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# Epidural infusion or combined femoral and sciatic nerve blocks as perioperative analgesia for knee arthroplasty†

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**Background.** Peripheral neural blockade appears to provide effective analgesia with potentially less morbidity than central neuraxial techniques. We compared the relative benefits of combined femoral (3-in-1) and sciatic nerve block with epidural blockade for postoperative knee arthroplasty analgesia.

**Methods.** Sixty patients, ASA I–III, undergoing unilateral knee replacement were prospectively randomized to receive either a lumbar epidural infusion or combined single-shot femoral (3-in-1) and sciatic blocks (combined blocks). All patients received standard general anaesthesia. Visual analogue pain scores and rescue opioid requirements were recorded at four time points postoperatively. Patient satisfaction, morbidity, block insertion time, perioperative blood loss and rehabilitation indices were also assessed.

**Results.** In both groups, pain on movement was well controlled at discharge from recovery and 6 h postoperatively but increased at 24 and 48 h. Median (95% CI) analogue scale scores were 0 (0–0), 15 (0–30), 55 (38–75) and 54 (30–67) mm for epidural block and 0.5 (0–22), 21.5 (10–28), 40 (20–50) and 34.5 (21–55) mm for combined block. VAS pain scores with the combined blocks were significantly lower at 24 h ($P$=0.004). Total morphine usage was low in both groups: median epidural group 17 mg (8–32) versus combined blocks 13 mg (7.8–27.5). Patient satisfaction was high in both groups with median (95% CI) scores of 100 (85–100), 83 (70–100) and 82 (57–90) mm for epidural and 90 (73–100), 100 (77–100) and 97 (80–100) mm for combined blocks (not significant). Perioperative blood loss and rehabilitation indices were also similar.

**Conclusions.** Combined femoral (3-in-1) and sciatic blocks offer a practical alternative to epidural analgesia for unilateral knee replacements.

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**Keywords**: anaesthetic techniques, epidural; anaesthetic techniques, regional, lumbar plexus; anaesthetic techniques, regional, obturator nerve; analgesic techniques, extradural; analgesic techniques, regional; pain, postoperative; surgery, orthopaedic; surgery, postoperative period

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## Introduction

Total knee replacement surgery is associated with severe postoperative pain.[1] Inadequate analgesia can produce unnecessary distress, suboptimal knee mobilization and medical complications due to immobility. These factors are likely to delay rehabilitation. Clinicians have adopted a number of analgesic strategies to minimize pain after knee arthroplasty. Randomized controlled studies suggest that regional techniques provide superior pain relief and faster postoperative knee rehabilitation than systemic analgesia.[2 3]

Until relatively recently, regional techniques have largely been confined to epidural or spinal approaches.[4] However, peripheral neural blockade has been shown to provide effective analgesia with potentially less morbidity than central neuraxial techniques. This prospective randomized controlled study compared the relative benefits of single-shot combined sciatic and femoral nerve blocks with the reference

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technique of epidural blockade for postoperative knee arthroplasty analgesia.

## Patients and methods

Following institutional ethical approval, we studied 60 adult patients undergoing unilateral primary total knee replacement in a randomized controlled trial. A patient information leaflet was provided and written informed consent obtained. Patients were excluded from the study if they refused consent, were ASA classification >3 or had a contraindication to the use of non-steroidal anti-inflammatory drugs, local anaesthetic agent, neuraxial blockade or tourniquet usage; painful polyarthralgia was also an exclusion criterion.

Patients were allocated randomly to one of two study groups. Group 1 received continuous lumbar epidural analgesia until the second postoperative day and group 2 received a single-shot combined sciatic plus femoral (3-in-1) block (combined block group). A computerized random number generator (Arcus Quickstat version 1.0) was used for group allocation and codes were stored by a third party in opaque sealed envelopes. Written consent was obtained prior to envelope opening. Patient characteristics were recorded. Baseline heart rate and non-invasive arterial blood pressure were recorded as well as pain scores at rest and on movement of the knee. A standard 100 mm visual analogue scale was used to assess pain intensity.

Patients were premedicated orally with lormetazepam 1 mg, diclofenac 50 mg and ranitidine 150 mg, 1.5 h preoperatively. Standard monitoring was applied before the regional technique and the surgeon was blinded in this respect.

### *Regional techniques*

All neural blocks were inserted before induction of anaesthesia. Group 1 received an epidural catheter at the clinically assessed lumbar two-thirds or three-quarters level. Following a test dose of bupivacaine 0.5%, 3 ml, a further 7 ml was administered and an infusion of bupivacaine 0.25% commenced after surgical incision.

Group 2 received single femoral (3-in-1) and sciatic blocks with insulated 22 gauge regional needles (Stimuplex®, Braun) attached to a peripheral nerve stimulator. The femoral nerve was identified by eliciting quadriceps contractions ('dancing patella') at a current setting below 0.5 mA; the procedure was based on Winnie's technique.[5] The sciatic block was undertaken using the classical Labat approach.[6] The sciatic nerve was identified by eliciting foot movements (dorsiflexion or plantar flexion) below 0.5 mA. Thirty millilitres of bupivacaine 0.375% was used for the femoral component and 25 ml of bupivacaine 0.375% for the sciatic component. For patients <70 kg, the doses were reduced proportionately (maximum dose bupivacaine 3 mg $kg^{-1}$).

If the epidural space could not be located by loss of resistance or neither peripheral nerve could be located with 0.5 mA stimulation, the patient was removed from the study and provided with parenteral opioid analgesia.

### *General anaesthesia*

General anaesthesia was induced with propofol 50–200 mg and fentanyl 50–100 μg. Patients had a laryngeal mask airway (LMA) inserted and breathed spontaneously, unless protection of the airway was required with an endotracheal tube (obesity, oesophageal reflux or problems related to malpositioning of the LMA). Atracurium with or without succinylcholine was used to facilitate endotracheal intubation and allow positive-pressure ventilation in these latter patients. Anaesthesia was maintained with nitrous oxide in oxygen and isoflurane (0.4–1.5%). A urinary catheter was inserted in group 1 patients.

Intraoperatively, boluses of fentanyl (25–50 μg) were given as indicated clinically. As well as the use of i.v. fluids, hypotension (defined as a systolic blood pressure <100 mm Hg) could be treated with incremental boluses of i.v. ephedrine (3 mg) or methoxamine (2 mg). The requirement for red blood cell infusion was left to the anaesthetist's discretion.

The use of a thigh tourniquet was left to the operating surgeon's discretion and, when used, the pressure was standardized at 350 mm Hg. All patients were prescribed regular oral ranitidine 150 mg daily and diclofenac 50 mg every 8 h postoperatively.

There was no indication for urinary catheterization in the combined block group and so it was not deemed feasible to mask the treatment groups postoperatively. Sensory testing was impractical in the recovery area owing to the bandaging of most of the operative limb. Thus the anaesthetist assessed the quality of analgesia, and for group 1 the epidural block was supplemented with bupivacaine 0.25%, ⩽10 ml, if necessary. The epidural infusion was terminated if analgesia was suboptimal after top-up. Supplementing femoral or sciatic nerve blocks is not considered safe owing to the risk of nerve trauma, and so group 2 patients with inadequate analgesia were treated with incremental doses of parenteral morphine.

All patients were given a patient-controlled analgesia (PCA) (Graseby) system of parenteral morphine to be used as rescue analgesia until the second postoperative day. This was programmed to deliver a 1 mg bolus of morphine sulphate with a lockout of 5 min. The patients had been taught to use the system preoperatively by the acute pain nurse specialist.

Patients were assessed at four time points: before leaving the recovery room and at 6, 24 and 48 h postoperatively. Clinical staff uninvolved with the study undertook this task. The primary outcome measure was quality of analgesia assessed with visual analogue pain scores on attempted movement. Morphine consumption was also recorded.

Other secondary outcomes included patient satisfaction; recorded using a 100 mm linear visual analogue scale. Side effects assessed were nausea, vomiting, confusion, pruritus, urinary retention and hypotension. Postoperative blood loss and relevant drug usage were recorded and orthopaedic rehabilitation indices were assessed by physiotherapy staff.

### *Statistical analyses*

A 10 mm difference in visual analogue pain scores was considered the smallest clinically significant difference. Sample size was based on the power analysis from a similar lower-limb neural block study, which adopted this 10 mm VAS difference, an $\alpha$ risk of 0.05 and a $\beta$ risk of 0.2.[7] This indicated that a minimum of 24 patients would be required for each group. Thus 30 patients in each group were recruited to allow for incomplete data collection.

Statistical analysis was performed using the programme Arcus Quickstat version 1.0. The Mann–Whitney *U*-test was used to analyse non-parametric data and ordinal data presented as median (interquartile range). This included VAS pain and satisfaction scores and duration of hospital stay. Parametric data are presented as mean and standard deviation and the independent Student's *t*-test was used to analyse the data. The Bonferroni correction was used to correct for multiple testing at the different time points.

## Results

A total of 95 patients were scheduled for unilateral knee arthroplasty during the trial period (see Fig. 1).

The two groups were similar in terms of age, weight, sex, baseline heart rate, systolic blood pressure and preoperative pain scores (Table 1). One patient was excluded from the trial after randomization owing to failure to locate the epidural space. All data analyses were performed after exclusion of this case; however, analyses on an intention-to-treat basis made no difference to outcomes.

Time in the anaesthetic room, duration of surgery, time in the recovery room and total theatre time were similar (Table 2). The epidural group data were analysed as a combined time for the epidural and routine urinary catheter to be inserted. There was no statistically significant difference between the two groups for block insertion time ($P$=0.92). Doses of fentanyl administered were similar.

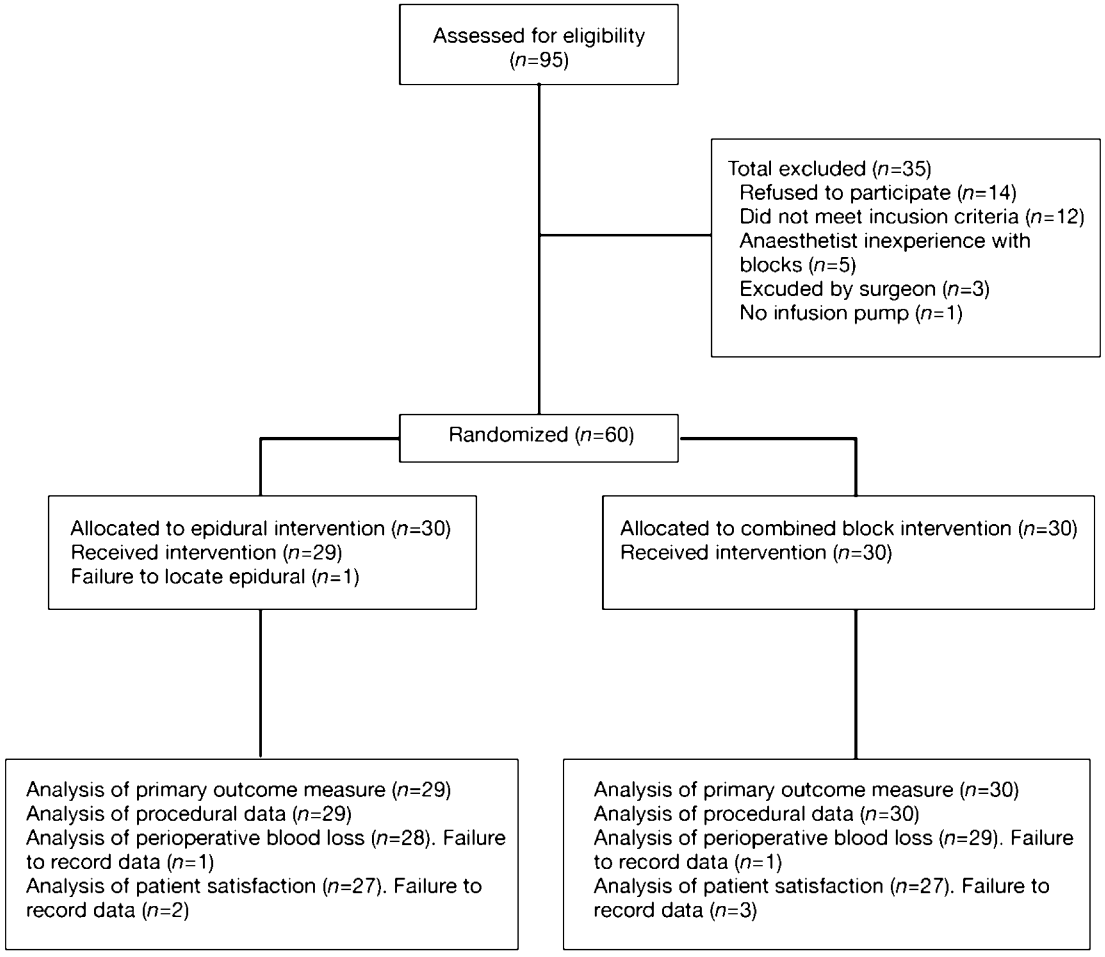


**Fig 1** Patient disposition diagram.

**Table 1** Patient characteristics and baseline visual analogue pain (VAS) scores at rest and on movement. Age, weight, heart rate and systolic blood pressure values are mean (SD) and VAS scores are median (range). There were no statistically significant differences between the groups

| | Epidural group ($n$=30) | Femoral/sciatic group ($n$=30) |
|---|---|---|
| Age (yr) | 73.13 (±9.0) | 72.33 (±9.5) |
| Weight (kg) | 78.7 (14.49) | 80.86 (13.23) |
| Sex (M/F) | 13/17 | 19/11 |
| Baseline heart rate (beats $min^{-1}$) | 73.1 (12.0) | 72.0 (9.68) |
| Systolic B/P (mm Hg) | 150.7 (24.1) | 147.0 (22.2) |
| Preoperative pain VAS (at rest) | 12 (0–33.5) | 16.5 (0–26.75) |
| Preoperative pain VAS (on movement) | 54.5 (43.5–81.3) | 63 (51.5–75) |

**Table 2** Perioperative procedural data for the study groups. Values are mean (SD)

| | Epidural group ($n$=29) | Femoral/sciatic group ($n$=30) | $P$ value |
|---|---|---|---|
| Block insertion time (min) | 13 (8–18.5) | 12.5 (10.8–15.5) | 0.92 |
| Time in anaesthetic room (min) | 29.6 (10.6) | 7.1 (8.3) | 0.34 |
| Duration of surgery (min) | 96.3 (29.5) | 87.2 (21.5) | 0.18 |
| Time in recovery (min) | 107.2 (30.0) | 100.7 (30.0) | 0.41 |
| Total theatre time (min) | 233 (40) | 214 (34) | 0.66 |

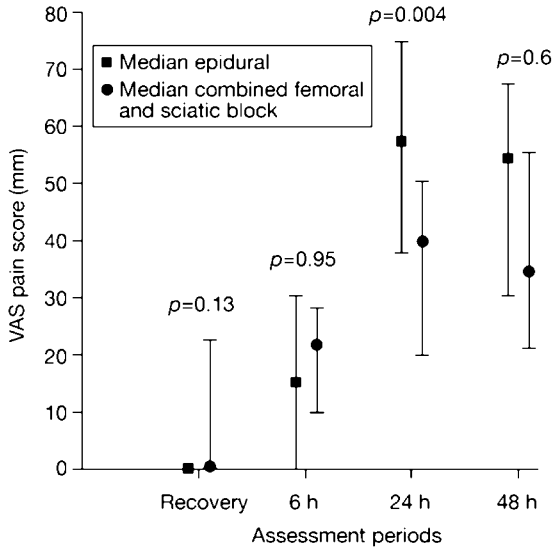


**Fig 2** Visual analogue pain scores on attempted movement. Values are median (95% CI). Assessment periods refer to discharge from recovery and 6 h, 24 h and 48 h postoperatively. VAS pain scores with the combined blocks were significantly lower at the 24 h assessment period ($P$=0.004).

Visual analogue pain scores with 95% CI are shown in Figure 2. The median analgesic efficacy of both groups was greatest at discharge from recovery and at 6 h postoperatively. Pain scores were higher at the 24 and 48 h assessments

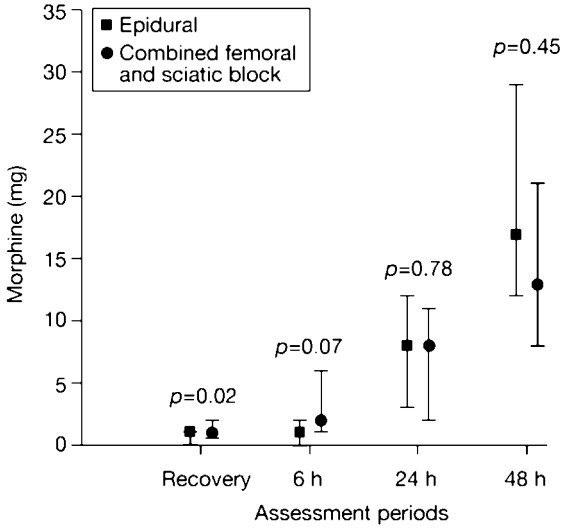


**Fig 3** Cumulative total morphine consumption (mg) at the four assessment periods. Values are median (95% CI).

in both groups. Median (95% CI) analogue scale scores were 0 (0–0), 15 (0–30), 55 (38–75) and 54 (30–67) mm for epidural block and 0.5 (0–22), 21.5 (10–28), 40 (20–50) and 34.5 (21–55) mm for combined block. VAS pain scores with the combined blocks were significantly lower at 24 h ($P$=0.004).

The epidural group had a greater number of patients with complete analgesia in recovery. Twenty-three of 29 patients reported no pain on attempted movement in this group compared with 16 of 30 in the combined block group (not significant).

Figure 3 shows the cumulative morphine PCA requirements at each assessment period. Morphine usage was low in both groups, with the epidural group consuming 17 (8–32) mg compared with 13 (7.8–27.5) mg in the combined block group at 48 h (not significant). One patient in the epidural group required morphine loading in recovery (10 mg total) compared with two patients in the femoral/sciatic group (9 mg each).

The median VAS scores for patient satisfaction are shown in Figure 4. Overall, satisfaction scores were high in both groups but there was a tendency towards statistical significance in favour of the combined block group at 48 h.

Most adverse events recorded were found to be similar. These included episodes of nausea, vomiting, confusion, pruritus and degree of motor block. Hypotension was a particularly frequent finding at the 24 h assessment in both groups: combined blocks group (37%) versus epidural group (27%) (not significant). The combined blocks group had a low incidence of urinary retention with 10% requiring postoperative catheterization. Motor block was assessed with difficulty due to knee bandaging. At the 48 h assessment two patients in both groups appeared to be unable to lift their leg against gravity. One of these from the epidural group was found subsequently to have developed sphincteric disturbance and a unilateral foot drop.

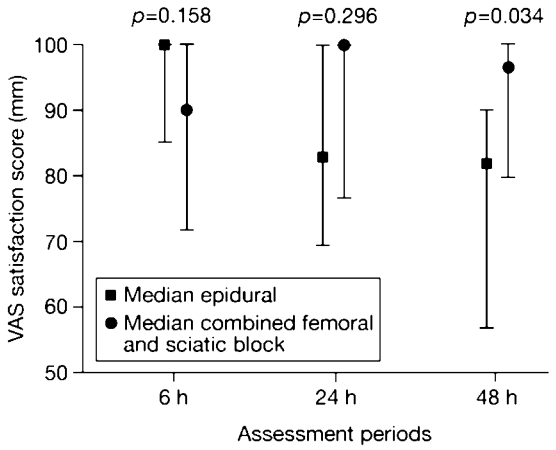


**Fig 4** Visual analogue patient satisfaction scores (0, total dissatisfaction; 100, total satisfaction). Values are median (95% CI).

**Table 3** Perioperative blood loss in the two study groups. Values are mean (SD). Data collection was incomplete for one patient in each group

| | Epidural group ($n$=29) | Femoral/sciatic group ($n$=30) | $P$ value |
|---|---|---|---|
| Blood loss intraoperatively (ml) | | | |
| With tourniquet | 71.3 (79.7) $n$=16 | 56.5 (+/−78.4) | 0.60 |
| Without tourniquet | 387.5 (218.6) $n$=12 | 421.5 (262) $n$=13 | 0.73 |
| Drain loss total (ml) | | | |
| With tourniquet | 756.0 (403.7) $n$=16 | 507.5 (272.7) $n$=16 | 0.05 |
| Without tourniquet | 804.6 (597.9) $n$=13 | 698.5 (427.8) $n$=13 | 0.61 |
| Total drain loss (ml) | 778.3 (490.1) $n$=29 | 593.1 (357.2) $n$=29 | 0.11 |
| Total perioperative blood loss (ml) | 962.9 (496.0) $n$=28 | 813.4 (433.0) $n$=29 | 0.23 |

**Table 4** Time to achieve rehabilitation indices. Data are median (interquartile range). There were no statistically significant differences between the groups

| | Epidural group | Femoral/ sciatic group |
|---|---|---|
| Straight-leg raise (days) | 3 (2–50) | 3 (2–5) |
| 85° flexion (days) | 5.5 (4–7) | 5 (3–7) |
| Hospital stay (days) | 8 (7–12) | 7 (7–9) |

Table 3 shows blood loss intraoperatively and postoperatively and differentiates between those performed with tourniquet and those without. Total blood loss (mean (SD)) was as follows: epidural group, 962.9 (496) ml; combined blocks group 813.4 (433) ml (not significant).

Three rehabilitation indices were analysed by senior physiotherapy staff: time to straight-leg raise (without lag), 85° active knee flexion and time to discharge (Table 4). These were similar in the two groups.

## Discussion

In this study both approaches provided excellent early postoperative analgesia although the quality of pain relief diminished later. We did not demonstrate an analgesic advantage from the local-anaesthetic-based epidural infusion during the later assessments. Indeed, there is some suggestion that the quality of analgesia was superior with the combined blocks. This is perhaps surprising as previous studies have shown that using bupivacaine for the combined blocks provides only 12–24 h of sensory blockade.[8]

A previous controlled study[9] also showed that morphine usage was decreased into the second postoperative day, far longer than the duration of sensory blockade. It was speculated that the prolonged opioid-sparing effect might reflect pre-emptive analgesic effects of the femoral/sciatic blocks as they were performed prior to resolution of the spinal anaesthesia under which surgery was performed. In our study, the blocks were undertaken prior to any surgically induced nociceptive stimulus. The potential benefit of pre-emptive analgesia is still unresolved.

There is scope for further improvement in the quality of pain relief provided by the combined blocks. This could be achieved by the addition of further pharmacological agents or insertion of paraneural catheters. Adding clonidine to the local anaesthetic has been found to delay first request for pain medication after lower-limb surgery.[10]

The sheath catheters available for infusing local anaesthetic have become increasingly sophisticated and technically easier to insert. However, there is still difficulty in inserting catheters where the approach onto the nerve is nearly vertical, such as in the posterior approach to the sciatic nerve. The femoral sheath is generally easier to access. A potential problem with these sheath infusions is the difficulty in determining when to stop the infusion, as the regression of anaesthesia is variable in time. Any protracted sensory or motor deficit could result in delayed mobilization.

The study protocol utilized the anterior approach (Winnie 3-in-1) to the lumbar plexus but this can often spare the obturator nerve. In the original description,[5] it was stated that a volume of $\geqslant$20 ml would ensure anaesthesia of femoral, lateral cutaneous and obturator nerves. However, Parkinson and colleagues[11] indicate that even when administering volumes of 0.5 ml $kg^{-1}$ of local anaesthetic, the solution often does not travel proximally enough to anaesthetize the obturator nerve. A further study using radiographic analysis demonstrated complete lumbar blockade with the 3-in-1 approach in only 38% of cases.[12]

The cutaneous component of the obturator is highly variable in its distribution and is occasionally absent. However, the posterior division contributes to the innervation of the knee joint. Lack of blockade would also fail to minimize ischaemic pain of the adductor muscles with prolonged tourniquet time. McNamee and colleagues[13] have confirmed a significant clinical benefit in adding a separate obturator block to CFSBs.

An alternative lumbar plexus approach to consider would be the posterior psoas compartment block. It has been suggested that learning and executing this block is not difficult, especially with the use of neurostimulation.[14] Using a combination of posterior lumbar plexus and sciatic nerve blocks

for lower-limb anaesthesia, complete sensory blockade was obtained in 40 out of 45 patients (89%). The main limitation with this approach is the potential risk of epidural blockade. In the aforementioned study the incidence of bilateral block was 9%. This posterior lumbar plexus approach is also amenable to a catheterization technique.

The quality of analgesia provided by the epidural infusion during the later assessment periods was disappointing. The reduced efficacy in pain relief occurred when direct anaesthetic input had usually ended. Despite thorough training of the ward nurses in caring for patients with epidural infusions, there appeared to be a tendency for them to accept a significant degree of patient discomfort. The charts showed that, according to their prescriptions, several patients with epidural infusions who demonstrated significant pain could have had higher epidural infusion rates. Failure to increase the rate may have been to avoid the risk of causing or worsening hypotension.

Epidural analgesia can be improved through the synergistic effect of opioids. This allows lower concentrations of local anaesthetic to be used and a reduction in the sympathetic and motor effects of the block. These benefits have been confirmed with abdominal surgery and for obstetric analgesia. The degree of advantage following knee surgery, where the number of affected dermatomes is more limited, has not been fully clarified.

PCAs were provided to reduce any difference in quality of pain relief between the two techniques. The degree to which either technique was opioid sparing could then be used as a marker of analgesic success. Researchers testing the efficacy of adjunctive analgesia or peripheral local anaesthesia commonly use this approach.[15–17] The median opioid usage by patients in the two groups was similar, despite marked differences in pain scores at the later assessments. There are a number of possible explanations of why this may have occurred. Tuition in the use of the PCA system may have been suboptimal. This explanation is unlikely, as the specialist acute pain nurse who provided the teaching undertook this task on a regular basis usually with good effect. Patients may also be limiting usage of the PCA to avoid opioid side effects such as nausea. However, analyses of the data on nausea and vomiting do not reveal significant differences between the two groups for these side effects.

Previous researchers have used confidence interval analysis of pain scores to quantify differences in quality of pain relief. It has been suggested that a 95% confidence limit pain score within 0–30 mm indicates adequate analgesia.[18] Despite the access to a PCA opioid system, several patients in both groups lie outside this limit at the 24 and 48 h assessments. This may be a reflection of patient expectation that they should experience some postoperative pain or their reluctance to use the PCA for other reasons such as avoiding side effects. The median preoperative VAS pain scores on movement for both groups are higher than the median 24 and 48 h pain scores. It may be that some patients use their degree of knee pain preoperatively as a marker for acceptable postoperative pain levels. Work is needed to explore this possibility further. This methodology would probably need to include more open questioning of patient perceptions and expectations.

There has been little published work assessing patient satisfaction with epidural and plexus blocks following knee arthroplasty. However, the emphasis on assessing patients' views and experiences on aspects of their health care has gathered momentum over recent years.[19] The Committee for Health Improvement (CHI) incorporates patient satisfaction as one of its fundamental yardsticks when assessing the quality of delivery of National Health Service hospital care. Therefore satisfaction would seem to be an important outcome measure in the current study. Whilst often assumed to be a unitary quantity, satisfaction is multidimensional in nature.[19] Good analgesia has been shown to be only one dimension of satisfaction. Conduct, patient expectations, side-effect problems and other psychological and cultural issues also influence it. Indeed, the assumption that good analgesia is a prerequisite for high satisfaction was disputed in a maternity study where mothers who had higher labour pain scores often had higher satisfaction scores postnatally.[20]

In this study, patient satisfaction is consistently high in both groups. There is a trend towards greater satisfaction in the combined blocks at the later assessment. A number of reasons can be postulated as to why this might be. One prominent difference between the two analgesic techniques is the selectivity to the operated side. The absence of a blockade to the non-operative limb may be reassuring to the patient as well as allowing greater mobility and independence. The majority of patients in this group (90%) have also avoided urinary catheterization.

One of the recognized benefits from central neuraxial techniques is reduced intraoperative blood loss. Randomized controlled trials have also indicated a 50% reduction in red cell transfusion requirements.[21] There is limited evidence to support a similar reduction using combined blocks during total knee replacements. One small study ($n$=30) has shown a significant reduction in intraoperative blood loss when compared with no neuraxial block for total knee replacements.[22] However, the block had no effect on total blood losses or homologous blood requirement. In this study, there was no significant difference in blood loss between the groups.

The time taken to undertake the regional block is an important consideration owing to financial and theatre efficiency implications. There is a common perception among many anaesthetists and orthopaedic surgeons that lower-extremity peripheral blockade is slow to perform and is less complete and less reliable than a central neuraxial blockade. The evidence from this study does not support this concern.

Previous controlled studies comparing 3-in-1 blocks with epidural analgesia have shown a much better side-effect profile for the former. The study by Singelyn and colleagues[2] showed that the continuous 3-in-1 blocks produced nearly four times fewer side effects. Whilst this was

initially demonstrated in a small-scale study, these authors have provided further support in a study of over 500 patients.[23]

Most of the complications observed in this study were minor and there was little difference between the two analgesic methods. An unexpected result was the similar incidence of hypotension. It had been expected that the sympatholytic effects of local-anaesthetic-based epidurals would result in a greater number of hypotensive episodes. The high incidence in both groups perhaps suggests that a substantial proportion of patients were hypovolaemic, particularly up to the 24 h assessment period.

The establishment of alternative anaesthetic or analgesic practices should be preceded by evidence that they do not confer a disadvantage to the patient and health care professional. Ideally they should also offer some additional benefit over the reference technique. This could include better pain relief, greater patient satisfaction, more cost-effective analgesia and more favourable postoperative recovery or rehabilitation profile.

This study suggests that the combined blocks offer a practical alternative to epidural analgesia for knee replacements. They provided acceptable postoperative analgesia and patient satisfaction was consistently high. Common surgical perceptions of their being slower and technically more difficult were not confirmed. There was also little difference in measured rehabilitation indices.

## Acknowledgements

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