

Influence of Anaesthesia Technique on Patient-Reported Outcomes After Total Knee Arthroplasty: A Prospective Randomized Comparison of Complete Peripheral Nerve Block versus General Anaesthesia with Continuous Femoral Block

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Research Article

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Abstract

Background

Total knee arthroplasty (TKA) is one of the most performed orthopaedic surgeries worldwide. The anaesthetic technique used has a considerable impact on the overall outcome. Peripheral nerve blocks (PNB) can help to manage postoperative pain. However, their exact impact on patient-reported outcome measures (PROM) remains unclear. This study compared the influence of a combined PNB (femoral block sciatic block and obturator single shot) and general anaesthesia (GA) with a femoral nerve block (FNB) on postoperative patient satisfaction and well-being following TKA.

Methods

This prospective, randomised, controlled clinical trial (RCT) involved 98 patients undergoing TKA, who were randomised into two groups: Group A (general anaesthesia with regional anaesthesia; $n = 50$) and Group B (combined regional anaesthesia with intraoperative propofol sedation; $n = 48$). The primary endpoint was the proportion of patients achieving an average score of 0–1 on the Anaesthesiological Follow-up Questionnaire for Patients (ANP) within the first three postoperative days. The secondary endpoints were defined as opioid consumption within the first four hours postoperatively, pain as measured by the Numerical Rating Scale (NRS) within the first three postoperative days (POD), range of motion (ROM) within the first three POD, and whether patients would opt for the same anaesthetic procedure again in the event of a future elective operation.

Results

There was no significant difference between the two groups regarding the primary endpoint (LS means: Group A 0.312 vs. Group B 0.323, $p = 0.797$). However, Group B used significantly fewer opioids ($p < 0.001$), had a lower NRS on all three postoperative days ($p = 0.014$, $p = 0.019$, $p = 0.003$) and exhibited a greater ROM ($p < 0.001$).

Conclusion

Combined PNB and GA with FNB following TKA result in equivalent patient outcomes in terms of satisfaction and postoperative symptoms. However, combined PNB is superior to GA with FNB in terms of postoperative analgesia and early postoperative knee function.

Trial registration:

The trial was retrospectively registered at DRKS (DRKS-ID: DRKS00041059) on July 23, 2026.

Introduction

TKA is one of the most common orthopaedic procedures worldwide, with demand continuing to rise. This is primarily due to an ageing population and the growing prevalence of symptomatic knee osteoarthritis [1, 2]. Although surgical techniques are becoming increasingly standardised, the optimal anaesthetic approach is still being researched. The choice of anaesthetic technique affects intraoperative haemodynamic stability, surgical conditions, postoperative pain management, joint function recovery, and the patient's overall experience [3, 4].

The quality of anaesthetic and perioperative care has evolved significantly over recent decades and efforts have been made to improve their assessment of quality. New metrics have been proposed to this end. However, further research is required before they can be successfully implemented [5]. Patient satisfaction and patient-reported outcome measures (PROMs) have become important quality indicators, joining traditional parameters such as haemodynamic parameters and complication rates. [5,6,7] Taking these factors into account, Hüppe et al. developed the ANP to capture the multidimensional nature of postoperative symptoms relating to pain, nausea, cognitive disturbances and satisfaction with perioperative care [6].

The approach to pain management in TKA has evolved into a multimodal approach. PNBs have been shown to improve postoperative analgesia when compared with the administration of systemic opioids and neuraxial techniques [3, 7–9]. Combining a sciatic nerve block (SNB) with a FNB can provide significant analgesic benefits, particularly in the early postoperative phase [7]. Within the framework of enhanced recovery after surgery (ERAS) programmes, motor-sparing techniques such as the adductor canal block (ACB) or infiltration between the popliteal artery and the knee capsule (iPACK) are increasingly being used to ensure adequate analgesia without compromising quadriceps function [10–12].

Despite the advantages of regional anaesthesia techniques, the relationship between effective analgesia and patient satisfaction and well-being is complex and not necessarily straightforward. Studies have shown that patient satisfaction is influenced by factors other than just pain intensity. These include expectations, communication, perceived control and nursing care, among others [13–16].

Little is known about whether a combined PNB involving a FNB, SNB and obturator single-shot, or GA with a FNB, is superior in terms of PROM and absence of symptoms. This study aimed to determine which of these two procedures achieves higher patient satisfaction and absence of symptoms, as measured by the ANP. To the best of our knowledge, no other studies have investigated patient satisfaction following TKA in relation to GA with FNB versus a combined FNB and SNB with an obturator single-shot.

Materials and Methods

This prospective RCT was carried out at the Department of Orthopaedic Surgery, Hannover Medical School, Diakovere Annastift, Hannover, Germany. The study was designed and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The study is a monocentric, randomised, parallel-group interventional trial with a 1:1 allocation ratio. The scientific framework was designed to test the superiority of the experimental therapy (group B) to the standard therapy (group A). The study protocol was approved by the Ethics Committee of Hannover Medical School (study number 5781), and all procedures were performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants for both anaesthetic techniques prior to randomization. Patients and the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Participants

Patients were enrolled between March 2011 and February 2012. Inclusion criteria were age ≥ 18 years, American Society of Anesthesiologists (ASA) physical status I–II, and elective primary TKA for primary knee osteoarthritis. Exclusion criteria included language barriers precluding questionnaire completion, ASA class III–IV, pre-existing neurological deficits in the limb to be operated, coagulopathies, infection at the planned catheter insertion site, prior surgery at the catheter site, and known allergies to any medications used in the study protocol. A total of 122 patients were screened, of whom 98 were randomized: 50 to group A and 48 to group B.

Randomization and Blinding

Central randomisation of the two anaesthetic procedures was carried out at the Institute of Biometry at Hannover Medical School using a predefined randomisation form. The form was completed in full and sent by fax to the Institute of Biometry, which processed it and returned it by fax. To balance known and unknown prognostic factors, randomisation with variable block lengths was performed for the two treatment groups. Randomisation was stratified by gender. In addition, partial monitoring was carried out for the primary endpoint. Prior to the commencement of the study, a randomisation agreement was drawn up, detailing which individuals were authorised to request and carry out randomisation at the Institute of Biometry.

In the Department of Anaesthesia and Intensive Care, the department secretary received the faxed result and communicated it to the anaesthetist on duty. The anaesthetist then visited the patient on the afternoon of their admission to inform them of the allocated anaesthetic procedure. Given the fundamentally different nature of the anaesthetic techniques (general anaesthesia with endotracheal intubation vs. regional blocks with sedation), blinding of patients was not feasible. An investigator-blinded design was utilized. Questionnaire assessors were not involved in the anaesthetic care.

Intervention

Group A (General Anesthesia with FNB)

Patients received total intravenous anesthesia (TIVA) using propofol and remifentanyl with endotracheal intubation and controlled ventilation. Anaesthesia depth was controlled using an integrated EEG system (Narcotrend®). A femoral nerve catheter was placed preoperatively under nerve stimulator guidance for postoperative analgesia with continuous local anesthetic infusion.

Group B (Complete Peripheral Nerve Block): Patients received a triple-component peripheral nerve block: (1) a FNB with catheter placement for continuous postoperative analgesia; (2) a transgluteal SNB with catheter technique; and (3) an obturator nerve block as a single-shot injection. Surgery was performed under these nerve blocks with propofol sedation and maintaining spontaneous breathing without endotracheal intubation.

Outcome Measures

The primary endpoint was the proportion of patients classified as "largely complaint-free," defined as achieving a mean questionnaire score of 0–1 on a four-point Likert scale (0 = not at all, 1 = somewhat, 2 = fairly, 3 = strongly). The questionnaire used was a modified version of the ANP by Hüppe et al. [6], comprising 81 items administered over three postoperative days. Items assessed intubation-related complaints, medication side effects, pain, general well-being, peripheral block-related symptoms, intraoperative awareness, memory, perioperative care quality, and organizational aspects of recovery.

Secondary endpoints included: (1) willingness to choose the same anaesthetic technique again; (2) total opioid consumption (morphine equivalents) during the first four postoperative hours; (3) pain intensity on a Numeric Rating Scale (NRS, 0–10) on POD 1–3; (4) passive knee flexion on POD 1–3; (5) extension deficit; (6) anaesthesia and surgery duration; (7) catheter-related infections; and (8) neurological complications.

Statistical Analysis

All analyses were conducted on an intention-to-treat (ITT) basis. The primary analysis and (1) willingness to choose the same anaesthetic technique again employed logistic regression to compare the proportion of largely complaint-free patients between groups. Unanswered questions were not replaced. Patients who answered fewer than 80% of the questions in the questionnaire were classified as not being largely symptom-free. As a sensitivity analysis of the primary endpoint, a two-way analysis of variance (ANOVA) was performed with the factors of sex and type of anaesthesia. Secondary continuously scaled endpoints were analysed using analysis of variance (ANOVA), and categorical variables were compared using chi-squared test. Missing values were not imputed for the sensitivity analyses and secondary endpoints. The sample size calculation estimated that 49 patients would be required in each group, with a significance level of 5%, a power of 90%, and a clinically relevant difference in the proportion of patients who are largely symptom-free of 30%.

Results

Contrary to expectations, and in contrast to all preliminary studies, all participants met the definition of being largely symptom-free. This meant that logistic regression was no longer a suitable method. Consequently, the primary endpoint was analysed using the chi-squared test with continuity correction. Furthermore, (1) willingness to choose the same anaesthetic technique again was analysed using Fisher’s exact test.

The flow of participants through enrolment, randomisation, allocation, follow-up, and analysis is shown in Fig. 1.

Patient Characteristics

The two groups were well balanced with respect to age, sex, BMI, and ASA classification (Table 1). The mean age was 67.6 ± 8.3 years, and 73.5% of participants were female. As part of the ITT analysis, patients who were unable to submit a questionnaire due to premature withdrawal from the study were assigned a negative assessment. Seven patients withdrew from the study prematurely: One patient in group B because of an acute arterial occlusion, another patient in Group B withdrew from the study on the evening before the operation, following randomisation and the operation of 5 patients (3 in group A and 2 in group B) was postponed due to elevated preoperative inflammatory markers.

Table 1
Patient Demographics and Baseline Characteristics

Parameter	All (n = 98)	Group A: GA (n = 50)	Group B: PNB (n = 48)
Female, n (%)	72 (73.5%)	34 (68.0%)	38 (79.2%)
Male, n (%)	26 (26.5%)	16 (32.0%)	10 (20.8%)
Age, years (mean $\pm$ SD)	67.6 ± 8.3	66.9 ± 8.3	68.3 ± 8.3
Height, cm (mean $\pm$ SD)	167.4 ± 8.7	167.8 ± 8.8	166.9 ± 8.6
Weight, kg (mean $\pm$ SD)	82.1 ± 15.5	83.4 ± 15.2	80.7 ± 15.9
BMI, kg/m ² (approx.)	29.3	29.6	29.0
ASA I, n (%)	8 (8.2%)	5 (10.0%)	3 (6.4%)
ASA II, n (%)	90 (91.8%)	45 (90.2%)	45 (93.6%)

Primary Endpoint

No significant difference was observed in the proportion of patients classified as largely complaint-free between the two groups ($p = 0.955$). The mean questionnaire scores were low in both groups, indicating high overall satisfaction. ANOVA sensitivity analysis yielded LS-Means of 0.312 (95% CI 0.255–0.369) for

Group A and 0.323 (95% CI 0.262–0.383) for Group B ($p = 0.797$). When analyzed by sex, no significant differences were found (male LS-Means 0.326, 95% CI 0.250–0.403 vs. female LS-Means 0.308, 95% CI 0.263–0.354; $p = 0.689$).

Chronological Complaint Assessment

Analysis of questionnaire responses by postoperative time interval revealed no significant between-group differences at any assessment point. In the immediate postoperative period (recovery room), mean scores were 0.511 (Group A) and 0.477 (Group B, $p = 0.558$). On POD 1, scores were 0.328 versus 0.323 ($p = 0.911$), decreasing to 0.266 versus 0.264 on POD 2 ($p = 0.961$) and 0.223 versus 0.224 on POD 3 ($p = 0.988$). Assessment of perioperative care on POD 3 showed a trend favoring Group A (0.182 vs. 0.294, $p = 0.071$), though this did not reach statistical significance.

Thematic Domain Analysis

Symptom-oriented thematic analysis (Table 2) revealed comparable scores across most domains. One statistically significant difference was found in the anesthesia care domain, where Group A reported lower complaint scores than Group B (0.122 vs. 0.245, $p = 0.04$). Intubation-related complaints, medication side effects, pain perception, peripheral block– and pain catheter-related symptoms, sleep, and memory did not differ significantly between groups.

Table 2
Questionnaire Assessment by Thematic Domains

Domain	Group A (mean)	Group B (mean)	p-value
Intubation-related complaints	0.111	0.104	0.822
Medication side effects	0.089	0.081	0.862
Pain	0.405	0.370	0.600
General questions	0.392	0.407	0.802
Peripheral block–/pain catheter-related sytoms	0.183	0.286	0.162
Sleep during operation	0.666	0.531	0.549
Memory	1.277	1.206	0.644
Anesthesia care	0.122	0.245	0.040
Organization and reconvalescence	0.273	0.369	0.232

Secondary Endpoints

As missing data were not imputed for the secondary endpoints, 91 patients where analysed (47 in group A; 44 in group B). Regarding piritramide consumption, 45 patients were analysed in group B. For pain scores on POD 1, data of one patient in group B was missing. For the knee extension deficit on POD 3,

data of one patient in group A was missing. Regarding anaesthesia duration, 45 patients were analysed in group B.

Re-selection of anaesthetic method

Forty-five of patients (95.7%) in Group A and 43 (97.7%) in Group B indicated they would choose the same anesthetic procedure again ($p = 1.00$). No significant difference was observed regarding sex.

Opioid Consumption

Mean piritramide consumption during the first four postoperative hours was significantly lower in Group B: 12.39 mg (95% CI 9–15) versus 21.98 mg (95% CI 19–24) in Group A, representing a 43.6% reduction ($p < 0.001$). No significant difference was observed regarding sex.

Pain Scores

Mean NRS pain scores were significantly lower in Group B at all postoperative time points (Fig. 2): POD 1, 3.96 (95% CI 3.2–4.7) versus 5.20 (95% CI 4.5–5.9), $p = 0.014$; POD 2, 3.24 (95% CI 2.6–3.9) versus 4.24 (95% CI 3.6–4.8), $p = 0.019$; POD 3, 2.34 (95% CI 1.7–2.9) versus 3.54 (95% CI 3.0–4.1), $p = 0.003$. No significant difference was observed regarding sex.

Knee ROM

Knee flexion was significantly greater in Group B at all postoperative assessments (Fig. 3): POD 1, 51.0° (95% CI 47.0–55.1°) versus 36.0° (95% CI 32.2–39.8°); POD 2, 66.3° (95% CI 61.7–71.0°) versus 48.7° (95% CI 44.4–53.0°); POD 3, 78.8° (95% CI 74.2–83.4°) versus 61.1° (95% CI 56.8–65.4°) (all $p < 0.001$). The extension deficit was also lower in Group B but did not reach statistical significance overall: POD 1, 1.76° (95% CI 0.89–2.63°) versus 1.78° (95% CI 0.97–2.60°), $p = 0.967$; POD 2, 0.60° (95% CI –0.59–1.80°) versus 1.60° (95% CI 0.48–2.72°), $p = 0.200$; POD 3, 0.55° (95% CI –0.16–1.25°) versus 1.23° (95% CI 0.56–1.91°), $p = 0.136$. When analyzed by sex, women showed a significantly lower extension deficit than men on POD 1 (women: 1.05°, 95% CI 0.40–1.69° vs. men: 2.50°, 95% CI 1.41–3.59°; $p = 0.025$) and POD 3 (women: 0.30°, 95% CI –0.22–0.83° vs. men: 1.48°, 95% CI 0.58–2.37°; $p = 0.027$).

Anesthesia Duration

Mean anesthesia duration was significantly longer in Group B (167.2 min, 95% CI 158.6–175.8 vs. 142.6 min, 95% CI 134.4–150.7; $p < 0.001$), reflecting the additional time required for placement of three separate nerve blocks.

Operation Duration. The duration of surgery was comparable in both groups without significant difference (Group B: 88.3 min, 95% CI 80.7–95.9 vs. Group A: 87.1 min, 95% CI 79.9–94.3; $p = 0.814$).

Adverse Events

Catheter-associated infections occurred in 8.3% of patients in Group A and 15.9% in Group B. The difference was not significant.

In Group B, five patients (10.4%) required a switch to general anaesthesia. One patient had the catheter placed on the wrong side, one was extremely agitated, one required a change to the surgical procedure, and two experienced failed regional anaesthesia.

There was one serious adverse event in Group B in the form of an acute arterial occlusion. The Data Safety Monitoring Board assessed this event as being unrelated to the anaesthetic procedure.

None of the patients showed any postoperative nerve impairment that could be interpreted as persistent paraesthesia or muscle paralysis in the area innervated by the respective nerve.

The results for both groups, including their significance levels, are summarised in Table 3.

Table 3
Primary and Secondary Outcomes

Outcome	Group A: (mean, 95% CI)	Group B: (mean, 95% CI)	p-value
Primary endpoint (LS-Means)	0.312 (95% CI 0.255–0.369)	0.323 (95% CI 0.262–0.383)	0.797
Opioid consumption, mg piritramide (4 h)	21.98 (19–24)	12.39 (9–15)	< 0.001
NRS pain, POD 1	5.20 (4.5–5.9)	3.96 (3.2–4.7)	0.014
NRS pain, POD 2	4.24 (3.6–4.8)	3.24 (2.6–3.9)	0.019
NRS pain, POD 3	3.54 (3.0–4.1)	2.34 (1.7–2.9)	0.003
Knee flexion, POD 1 (°)	36.0 (32.2–39.8)	51.0 (47.0–55.1)	< 0.001
Knee flexion, POD 2 (°)	48.7 (44.4–53.0)	66.3 (61.7–71.0)	< 0.001
Knee flexion, POD 3 (°)	61.1 (56.8–65.4)	78.8 (74.2–83.4)	< 0.001
Knee extension deficit, POD 1 (°)	1.78 (0.97–2.60)	1.76 (0.89–2.63)	0.967
Knee extension deficit, POD 2 (°)	1.60 (0.48–2.72)	0.60 (– 0.59–1.80)	0.2
Knee extension deficit, POD 3 (°)	1.23 (0.56–1.91)	0.55 (– 0.16–1.25)	0.136
Anesthesia duration, min	142.6 (134.4–150.7)	167.2 (158.6–175.8)	< 0.001
Operation duration, min	87.1 (79.9–94.3)	88.3 (80.7–95.9)	0.814
Would choose same technique, n/N (%)	45/47 (95.7%)	43/44 (97.7%)	1.00
Catheter-site infection, n (%)	4 (8.3%)	7 (15.9%)	0.263

Discussion

The introduction of the ERAS principle to knee arthroplasty has led to an increased focus on patient well-being and satisfaction [17]. Due to the potential impairment of early mobilisation caused by motor neuron block, the role of nerve block anaesthesia in knee arthroplasty was decreased because of early postoperative mobilisation [18]. However, newer techniques can avoid this negative effect by using motor-sparing methods [19]. Nevertheless, the impact of various anaesthetic procedures used in total knee arthroplasty (TKA) on patient satisfaction and well-being and which of all techniques provides the highest patient satisfaction and well-being remains unclear.

The study aimed to investigate whether patient satisfaction and subjective well-being differ among patients undergoing primary TKA depending on the anaesthetic technique chosen. Patients who underwent combined PNB required significantly fewer opioids postoperatively, demonstrated significantly better knee flexion, and reported significantly less pain on the NRS. Nevertheless, the study found that the two anaesthetic techniques examined (GA with FNB versus combined PNB) do not differ significantly in terms of patient satisfaction and well-being, as measured by a modified ANP.

Overall, comparing the literature proved difficult as only three studies were identified in which the control group underwent TKA using a combination of regional anaesthesia and sedation [20–22]. In two of these studies, the control group did not receive general anaesthesia [20, 21]. Kim et al. compared a combined spinal-epidural nerve block with a femoral/sciatic nerve block combined with a lateral femoral cutaneous nerve block. They found no differences in terms of perioperative side effects, satisfaction with surgical anaesthesia and postoperative analgesia, willingness to recommend the same surgical anaesthesia and postoperative analgesia to others, or postoperative VAS. However, there was a significant increase in analgesic use in the catheter group [20]. In their randomised study, Liu et al. compared general anaesthesia with a combination of lumbar plexus and sciatic block anaesthesia. As in our study, patient satisfaction did not differ significantly. As measured by the Post-operative Quality Recovery Scale, the PNB group performed significantly better in all domains except activities of daily living and required significantly fewer painkillers [21]. This is also consistent with the results of our study. Another study compared a psoas sciatic block with combined spinal epidural anaesthesia and found no differences in terms of complications, early mobilisation and patient satisfaction [22].

Reinbach et al. compared patient satisfaction levels, with using the ANP, among patients who received a local infiltration analgesia (LIA) or a combination of a distal sciatic and femoral single-shot block during TKA [23]. The study found that the LIA produced higher levels of patient satisfaction. No difference was observed in terms of ROM on the fifth postoperative day. However, the LIA group experienced more pain on the fifth postoperative day. However, well-being was not assessed until six weeks postoperatively, and general anaesthesia and spinal anaesthesia were unevenly distributed across both groups. A prospective service evaluation showed that there was no significant difference in patient satisfaction or recommendation of the anaesthetic procedure between patients who received GA and those who received regional anaesthesia during TKA [24]. These results are consistent with ours. A meta-analysis

of 16 RCTs comparing GA or SA with a perineural block versus epidural analgesia during TKA found no significant differences in patient satisfaction, pain or ROM [9]. In general, the data on patient satisfaction and anaesthetic techniques in total knee arthroplasty is highly varied, highlighting the need for further research [25].

Regarding analgesia and opioid consumption in the early postoperative phase, findings of most studies are consistent with ours, demonstrating that regional anesthesia techniques improve analgesia and reduce opioid consumption after TKA [3, 4, 19, 26, 27].

Our study revealed significantly greater knee flexion in the PNB group. In a prospective observational study, Han et al. demonstrated that patients under general anaesthesia with PNB or ACB exhibited greater flexion and better mobilisation than those without regional anaesthesia [26]. Another prospective, randomised study compared GA with FNB and sciatic single-shot with GA using continuous LIA [28]. No difference in range of motion (ROM) was observed. Tan et al. conducted a randomised study on ROM under GA and found no difference between ACB, FNB and a femoral triangle block [29]. Moreno et al. compared LIA and FNB under GA in total TKA patients and found no difference in terms of step counts, VAS, and opioid consumption [30]. Reviews and meta-analyses indicate that the concurrent use of multiple regional techniques is associated with greater ROM [31, 32].

Despite the PNB group experiencing superior analgesia, this did not result in significantly higher patient satisfaction. Although a large prospective study demonstrated that pain is a significant predictor of dissatisfaction, the reciprocal influence of pain and satisfaction was not linear: mild and low levels of pain did not differ significantly from one another in terms of patient satisfaction [15]. Patient satisfaction is a complex factor influenced by multiple dimensions. These include communication quality, anaesthetist workload, level of supervision, the patient–physician relationship, and psychological factors such as anxiety and expectations, which modulate pain perception and treatment satisfaction, as well as nocebo and placebo effects [6, 13, 14, 16, 33]. In our study, the overall level of complaints, as measured by the ANP, was substantially below 1, indicating that the standard of care and information provided to patients regarding anaesthesiological procedures met their expectations.

In the PNB group, 10.4% of patients required a switch to general anaesthesia. This rate, however, is consistent with that reported in the relevant literature and reflects the technical challenges of performing three consecutive blocks [19].

It is notable that Group A reported significantly fewer complaints in the anaesthesia care domain than Group B. This could be attributed to the nature of the anaesthesia itself. During general anaesthesia, patients are unconscious. The patients in Group B, on the other hand, were sedated during surgery. Thus, the patients' expectations formed during the procedure may have led to this discrepancy [16, 34].

A significant reduction in opioid use was achieved in the PNB group. This finding is also reported in the relevant literature [35].

The findings of this study warrant particular consideration within the contemporary framework of fast-track surgery and ERAS protocols, which have fundamentally transformed perioperative management in arthroplasty [36, 37]. Modern fast-track programs prioritize same-day or next-day discharge, opioid-sparing multimodal analgesia, and early mobilization beginning on the day of surgery [36, 38]. However, Sponheuer et al. demonstrated in a retrospective analysis that the type of anaesthetic technique employed for total hip and knee replacement did not affect length of stay or patient satisfaction [37]. These observations are consistent with the primary endpoint of our study. Various anaesthetic approaches can achieve high levels of patient satisfaction and well-being if a structured perioperative protocol is followed and adequate communication with the patient is ensured.

Thanks to improved flexion and analgesia, coupled with high patient satisfaction and well-being, and the potential to reduce complications in TKA patients, PNB combinations can also be integrated into modern fast-track and ERAS protocols today [8, 35, 36].

The study has several limitations. One is the timing of the data collection. At the time, ERAS and fast-track programmes had not yet become widely established in orthopaedics. Consequently, the focus of anaesthetic techniques for TKA was not on motor-sparing procedures aimed at improving postoperative quadriceps function. The combination of a femoral and sciatic block in our study could potentially have affected the early mobilisation of patients adversely.

Secondly, only patients with an ASA I to II score were included, so the findings may differ among patients with higher ASA scores. Also, blinding was not possible due to the fundamentally different nature of the techniques. Furthermore, questionnaires are always susceptible to social desirability bias.

In addition to its study design and relatively large patient sample size, one of the study's strengths lies in its use of a robust, validated questionnaire to assess patient satisfaction [6, 39].

In summary, combined PNB techniques achieve a level of patient satisfaction that is comparable to GA with a FNB. Considering new motor-sparing approaches, the advantages associated with combined PNB techniques allow for the integration of PNBs into fast-track TKA concepts.

Conclusion

This prospective RCT demonstrates that a combined PNB technique (FNB, SNB and obturator single-shot) provides patient-reported satisfaction equivalent to GA with FNB after elective TKA, as measured by the validated ANP questionnaire. However, the PNB technique offered significant advantages, including a substantial reduction in opioid consumption, consistently lower pain scores, and superior early knee flexion at all measured time points. Given the 10% conversion rate to GA, a patient-specific approach should generally be adopted.

Abbreviations

ACB = Adductor canal block

ANCOVA = Analysis of covariance

ANOVA = Analysis of variance

ANP = Anästhesiologischer Nachbefragungsbogen für Patienten (Anaesthesiological Postoperative Questionnaire for Patients)

ASA = American Society of Anesthesiologists

BMI = Body mass index

CI = Confidence interval

ERAS = Enhanced recovery after surgery

GA = General anesthesia

iPACK = Infiltration between the popliteal artery and capsule of the knee

ITT = Intention-to-treat

LIA = local infiltration analgesia

LS-Means = Least squares means

NRS = Numeric rating scale

PNB = Peripheral nerve block

POD = Postoperative day

PROM = Patient-reported outcome measurement

RCT = randomized controlled trial

SD = Standard deviation

SNB = Sciatic nerve block

TIVA = Total intravenous anesthesia

TKA = Total knee arthroplasty

VAS = Visual analogue scale

Declarations

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Author contributions

ST Writing - Original Draft Preparation, MP, BEF, ST Conceptualisation, BEF Formal Analysis, MP, BEF Methodology, BEF Investigation, ST, AD, MH, AR Visualization, MP Supervision, ST, AD, MH, AR, MP Writing - Review & Editing

All authors read and approved the final manuscript.

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Data availability

The datasets used and analysed in the current study, trial protocol and statistical analysis plan are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the local Ethics Committee of the Hannover Medical School (No. 5781). Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Figures

Fig. 1

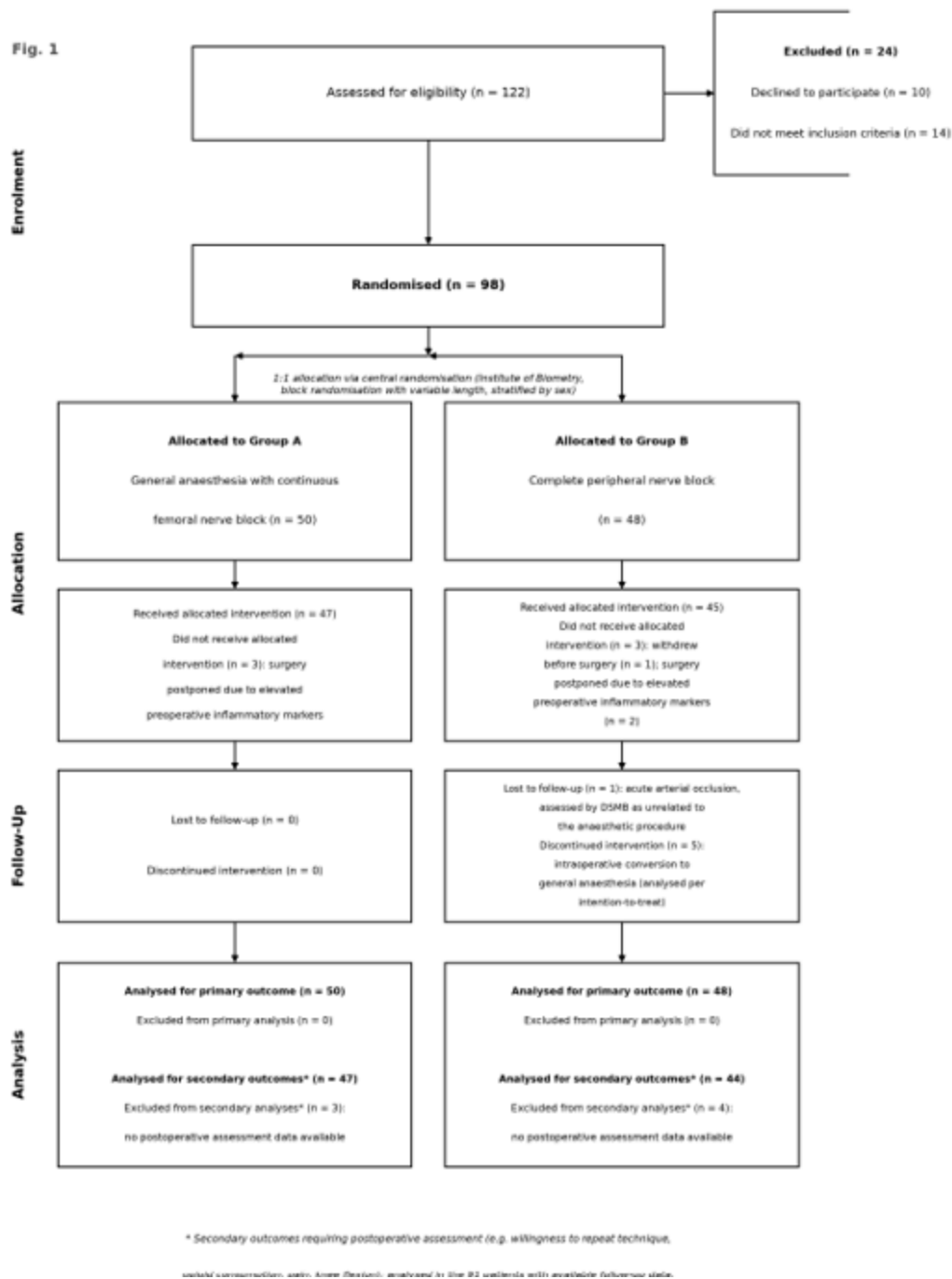


Figure 1

CONSORT flow diagram of enrolment, randomisation, allocation, follow-up, and analysis of study participants (N = 122 assessed for eligibility, 98 randomised).

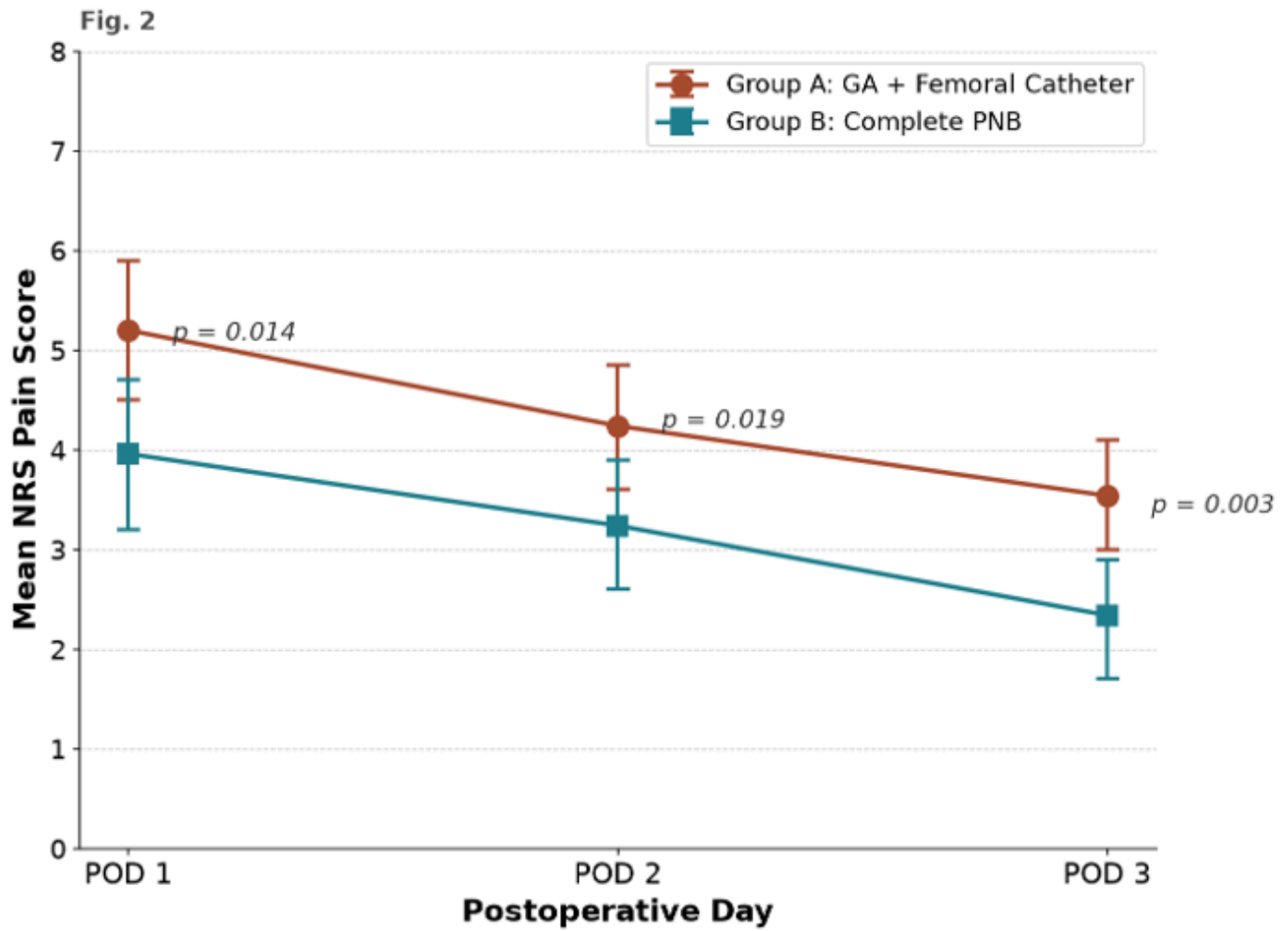


Figure 2

Pain on NRS over 72 hours. Data are presented as mean with 95% confidence intervals. All differences were statistically significant ($p < 0.05$).

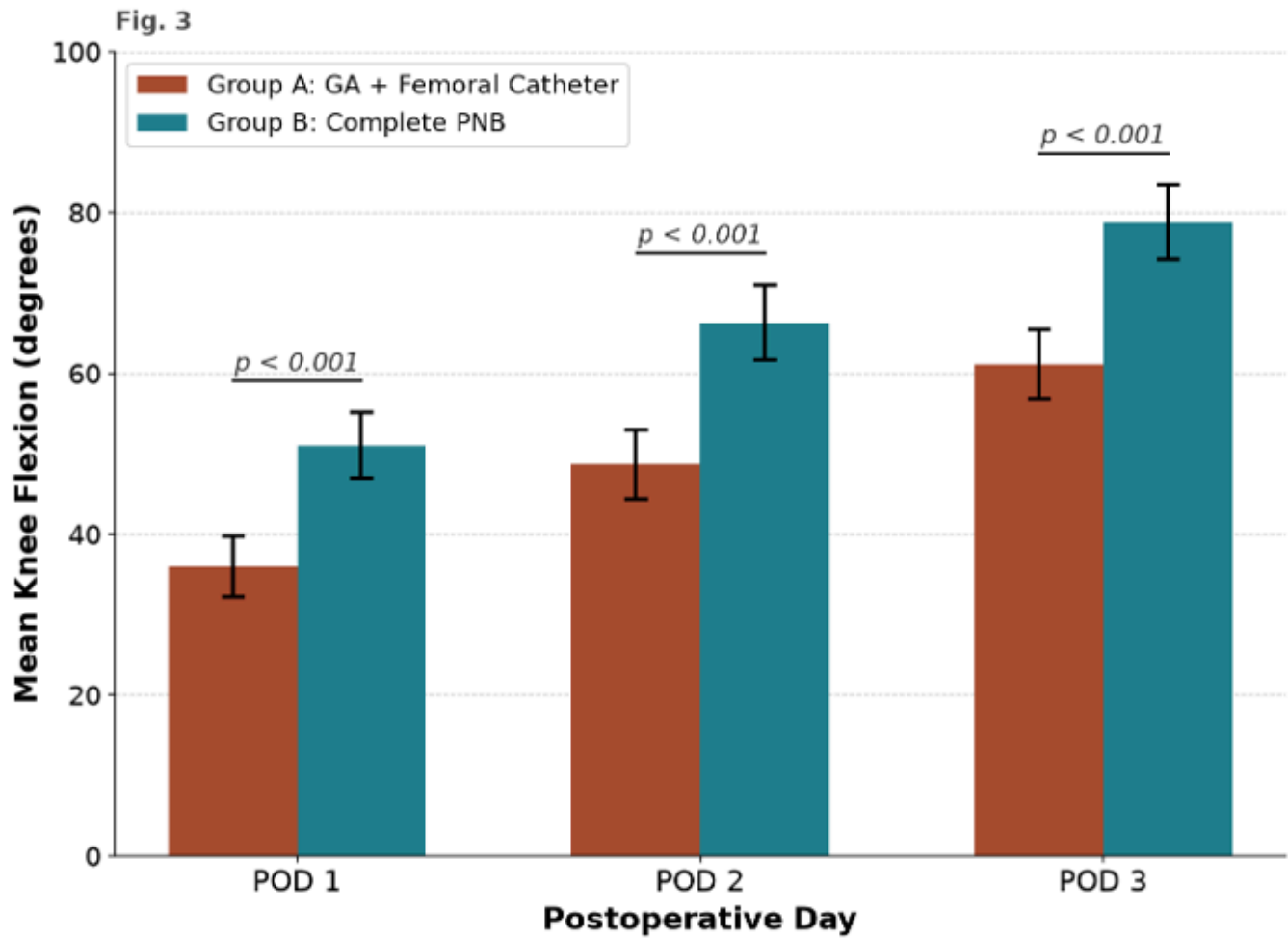


Figure 3

Knee flexion over 72 hours. Data are presented as mean with 95% CI. All differences were significant ($p < 0.001$).