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An anatomic study of local infiltration analgesia in total knee arthroplasty☆

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ABSTRACT

Background: Local infiltration analgesia (LIA) is a relatively novel technique developed for effective pain control following total knee arthroplasty (TKA), reducing requirements for epidural or parenteral postoperative analgesia. This study investigated the anatomical spread of an LIA used in TKA to identify the nerve structures reached by the injected fluid.
Methods: Six fresh-frozen cadaveric lower limbs were injected according to a standardised LIA technique with a solution of latex and India ink to enable visualisation. Wounds were closed and limbs placed flat in a freezer at −20 °C for two weeks. Limbs were then either sliced or dissected to identify solution locations.
Results: Solution was found from the proximal thigh to the middle of the lower leg. The main areas of concentration were the popliteal fossa, the anterior aspect of the femur and the subcutaneous tissue of the anterior aspect of the knee. There was less solution in the lower popliteal fossa. The solution was found to reach the majority of nerves, with good infiltration of nerves supplying the knee.
Conclusions: These results support the positive clinical outcomes with this LIA technique. However, the lack of infiltration into the lower popliteal fossa suggests more fluid or a different injection point could be used. The solution reaching the extensor muscles of the lower leg is likely to have no beneficial analgesic effect for a TKA patient. The LIA technique is already used in clinical practice following total knee arthroplasty. Results from this study show there may be scope to optimise the injection sites in LIA technique.

1. Introduction

Total knee arthroplasty has become an increasingly common procedure worldwide and refinement in the postoperative rehabilitation of these patients is continually developing. The current 'gold standard' treatments for pain relief following knee surgery are epidural anaesthesia or a continuous femoral nerve blockade [1,2]. Such treatments are often accompanied by numerous side effects: nausea; sedation; hypotension; urinary retention; partial motor block; and increased venous stasis [3,4]. As a result these techniques may hinder recovery and increase hospital stay [3–5].

Adequate pain relief in addition to maintenance of normal muscular tone has been shown to optimise accelerated recovery [6]. Kerr and Kohan have published a technique of 'Local Infiltration Analgesia' (LIA) where large volumes of local anaesthetic are infiltrated immediately after surgery [7]. Results from this technique have found that intra-articular injections of local anaesthetic improve postoperative pain scores, reduce hospital stay, reduce postoperative morphine consumption, and increase postoperative mobilisation [5–9]. Based on results reported in the literature [6,10–12], our institution adopted a revised version of this technique [18] into our intraoperative knee arthroplasty management, where it has confirmed previously published results [13,18]. Published work on LIA techniques describes the location as well as quantitative amount of injected fluid around the knee joint [6,7,18]. However, anatomical studies looking specifically at the spread of the local anaesthetic, or its relation to the anatomy and nerve supply of the knee, have been previously unreported.

To further understand the technique we aimed to perform a cadaveric study to assess the anatomical spread of the standard injections used intra-operatively in the LIA technique, to identify the nerve structures covered by injections and to identify areas of excessive or inadequate coverage and so highlight possible areas for refinement.

2. Materials and methods

A total of six fresh, unembalmed cadaveric knees which had been stored frozen (−20°) since acquisition were used. After de-frosting to room temperature, the knees were prepared and injected by an experienced consultant orthopaedic surgeon (FP) who specialises in lower limb arthroplasty and routinely uses our institution's LIA technique in

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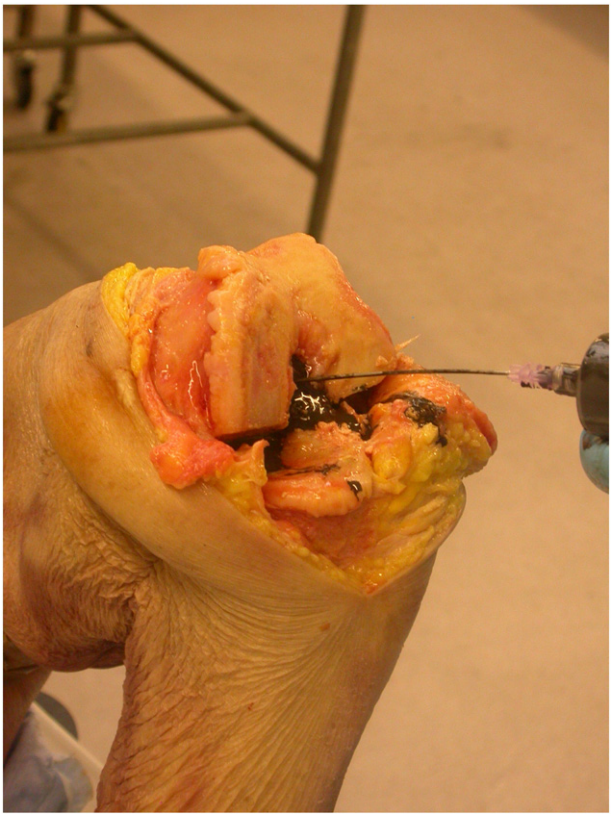

Fig. 1. Posterior infiltration: The cadaveric knee is fixed on a 90° clamp. The posterior condyles have been resected after a medial approach and the patella is everted. The dye solution is being injected into the intercondylar area.

clinical practice [18]. White latex (Trylon Ltd., Wollaston, Northants) and cold water were mixed together in a ratio of 1:9 and a small amount of black India ink added to form a black dye solution of watery consistency that could be injected but would then set hard, enabling the dissection and slicing of the specimens without fear of the injected bolus leaking away. This enabled the visualisation of the spread and coverage of the LIA injections [22–24]. Each cadaveric knee specimen was prepared using the following method:

A tight tape was applied to the top of the thigh section simulating any restriction to the proximal flow of the injected fluid that might be caused by the use of a tourniquet. The knee was then fixed at 90° with the femur held in a clamp. A midline incision was made through the skin and the capsule opened via a medial parapatellar approach. The patella was reflected and the posterior femoral condyles were prepared as per a primary knee total joint arthroplasty (Fig. 1). The anterior cruciate ligament and medial and lateral menisci were also removed. A total of 180 ml of dye solution was drawn up in three 60 ml syringes, and injected into the tissues using the technique used within our institution [18]:

1) 60 ml injected through the posterior capsule — 20 ml in the posterior medial capsule with the needle parallel to the posterior femoral cortex; 20 ml in the posterior lateral capsule with the needle parallel to the posterior femoral cortex; 10 ml in the notch (intercondylar area) into the posterior cruciate ligament (Fig. 1); 10 ml in the medial and lateral collateral ligaments.
2) 30 ml injected anteriorly into the supra patellar region but proximal to the margin of the anterior capsule, with the needle being inserted perpendicular to the anterior cortex of the femur until it reached the bone, and 30 ml along the edges of the medioparapatellar arthrotomy from proximal origin to the tibial tuberosity (Fig. 2).
3) Before wound closure, the subcutaneous tissues adjacent to the incision were infiltrated with 60 ml of solution.

The incision was then stitched with a continuous suture and the limb placed flat in a freezer at −20 °C. To allow the dye solution to fully set the limbs were stored in this state for a further two weeks [22–24]. After this time four of the limbs were sliced whilst still frozen into 3 cm thick sections and each section photographed. The remaining two limbs were dissected according to a dissection manual [14] and photographed. During the dissection all areas that were not infiltrated with dye were removed. In order to photograph nerves that had been completely covered in dye, the dyed tissues were cut open or removed.

Fig. 2. Anterior infiltration: Injection into anterior aspect of femur.