Unicompartmental versus Tricompartmental Knee Arthroplasty with Continuous Adductor Canal and Femoral Nerve Blocks Analgesic Requirements and Implications for Discharge Readiness

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Abstract

Background: The relative analgesic requirements for tricompartmental (TKA) and unicompartmental (UKA) knee arthroplasty and their effects on discharge readiness remain unexamined when continuous adductor canal and femoral nerve blocks are used for analgesia in the immediate postoperative period.

Methods: Data were collected from 2 previously-published clinical trials involving subjects undergoing TKA (n=79) or UKA (n=30) randomized to either an adductor canal or femoral perineural catheter and ropivacaine 0.2% infusion for 2 (UKA) or 3 (TKA) days. Originally, we compared each catheter location (adductor vs. femoral) while holding surgical procedure constant (comparing solely TKAs and solely UKAs). We now compare type of surgical procedure (TKA vs UKA) while holding catheter location (adductor vs. femoral) constant. The primary outcome was the time to attain 4 discharge criteria including pain, opioid requirements, and ambulation/mobilization.

Results: For adductor canal catheters, UKA patients reached all 4 discharge criteria in 35 [24—43] hours which was significantly faster than those given TKA who took 55 [43—63] hours (difference: 18h; 95%CI 9 to 28 h; P<0.001). The results were similar for femoral catheters: UKA patients reach all four discharge criteria in 40 [27—58] hours which was significantly faster than those given TKA who took 61 [49—69] hours (difference: 20; 95%CI 4 to 30 h; P=0.009). For both catheter locations, pain scores, opioid requirements, and mobilization endpoints were better with UKA than TKA.

Conclusion : UKA induces less pain and requires less opioid than TKA, regardless of perineural catheter location. Consequently, patients who have UKA are ready for discharge sooner.

Introduction

Tricompartmental knee arthroplasty (TKA) is the most common surgical procedure for the treatment of severe degenerative disease of the knee, with more than 700,000 procedures being done within the United States in 2013. Unicompartmental knee arthroplasty (UKA) is an alternative to TKA for individuals with knee arthrosis limited to one compartment of the knee. UKA has been associated with decreased costs,[1] early functional improvement,[2, 3] improved range of motion[4] and reduced hospital length of stay[3] relative to TKA. However, it is performed less often than TKA[4] because there are fewer appropriate candidates, along with some concern that revisions may more often be necessary[5] (although implant survival is similar with each procedure).[6, 7] Both surgeries are associated with moderate-to-severe postoperative pain that typically requires intravenous analgesia, impairs mobility, and prolongs hospitalization.[8, 9]

Continuous femoral blocks are effective components of multimodal analgesia that speed discharge readiness for both TKA and UKA.[8, 10, 11] Continuous adductor canal blocks, a more recent technique, improves mobilization compared with femoral nerve block while providing similar analgesia and supplemental analgesic requirements for both TKA[12–18] and UKA.[9] Whether the benefit of UKA on hospital duration is preserved in patients given adductor canal blocks remains unknown. More generally,

the relative analgesic requirements for TKA and UKA and their potential effects on discharge readiness remain unexamined when continuous adductor canal and femoral nerve blocks are used to provide pain control in the immediate postoperative period. We therefore analyzed data from two previously-published dual-center, randomized, controlled clinical trials that examined continuous adductor canal and femoral nerve blocks on discharge readiness following TKA and UKA.

Methods

Enrollment. Data from two previously-published clinical trials involving subjects undergoing UKA[9] or TKA[12] were analyzed. For the current retrospective study, no IRB oversight was required because the Common Rule exempts research, “involving the collection or study of existing data… if these sources are publicly available or if the information is recorded by the investigator in a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.”[19] Enrollment was originally offered to patients who were adults (≥ 18 years old) scheduled to have a primary unilateral TKA or UKA, and whose desired postoperative analgesic plan included a perineural local anesthetic infusion for postoperative analgesia.

Following written, informed consent, subjects were randomized to one of two treatment groups: an adductor canal or femoral perineural catheter. Perineural catheters (FlexBlock, Teleflex Medical, Research Triangle Park, North Carolina) were inserted preoperatively in an unmasked fashion. Lidocaine 2% (30 mL) was injected via the catheters in divided doses following negative aspiration at the time of catheter placement. A ropivacaine 0.2% infusion was begun via the perineural catheter with a basal rate of 6 mL/h, a 4 mL bolus, and a lock-out of 30 minutes using a portable, programmable, electronic infusion pump (ambIT PreSet, Summit Medical Products, Inc. Salt Lake City, Utah).

For surgical anesthesia, subjects received a spinal or general anesthetic. Intravenous fentanyl, hydromorphone and/or morphine were administered intraoperatively, as needed. After joint closure, the entire joint was infiltrated using 30 mL of ropivacaine (0.5%), ketorolac (30 mg), epinephrine (5 µg/ml), and tranexamic acid (2 gm).

Postoperatively, all patients received oral acetaminophen, celecoxib, and sustained release oxycodone. For breakthrough pain, patients activated the ropivacaine infusion pump bolus button (4 mL, 30 min lock-out). When necessary, rescue opioid was titrated to pain severity. The ropivacaine infusion rate was initiated at 6 ml/hr and titrated to subject comfort and ambulatory ability.

The primary outcome was the time to attain four discharge criteria: (1) adequate analgesia [0–10 verbal response score] for pain < 4]; (2) independence from intravenous analgesics for 12 hours; (3) ability to independently stand, walk 3 meters, return and sit down; and, (4) ability to independently ambulate 30 meters. These criteria were assessed at the end of each eight-hour nursing shift. Pain scores were recorded every 4 hours and when patients requested supplemental analgesics. Subjects participated in physical therapy sessions twice daily, beginning as early as the afternoon of surgery if they reached the orthopedic wards by 14:00 the day of surgery.

Secondary end points included each of the four individual discharge criteria of the primary end point; supplemental oral opioid consumption; attaining a standing position without assistance; passive knee flexion and extension (measured with a goniometer); catheter site leakage; and, the incidence of catheter dislodgement. Infusion pump memory was interrogated daily, and provided the basal infusion rate, self-administered bolus dose attempts and delivery, infused volume, and infusion duration. Patients were discharged home after meeting all aspects of the composite primary endpoint criteria, and at the discretion of orthopedic surgeons, but not before postoperative day (POD) 2 for UKA or 3 for TKA. Perineural catheters were removed before hospital discharge.

The two underlying studies each involved either UKA or TKA procedures and compared continuous adductor canal and femoral nerve blocks.[9, 12] We then, in the same population, instead compared UKA to TKA, while holding catheter location (adductor vs. femoral) constant. In effect, the current study considered differences between UKA and TKA while controlling for catheter location. The surgical approach was not randomized, instead being largely dictated by the distribution of arthritis, surgeon recommendation, and patient preference.

Statistical analysis. We summarized group characteristics using counts and percentages and means and standard deviations (SDs). Wilcoxon, Kruskal-Wallis, and Pearson's Chi-square tests were used for group differences. Key continuous variables were plotted using box-plots with Wilcoxon tests and Kaplan-Meier plots for log-rank tests. The investigators adapted the time-to-event approaches used in the two original manuscripts (Cox Proportional Hazards model).[9, 12]

Since there were no censored observations, we also explored linear or log-linear models. The model included covariates that differed significantly between the UKA and TKA groups (among age, height, weight, and BMI) by Wilcoxon or Pearson Chi-square tests. The UKA/TKA effect in each of the adductor canal and femoral nerve subgroups were calculated. Secondarily, these groups were pooled and the interaction between unicompartmental and tricompartmental sites, and between adductor and femoral blocks, were considered in the aggregate model.

Results

From January 2013 to September 2014, a total of 109 patients—79 TKA and 30 UKA—were randomized to receive either a continuous adductor canal (n = 53) or femoral (n = 56) nerve block (Tables 1 and 2).

Table 1

Anthropomorphic and pre-randomization surgical characteristics of the study subjects with continuous ADDUCTOR CANAL catheters and infusion.

	Tricompartmental (n = 38)	**Unicompartmental (n = 15)**
Age (yr)	67 ± 9	70 ± 10
Sex (female)	23 (59%)	7 (47%)
Height (cm)	169 ± 11	170 ± 11
Weight (kg)	87 ± 16	82 ± 16
Body mass index (kg/m^2)	31 ± 5	28 ± 3
Surgeon (A)	25 (66%)	12 (80%)
Hospital (Thornton)	30 (79%)	12 (80%)
Values are reported as mean ± SD or number of subjects (percentage of treatment group)		

Table 2

Anthropomorphic and pre-randomization surgical characteristics of the study subjects with continuous FEMORAL NERVE catheters and infusion.

	Tricompartmental (n = 41)	**Unicompartmental (n = 15)**
Age (yr)	66 ± 7	68 ± 12
Sex (female)	27 (66%)	7 (47%)
Height (cm)	168 ± 10	167 ± 8
Weight (kg)	84 ± 16	83 ± 14
Body mass index (kg/m^2)	29 ± 5	30 ± 4
Surgeon (A)	25 (61%)	9 (60%)
Hospital (Thornton)	33 (80%)	12 (80%)
Values are reported as mean ± SD or number of subjects (percentage of treatment group)		

Primary end point. For adductor canal catheters, UKA patients reached all four discharge criteria in 35 [24–43] hours which was significantly faster than those given TKA who took 55 [43–63] hours (Fig. 1a, difference: 18 h; 95%CI 9 to 28 h; $P < 0.001$). The results were similar for femoral catheters: UKA patients reached all four discharge criteria in 40 [27–58] hours which was significantly faster than those given

TKA who took 61 [49–69] hours (Fig. 1b, difference: 20; 95%CI 4 to 30 h; P = 0.009). For both catheter locations, pain scores, opioid requirements, and mobilization endpoints were better with UKA than TKA.

Secondary end points. For both catheter locations the Timed Up and Go test was completed faster and by more UKA than TKA patients (Fig. 2). Ambulation distance and the fraction of subjects who achieved the goal of ambulating 30 meters were also significantly greater after UKA (Fig. 3).

For both catheter locations, average pain scores at rest and the fraction of subjects with pain scores less than 4, were higher for TKA than UKA patients (Fig. 4). As thus might be expected, for both catheter locations, opioid requirements were higher after TKA than UKA, and more UKA patients were free of intravenous opioid treatment at all time points in the first two postoperative days (Fig. 5).

Discussion

This analysis of two previously-published randomized trials provides strong evidence that, compared to TKA, UKA shortens the time to discharge readiness by inducing less pain, requiring fewer supplemental opioid analgesics, and increasing mobilization in the presence of either continuous adductor canal or femoral nerve blocks.

When comparing UKA with TKA, the orthopedic literature currently addresses implant survivorship,[5, 20–23] financial impact,[1, 2, 5, 24] functional improvement,[2, 3, 25, 26] range of motion,[3] and hospital length of stay.[1, 3, 24] Numerous studies in the orthopedic literature compare implant survival and need for revision arthroplasty for UKA with TKA due to their major impact on long-term prognosis and cost. These studies report survival of 82–95% for UKA and 91-98.9% with TKA,[5, 20, 22] while the majority of UKA revisions resulted from disease progression[20] and aseptic loosening of the implant.[20, 22] The financial impact of performing UKA versus TKA has been examined for short and long term costs revealing mixed results that both favor UKA over TKA[1, 2, 24] and favor TKA over UKA.[5] Some of the reduced financial impact is related to shorter hospitalization following UKA relative to TKA reported by multiple studies.[1–3, 24]

Short and long term functional outcomes have also been examined, as pain and functional decline are the two primary reasons why patients seek to have knee arthroplasty.[27] Patients' self-perceived functional outcome is greater with UKA than TKA.[2] They perform better on industry functional outcome assessments such as the Knee Society and Oxford Questionnaire following UKA and TKA.[3] They also perform physical tasks such as kneeling, climbing or descending stairs, and walking more than 12 months postoperatively better with UKA than TKA.[25, 28]

Our study appears to be the first comparing UKA and TKA for discharge readiness, analgesia, and early functional outcomes with either continuous adductor or femoral nerve blocks. Though prior studies of both continuous femoral nerve block and continuous adductor canal block demonstrate their effectiveness to improve analgesia and functional outcomes and hasten discharge readiness for each surgery independently,[8–15, 18] this study supports that the impact of type of surgery is greater than the

impact of continuous perineural blockade for discharge readiness, analgesia and early functional outcomes. We hypothesize that this may result from less tissue trauma associated with the more limited anatomic involvement for UKA compared with TKA.

Our results add to existing literature supporting the treatment of unicompartmental knee degeneration with unicompartmental knee arthroplasty rather than a tricompartmental knee arthroplasty—although tricompartmental procedures remain common even in patients with degeneration limited to one compartment.[29, 30] For this subset of knee replacement candidates, decreased pain, improved ambulation and mobilization and earlier discharge may translate to perioperative decreased cost and improved patient satisfaction.

Limitations. Although subjects from the original two trials were randomized to receive either adductor canal or femoral nerve blocks, subjects were not randomized to either TKA or UKA as selection criteria differ between the two surgical procedures. Additionally, the previously published studies — on which the current analysis is based — were not masked to treatment group.

Conclusions. UKA induces less pain and requires less supplemental opioid than TKA — regardless of perineural catheter insertion location. Consequently, patients who have UKA are ready for discharge sooner.

Abbreviations

IRB
institutional review board
TKA
tricompartmental knee arthroplasty
UKA
unicompartmental knee arthroplasty

Declarations

Ethics Approval and Consent to participate: For the current retrospective study, no IRB oversight was required because the Common Rule exempts research, “involving the collection or study of existing data… if these sources are publicly available or if the information is recorded by the investigator in a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.” The original study followed Good Clinical Practice and was conducted within the ethical guidelines outlined in the Declaration of Helsinki. That trial was prospectively registered at clinicaltrials.gov (NCT01759277) and the University of California San Diego Institutional Review Board (San Diego, California) approved all study procedures.

Consent for Publication: Not applicable.

Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request with the removal of all direct or indirect identifiers.

Competing Interests: The author Brian M. Ilfeld has competing financial interests in the following companies: Smiths Medical (St. Paul, MN), InfuTronix (Natick, MA), and Ferrosan Medical (Szczecin, Poland). The remaining authors declare that they have no competing interests.

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Authors' Contributions: J.F.S, A.T.M. and B.M.I. participated in protocol design, patient recruitment, data collection and study execution of the original studies, and manuscript authorship; N.J.K., S.J.M., W.B.A., A.M.M., B.K., S.T.B. and F.B.G. participated in patient recruitment, data collection and study execution of the original studies and manuscript revision; D.M.C. participated in manuscript authorship; M.C.D. participated in protocol design, data analysis and manuscript authorship.

Acknowledgments: Not applicable.

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Figures

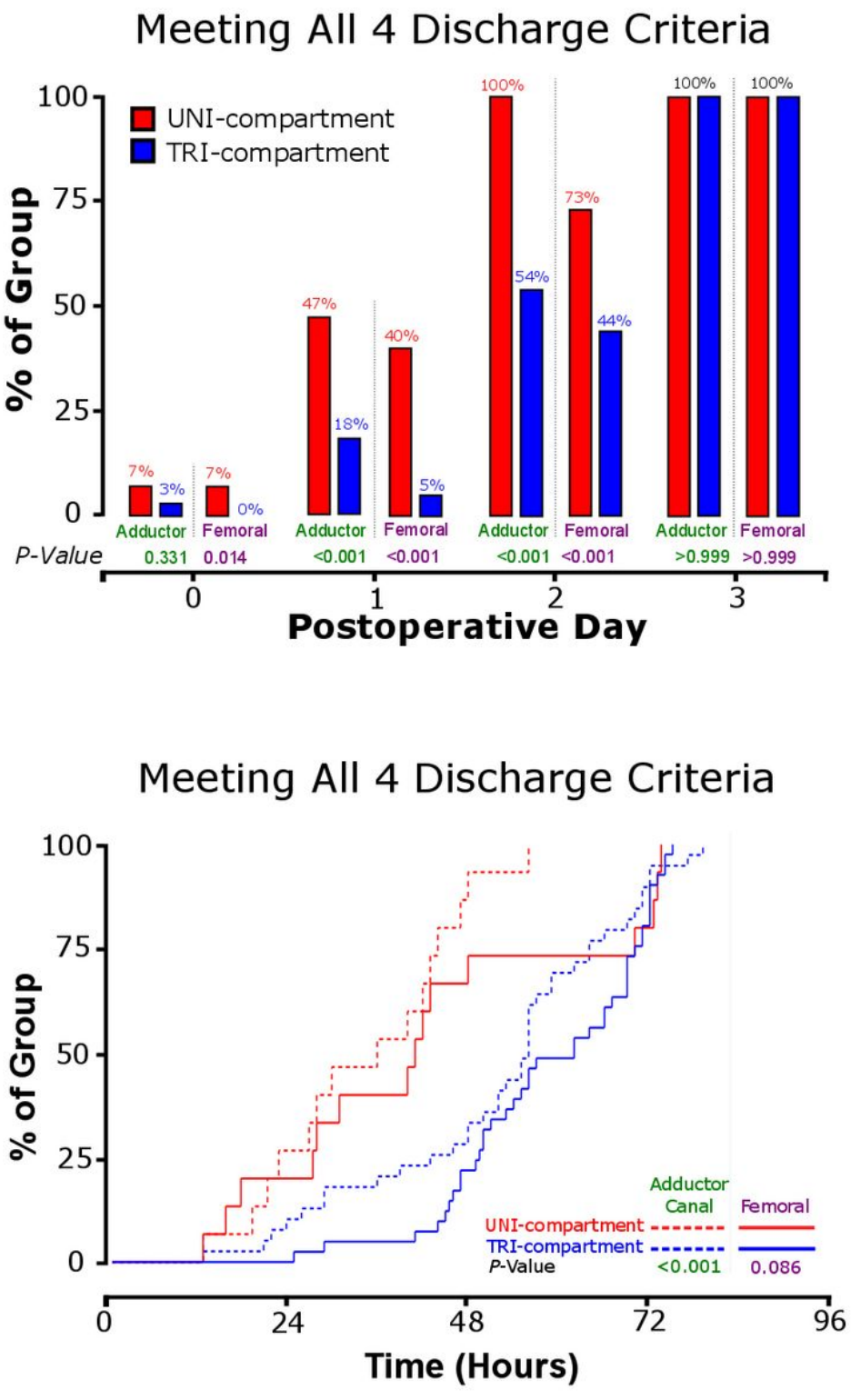
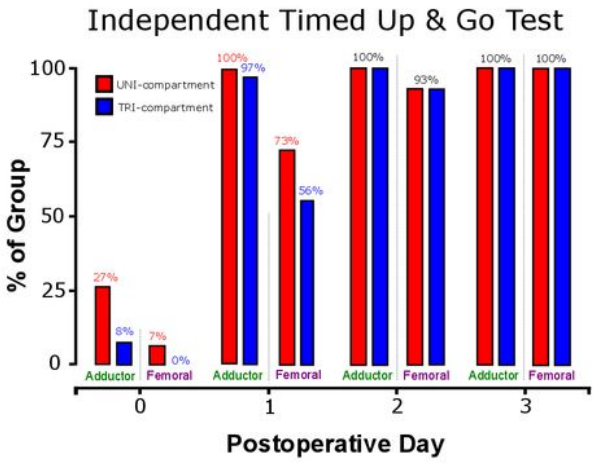
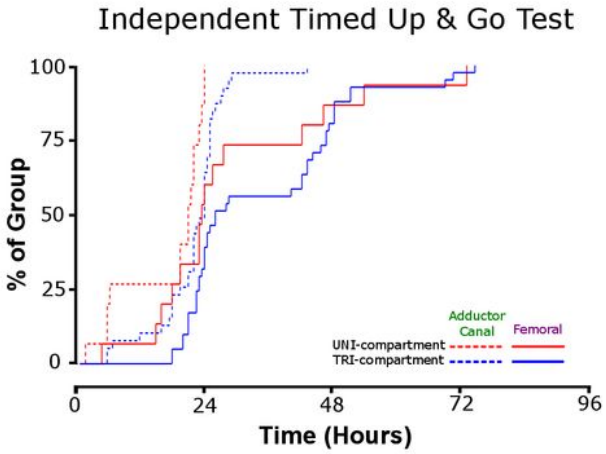


Figure 1

Effects of surgical procedure for UKA and TKA with adductor canal and femoral catheters—on the time to reach four important discharge criteria (adequate analgesia, independence from intravenous opioids, independent ambulation ≥ 30 m, and the ability to independently stand, walk 3 m, return, and sit down).

Data presented are the percentage of each group to achieve all four criteria at each time point (A). Kaplan–Meier estimates of the cumulative percentages of subjects meeting all four discharge criteria at each time point and subsequent time points (B). For adductor canal catheters, TKA subjects reached all four discharge-readiness criteria in a median (25th-75th percentiles) of 55 (43–63) hours, compared with 35 (24–43) hours for UKA (difference: 18 h; 95%CI 9 to 28 h; P<0.001). For femoral catheters, TKA subjects reached all four criteria in 61 (49 – 69) hours, compared with 40 (27–58) hours for UKA (difference: 20; 95%CI 4 to 30 h; P=0.009).





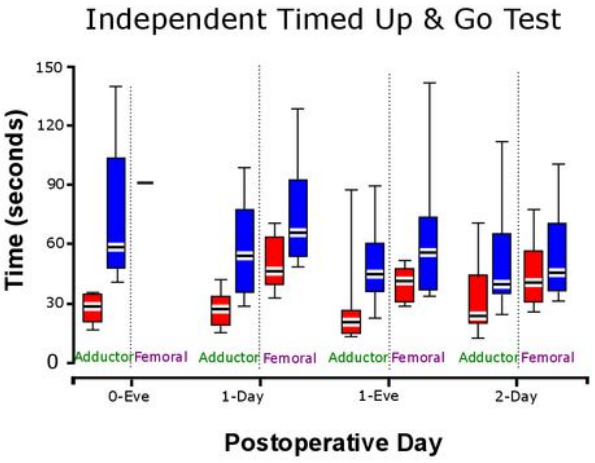
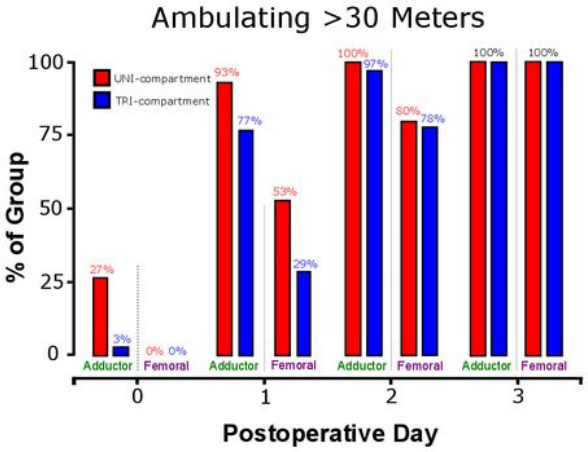
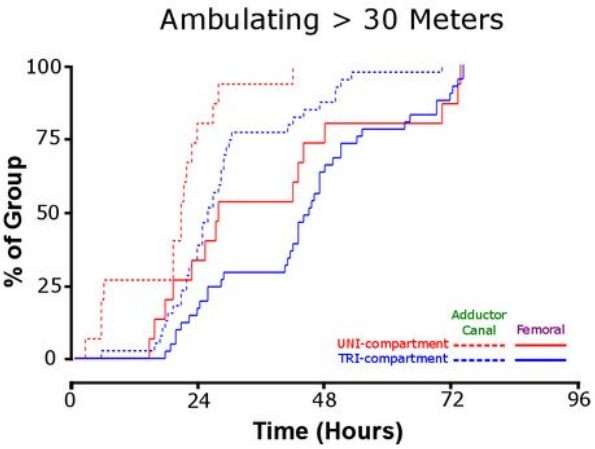


Figure 2

Effects of surgical procedure for UKA and TKA with adductor canal and femoral catheters—on the Timed Up and Go test (independently stand, walk 3 m, return, and sit down), using a four-legged walker. Data presented are the percentage of each treatment group to achieve the specified criteria at each time point (A); Kaplan–Meier estimates of the cumulative percentages of subjects meeting the specified criteria at each time point and subsequent time points (B); and time to perform the specified criteria as median (horizontal bar) with 25th to 75th (box) and 10th to 90th (whiskers) percentiles (C).





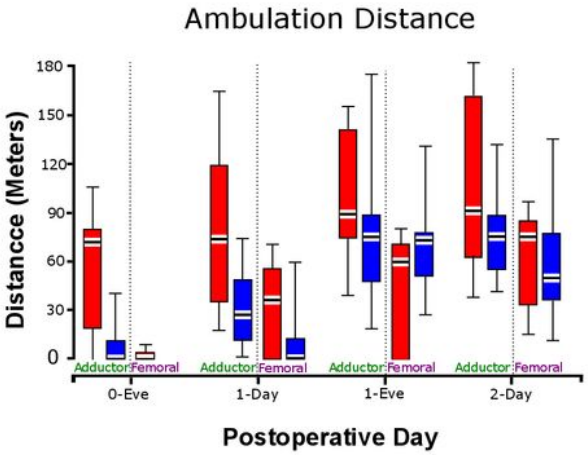
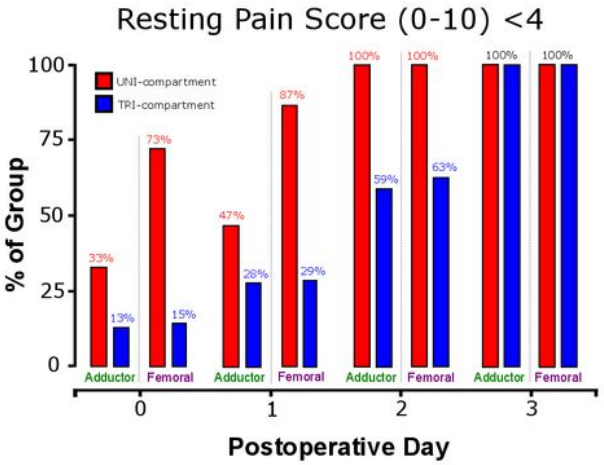
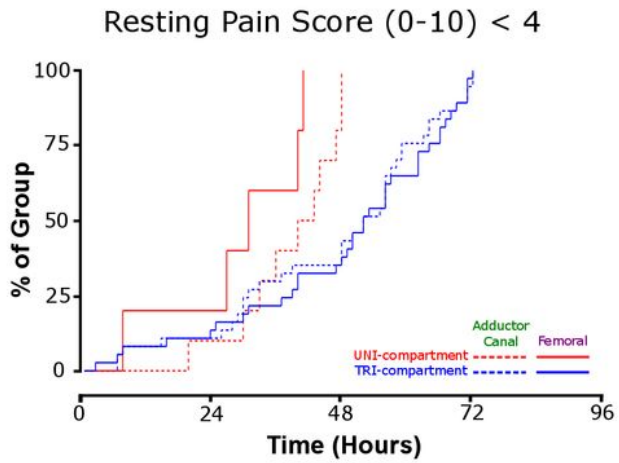


Figure 3

Effects of surgical procedure for UKA and TKA with adductor canal and femoral catheters on ambulation, using a four-legged walker. Data presented are the percentage of each treatment group to ambulate at least 30 m at each time point (A); Kaplan–Meier estimates of the cumulative percentages of subjects ambulating at least 30 m at each time point and subsequent time points (B); and distance of ambulation as median (horizontal bar) with 25th to 75th (box) and 10th to 90th (whiskers) percentiles (C).





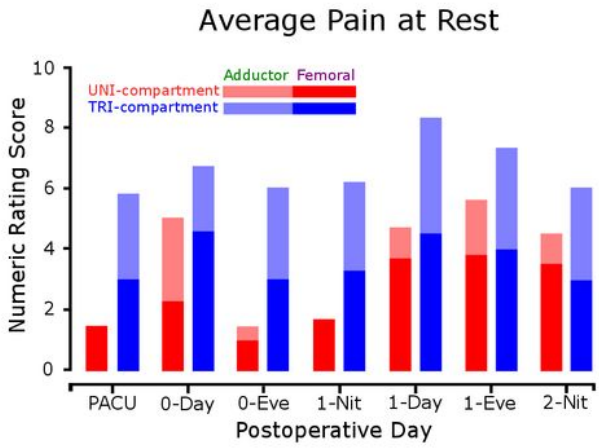
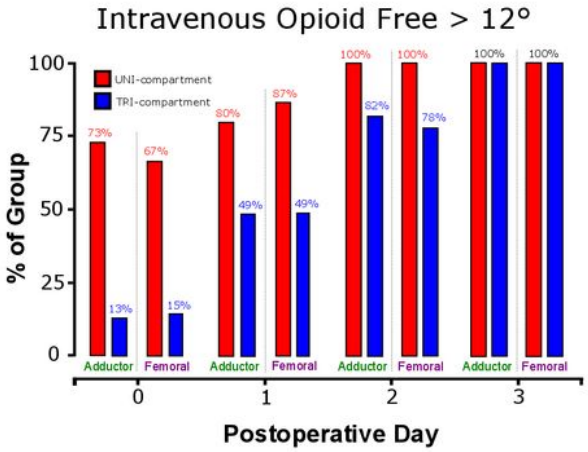
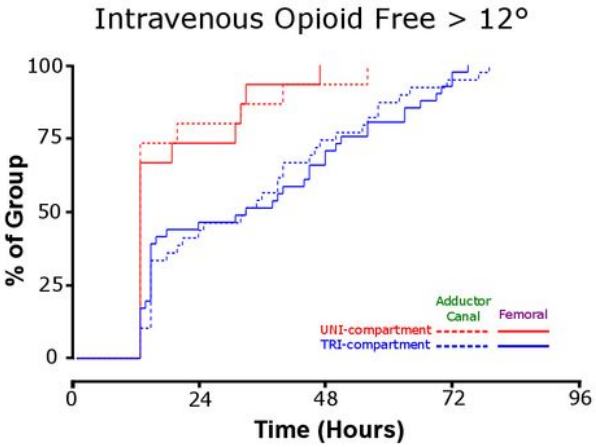


Figure 4

Effects of surgical procedure for UKA and TKA with adductor canal and femoral catheters on analgesia. Data presented are the percentage of each treatment group to have a mean numeric rating scale (NRS) for pain less than 4 at each time point (A); Kaplan—Meier estimates of the cumulative percentages of subjects with a mean NRS less than 4 at each time point and subsequent time points (B); and mean NRS presented as median (horizontal bar) with 25th to 75th (box) and 10th to 90th (whiskers) percentiles (C).





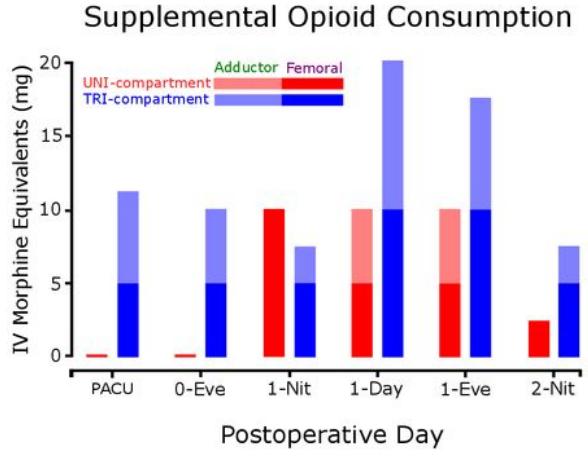


Figure 5

Effects of surgical procedure for UKA and TKA with adductor canal and femoral catheters on supplemental opioid requirements. Data presented are the percentage of each treatment group free of intravenous opioids for the previous 12 h at each time point (A); Kaplan–Meier estimates of the cumulative percentages of subjects free of intravenous opioids for the previous 12 h at each time point and subsequent time points (B); and mean oral and intravenous supplemental opioid requirements (expressed as morphine equivalents) as median (horizontal bar) with 25th to 75th (box) and 10th to 90th (whiskers) percentiles (C).