
11. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989;248:13–4. CrossRef
12. Toftdahl K, Nikolajsen L, Haraldsted V, Madsen F, Tønnesen EK, Søballe K. Comparison of peri- and intraarticular analgesia with femoral nerve block after total knee arthroplasty: a randomized clinical trial. Acta Orthop 2007;78:172–9. CrossRef
13. Affas F, Nygårds EB, Stiller CO, Wretenberg P, Olofsson C. Pain control after total knee arthroplasty: a randomized trial comparing local infiltration anesthesia and continuous femoral block. Acta Orthop 2011;82:441–7. CrossRef
14. Carli F, Clemente A, Asenjo JF, Kim DJ, Mistraletti G, Gomarasca M, et al. Analgesia and functional outcome after total knee arthroplasty: periarticular infiltration vs continuous femoral nerve block. Br J Anaesth 2010;105:185–95.
15. Yadeau JT, Goytizolo EA, Padgett DE, Liu SS, Mayman DJ, Ranawat AS, et al. Analgesia after total knee replacement: local infiltration versus epidural combined with a femoral nerve blockade: a prospective, randomised pragmatic trial. Bone Joint J 2013;95-B:629–35. CrossRef
16. Krenzel BA, Cook C, Martin GN, Vail TP, Attarian DE, Bolognesi MP. Posterior capsular injections of ropivacaine during total knee arthroplasty: a randomized, double-blind, placebo-controlled study. J Arthroplasty 2009;24(6 Suppl):138–43. CrossRef
17. Mahadevan D, Walter RP, Minto G, Gale TC, McAllen CJ, Oldman M. Combined femoral and sciatic nerve block vs combined femoral and periarticular infiltration in total knee arthroplasty: a randomized controlled trial. J Arthroplasty 2012;27:1806–11. CrossRef
18. Sakai N, Inoue T, Kunugiza Y, Tomita T, Mashimo T. Continuous femoral versus epidural block for attainment of 120° knee flexion after total knee arthroplasty: a randomized controlled trial. J Arthroplasty 2013;28:807-14.
19. Jones CA, Cox V, Jhangri GS, Suarez-Almazor ME. Delineating the impact of obesity and its relationship on recovery after total joint arthroplasties. Osteoarthritis Cartilage 2012;20:511–8. CrossRef
20. Bugała-Szpak J, Kusz D, Dyner-Jama I. Early evaluation of quality of life and clinical parameters after total knee arthroplasty. Ortop Traumatol Rehabil 2010;12:41–9.
21. Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, Ritter PL. CHAMPS physical activity questionnaire for older adults: outcomes for interventions. Med Sci Sports Exerc 2001;33:1126–41. CrossRef