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Anatomical Landmarks for Intraoperative Adductor Canal Block in Total Knee Arthroplasty: A Cadaveric Feasibility Assessment

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Background: Postoperative analgesia after knee arthroplasty forms a basis for an optimal range of motion after surgery. Femoral nerve blocks are established as a sensory nerve blockade but at the expense of quadriceps weakness delaying postoperative mobilization. The adductor canal block (ACB) similarly provides sensory blockade but preserves quadriceps function. If ACB is performed intraoperatively, it would reduce the time and cost needed for ACBs. This study aimed at investigating possible landmarks making it feasible to perform ACB intraoperatively.
Material and methods: Twenty-seven knees were used. The superior pole of the patella, medial epicondyle, and adductor tubercle was proposed as landmarks to perform the ACB through a medial parapatellar approach. A needle was directed toward the adductor tubercle until a tactile feedback was felt. Ten to 15 mL India ink were injected using this technique. The adductor canal was dissected to visualize the ink spread and determine whether the saphenous nerve and the nerve to vastus medialis were exposed to the ink.
Results: The anatomic landmarks were easily identified in all knees. The ACB resulted in the saphenous nerve and nerve to vastus medialis being bathed in ink consistently. A volumetric relationship was noted with the injectate. No injury to the neurovascular structures was observed.
Conclusions: An accurate and safe technique with reliable anatomic landmarks was presented to perform an ACB. In addition, an increase in injected ink volume correlated to an increase in the spread of ink; thus, we postulate that 10 mL of local anesthetic may be sufficient for an adequate regional block.

Introduction

Total knee arthroplasty (TKA) has been shown as an effective surgical treatment for knee osteoarthritis [1]. Postoperative analgesia after TKA has been a significant challenge. Current literature on perioperative analgesia has shown that achieving adequate pain relief encourages early ambulation, reduces hospital length of stay, and improves postoperative outcomes [2].

Peripheral nerve blockades such as the femoral nerve block (FNB) and adductor canal block (ACB) are widely used. FNB provides excellent pain control but leads to quadriceps weakness delaying mobilization and increasing the risk of falls. In contrast, ACB targets both the saphenous nerve (SN) and the nerve to vastus medialis (NVM), which contributes to the innervation of the anteromedial aspect of the knee joint [3]. Kwofie et al. compared FNB with ACB and demonstrated that ACB results in significant quadriceps motor sparing and preserves balance [4]. Mudumbai et al. have shown that patients with ACB, when compared to FCB, had earlier ambulation postoperatively and were also able to ambulate longer distances at 24 hours [5,6]. Hence, ACB has become an increasingly popular choice for peripheral analgesia after TKA, as it

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is predominantly a sensory nerve blockade preserving quadriceps motor function [5–10].

Periarticular local anesthetic injection performed intraoperatively by the surgeon has been established to be effective in managing postoperative pain after TKA [11]. This periarticular local anesthetic injection could be augmented with ACB to achieve optimal postoperative analgesia while at the same time limiting the effects to the sensory branches of the supplying nerves. The ACB is typically performed by the anesthetist under ultrasound guidance at the mid-thigh region, as the SN and NVM exit in the distal third of the canal [3,12]. Orthopedic surgeons have a different view intraoperatively, which may potentially afford an equally accurate but more direct approach to the adductor canal using anatomical landmarks. If an ACB can be performed by the surgeon intraoperatively at the level of the knee, this would reduce the anesthetic time-related costs and need for ultrasound equipment.

The aim of this cadaveric feasibility study was to develop an ACB technique based on palpable intraoperative anatomical landmarks and investigate its efficacy and safety. We hypothesized that using the adductor tubercle as a landmark will assist surgeons in consistent and accurate performance of an ACB during knee replacement.

Material and methods

Human ethics committee (H17-066) and Ngai Tahu research consultation committee (Part 51 2017) approved the research on human cadavers procured. Twenty-seven knee specimens were used in this study. Tissues were embalmed with formaldehyde-based embalming including ethanol, phenoxyethanol, and glycerine [13].

All samples underwent a medial parapatellar approach to the knee. We proposed 2 key structures that were important to perform an ACB: (1) the adductor tubercle, which was positioned approximately 20 mm distal to the level of the superior border of the patella and 10 mm cranial of the medial epicondyle; (2) adductor magnus tendon, floor of the adductor canal, attaching to adductor tubercle was thick, round in appearance, and was robust to provide tactile feedback (Fig. 1). The ACB technique used in this study involved inserting a 10-ml syringe with a blunt 22 G needle with India ink, aimed 15-20 degrees in a coronal plane toward the adductor tubercle until resistance was felt against the robust adductor magnus tendon (Fig. 2). Once resistance was encountered, the tip of the needle was directed cranially toward the adductor canal before India ink was injected. We chose India ink as it has previously been used to mimic local anesthetic spread in cadaveric studies [14]. We then dissected the adductor canal to assess whether ink was successfully infiltrated into the adductor canal (Fig. 3). To do this, the skin and subcutaneous tissues were dissected carefully, revealing the sartorius and vastus medialis muscle and their distal insertions. An anatomical plane was developed between these 2 muscles to reveal the neurovascular structures of the adductor canal. The SN and NVM were assessed for evidence of being bathed in India ink. We also assessed the neurovascular structures in the vicinity of the needle to assess the safety of this technique.

In order to assess whether there was a volumetric relationship that existed with the amount of ink injected, we compared 2 different volumes of injectate. Twelve cadavers were injected with 10 ml of ink, and 15 cadavers were injected with 15 ml of ink. Ink spread distance, from the point of needle insertion to the most proximal point where the ink had spread, was assessed.

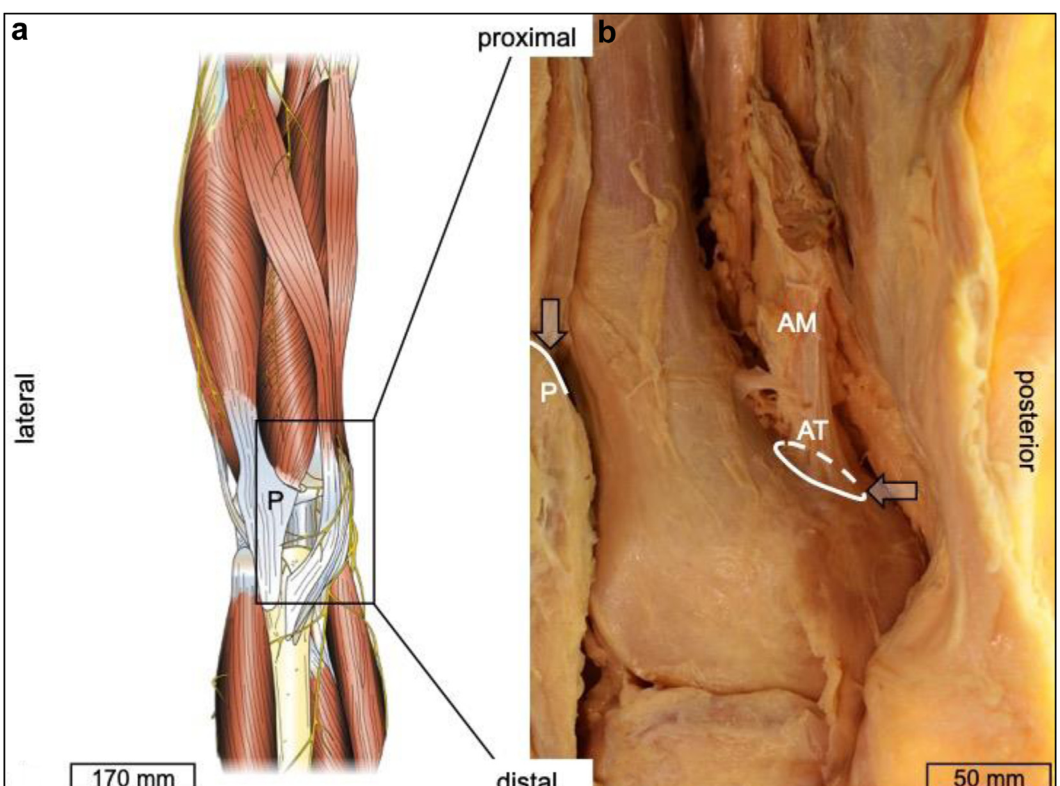

Figure 1. Demonstrating anatomical landmarks for ACB on the knee prosection. a: Sketch demonstrating anteromedial overview of a right knee, b: Magnification of 1a in a knee specimen. AM, adductor magnus tendon; AT, adductor tubercle; P, patella.

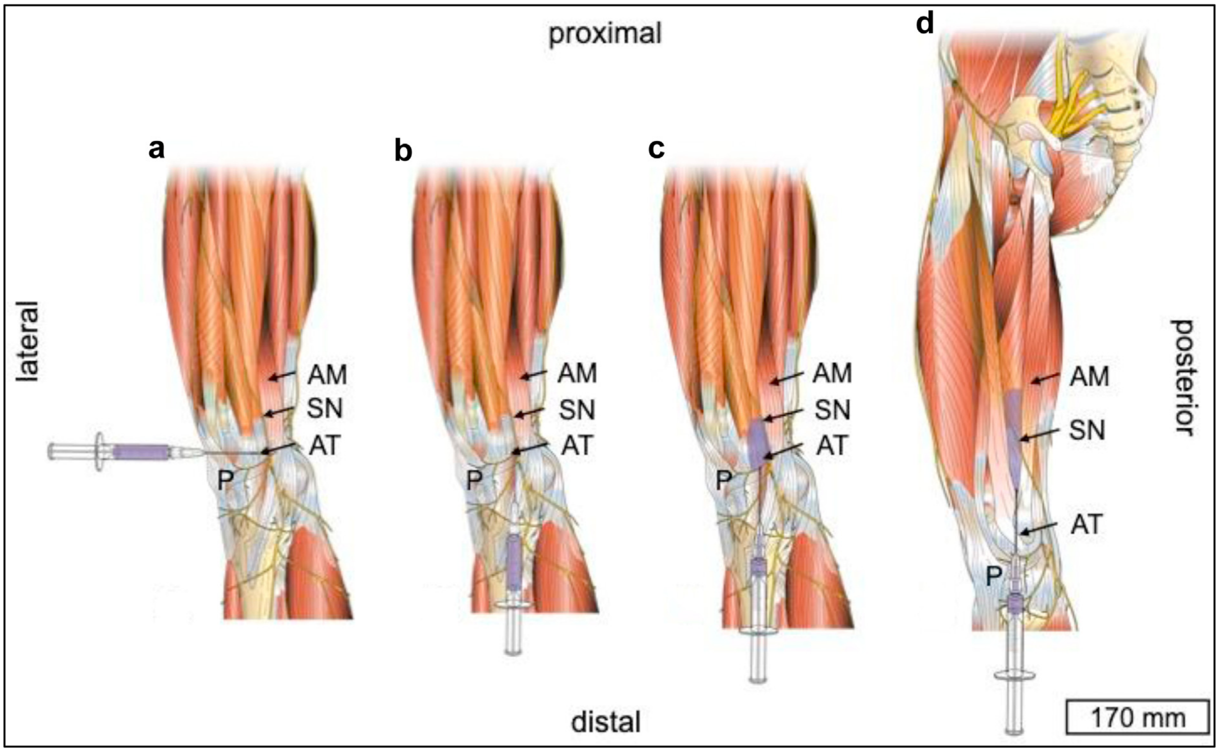

Figure 2. Demonstrating the technique of adductor canal block (ACB). a, a needle is directed directly towards the adductor tubercle until a resistance is perceived, b, the needle is turned upwards 90°, before the anesthetic is injected, then spreading into the adductor canal (c and d). AM, adductor magnus tendon; AT, adductor tubercle; P, patella; SN, saphenous nerve.

Statistics tests

Excel Version 16.15 (Microsoft Corporation, Redmond, WA) and GraphPad Prism software version 8 (GraphPad Software, La Jolla, CA) were used. *P* values equal or less than 0.05 were considered to be statistically significant. The D'Agostino-Pearson test was used to determine whether the data set was normally distributed. One-way ANOVA and Sidak's tests were used to assess if there were any statistical differences between groups. Pearson correlations coefficients (CC) were used to evaluate the relationship between the groups.

Results

All 27 knees were used. The mean age at death was 83 years (range 62-98 years), 15 were female (3 bilateral), and 8 were male (1 bilateral). Sixteen were left knees, and 11 were right knees.

Both the SN and NVM were bathed in ink after the injection of volumes of 10 ml and 15 ml, respectively. The majority of the ink was spread within the adductor canal and along the epimysium of the sartorius muscle. At the puncture site, neither the SN nor NVM were injured. The femoral artery and vein are posterolateral of the injection site. No injury to these vessels were identified.

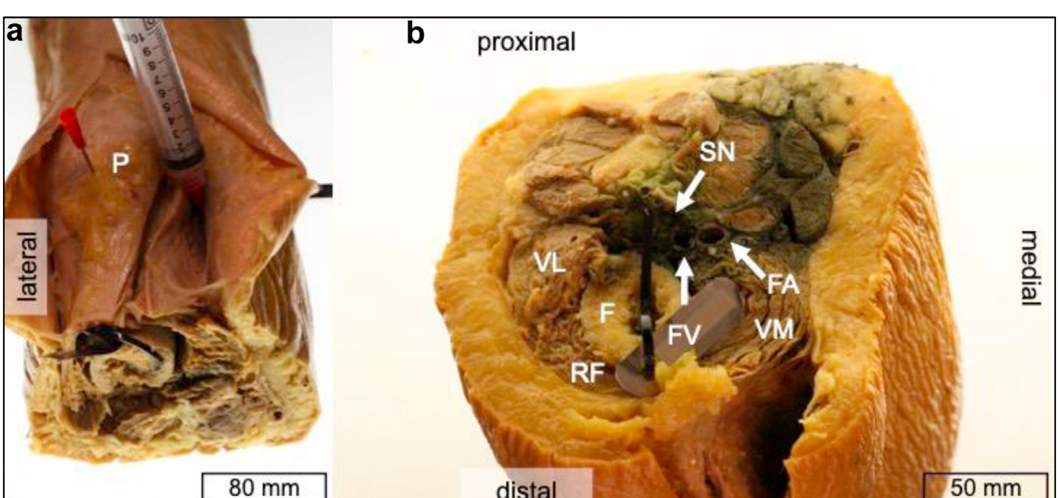

Figure 3. Demonstrating the injection technique on the knee prosection. a, anteromedial view of a right knee specimen; b, cross section demonstrating the ink spread; F, femur; FA, femoral artery; FV, femoral vein; P, patella; SN, saphenous nerve; VL, vastus lateralis muscle; VM, vastus medialis muscle.

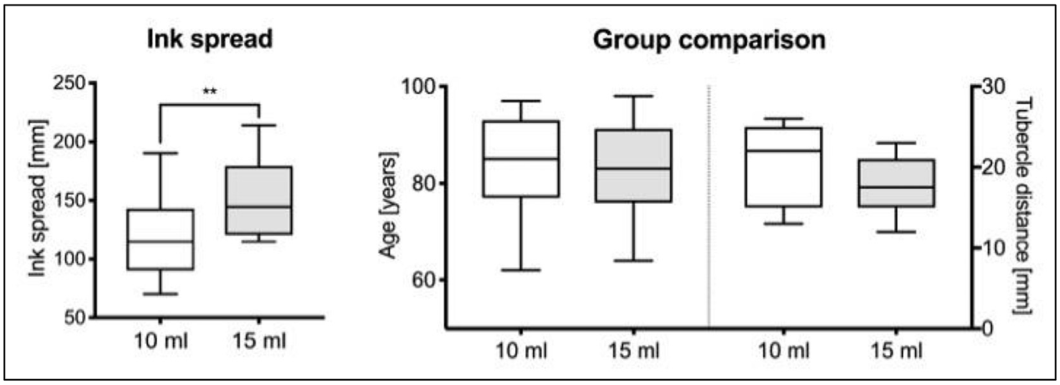

Figure 4. Box plots show the 25th percentile, median, and 75th percentile whiskers minima and maxima. **indicating highly significant statisical difference.

The average distance from the point of needle to the adductor tubercle was calculated to be 19 mm (range, 12-26 mm). There was no statistically significant difference between male and female, left and right, or the age of the cadavers.

Cadavers injected with 10 ml and 15 ml of ink resulted in an average ink spread distance of 119 mm (range 70-190 mm) and 150 mm (range 115-214 mm), respectively. In 2 cadavers, the ink reached the proximity of the femoral nerve.

The data obtained for the volumetric analysis, gender comparison, and side comparison were normally distributed as indicated by the D'Agostino-Pearson test. Ink spread was significantly larger in the 15-ml groups than that in the 10-ml group with 149.8 and 121.7 cm, respectively ($P = .008$). Further comparisons of left-right and male-female yielded no significant difference (Fig. 4). The volume applied and the ink spread had a moderate correlation (CC = 0.48).

Discussion

Periarticular local anesthetic injection, ultrasound-guided ACB, and patient-controlled anesthesia have all been shown to be effective measures in managing postoperative pain, while at the same time preserving quadriceps motor function after TKA [11]. Surgeon-performed periarticular local anesthetic injections have been shown to be an effective, quick, and reliable method of analgesia after TKA [11]. This study has shown cadaveric evidence that an ACB can be reliably and safely performed by the surgeon intraoperatively without the need for radiological guidance or anesthetic involvement.

The technique described in this study is similar to the tactile feedback technique described for a fascia iliaca block performed in the hip fracture setting [15]. The tactile feedback is felt against the adductor magnus tendon using a blunt needle. This technique has also been shown to be safe as there are no major vascular structures in the vicinity of the adductor tubercle. Furthermore, the use of a blunt needle reduces the risk of neurological injury of the SN or NVM, and in our study, no injury of neurovascular structures was identified.

Pepper et al. described an ACB which they performed in 11 cadavers with an accuracy of 86%, but they did not describe the anatomical landmarks for the injection [16]. Kavolus et al. used the femoral transepicondylar axis as their anatomical landmark to perform the ACB in cadavers with an accuracy of 72% [17]. Our study uses the superior pole of the patellar and medial epicondyle as the anatomical landmarks to estimate the location of the adductor tubercle. Furthermore, our study is the only study to assess the diffusion of injectate around both the SN and NVM, as we believe that both these nerves are crucial sensory nerves to the knee.

We observed a volumetric relationship to the spread of ink injected into the adductor canal, but only found a weak correlation and statistical insignificance when comparing 15 ml to 10 ml of injectate. We believe this reflects the small sample in this study; however, we feel that it warrants mention as excessive injectate would defeat the purpose of this block if the local anesthetic spreads to femoral nerve causing loss of quadriceps motor function.

There are multiple limitations to this given study. First, the cadavers were chemically embalmed, which makes the tissues more rigid and tissue planes less pliable. Second, the number of cadavers was limited. Third, we used India ink to visualize the spread of the injectate, but this may possess a different viscosity and diffusion patterns to local anesthetics. Further clinical research is therefore warranted to determine its safety and efficacy in patients.

Conclusions

This study describes an accurate technique with reliably identifiable anatomical landmarks to perform the ACB in cadavers. This technique successfully infiltrated the adductor canal and bathed the SN and NVM in all cases without evidence of neurovascular injury. In addition, an increase in injected ink volume correlated to an increase in the spread of ink; thus, we postulate that 10 ml of local anesthetic is sufficient for an adequate regional block.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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