Injury to the lateral femoral cutaneous nerve during minimally invasive hip surgery: a cadaver study

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ABSTRACT

INTRODUCTION A smaller skin incision as part of minimally invasive surgery (MIS) for total hip arthroplasty (THA) is thought to reduce local tissue trauma. Preservation of cutaneous nerves may reduce postoperative pain and improve rehabilitation. The standard lateral approach (SLA) and two MIS approaches (anterolateral [ALA] and posterior [PA]) were compared to determine which incision preserved cutaneous nerves.

PATIENTS AND METHODS Fifteen cadaveric hip specimens were dissected to establish the course of branches of the lateral femoral cutaneous nerve. The number of branches divided by each of the three incisions was recorded.

RESULTS The MIS incisions resulted in significantly less nerve division compared with the SLA. The mean difference between the SLA and the ALA was 4.4 ($P < 0.0001$), and between the SLA and the PA was 1.4 ($P = 0.0005$). The ALA divided significantly fewer nerves compared with the PA (mean difference = 3; $P = 0.0001$).

DISCUSSION There is little evidence of the benefit of one MIS approach over another in the literature. The ALA preserved significantly more cutaneous nerves in this study. These results need corroboration with clinical outcomes to determine their significance.

KEYWORDS

Hip replacement arthroplasty

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Interest in minimally invasive surgery (MIS) for total hip arthroplasty (THA) has been driven by the perceived benefits, such as a reduction in peri- and postoperative complications, shortened in-patient stay and reduced healthcare costs.¹ Potential benefits of a shortened skin incision include a reduction in wound pain, rapid rehabilitation, and improved cosmesis.^{1–5} However, reports in the literature are mixed, and these claims have yet to be proven definitively in randomised clinical trials.^{4,5} Four MIS approaches have been described – anterior, anterolateral (ALA), posterior (PA) and two incision.^{1,6} The optimal approach has yet to be determined.^{6,7}

In this context, we were interested in the cutaneous nerve supply of the lateral thigh. Painful neuroma formation following cutaneous nerve injury is well documented in other areas of the body.^{8–10} Surgical incisions aligned parallel to cutaneous nerves reduce sensory disturbance following knee arthroscopy and iliac crest bone graft harvesting.^{11–15} Should skin incisions for THA aim to preserve cutaneous nerves in order to reduce troublesome symptoms, and improve rehabilitation and patient satisfaction?

The lateral femoral cutaneous nerve (LFCN) supplies sensation to skin over the anterior, lateral and posterolateral thigh from the inguinal ligament to the knee. Its normal course takes it inferior to the inguinal ligament on the anterior surface of the thigh, deep to fascia lata. It then divides into branches prior to piercing the fascia lata. However, cadaver studies have shown variation in course and branching patterns. Murata *et al.*¹⁴ looked at 108 LFCNs and found 41% cross the level of the inguinal ligament over, or lateral to, the anterior superior iliac spine (ASIS). The LFCN divided into its branches prior to passing the inguinal ligament in 28% of specimens in one study,¹⁵ and four branching patterns have been identified in the proximal thigh.¹⁶ Grothaus *et al.*¹⁵ have established a ‘danger zone’ in the anterior thigh where nerve branches are invariably found. This is a rectangular area 7 cm medially and 12 cm inferiorly from the ASIS.¹⁵ There have been reports of pain and sensory disturbance in the distribution of the LFCN following other procedures.¹⁴

Two commonly used MIS approaches (anterolateral [ALA] and posterior [PA]) were compared to the standard direct lateral (SLA) Hardinge approach.¹⁷ Other MIS incisions are per-

Figure 1 Landmarks and incision lines. A, anterior superior iliac spine; C, tibial tuberosity; D, greater trochanter. Line A–C, path of the LFCN.

formed less commonly due to their complexity. The MIS incisions have been evaluated previously and found to provide adequate exposure to the hip joint.^{18–20} The ALA was developed from the Watson-Jones approach and utilises the intermuscular plane between gluteus medius and tensor fascia lata. An incision measuring 6–7 cm is made from the anterior tubercle of the greater trochanter towards the ASIS, and subcutaneous tissue and fascia are divided in line with the skin incision.²⁰ For the PA, a 6–10 cm straight incision is made over the posterior aspect of the greater trochanter (GT), parallel with the femoral shaft. Less than one-third of the incision extends proximal to the GT. Subcutaneous tissue is sharply dissected down to fascia, and the fascia lata is incised parallel to the femur and at the tip of the trochanter the incision is angled posterior into the gluteus maximus.¹⁸

We aimed to establish which of these three approaches results in the least cutaneous nerve injury.

Patients and Methods

Fifteen embalmed cadaveric specimens (9 male, 6 female) were studied by two of the authors. Dissection was performed on randomly selected hips with each of the authors dissecting both left and right sides. Initially, measurements were taken and guidance lines were drawn onto the specimens. Four clinically relevant and easily reproducible bony landmarks were marked (Fig. 1) – the ASIS (A), medial malleolus (B), tibial tuberosity (C), and the superior point of the GT (D). All of these landmarks were defined by palpation or insertion of a needle. Limb length was recorded as the distance between A and B. A line was drawn between A and C. The proximal part of the line AC represented the usual course of the LFCN trunk inferior to the inguinal ligament and deep to fascia lata.¹⁶ Line A–C

became the reference line from which all nerve measurements were taken.

Next, lines representing all three incisions were drawn onto the cadavers. To represent the SLA, a 20-cm line was drawn parallel to the femur (D being the midpoint), with a proximal posterior curve. To represent the PA, a 10-cm line was drawn over the posterior aspect of the GT as described earlier. The ALA was represented by a 10-cm line drawn from the anterior tip of the GT in the direction of the ASIS (Fig. 1).

A standardised flap technique was used by both authors for the subcutaneous dissection. The curved incision was made using a scalpel medial to the marked surgical incision lines to create the skin flap. Careful dissection was performed down to fascia lata to preserve all nerve branches of the LFCN superficial to the fascia (Fig. 2). Structures resembling nerve branches were dissected back to their common nerve trunk (approximating to the line A–C on the overlying skin), where possible, to verify their origin.

Figure 2 Dissection of the lateral thigh (left) showing cutaneous nerves.

Table 1 Summary of results

	No.	Side	Sex	Limb length (A–B) mm	Number of nerves	Angle of nerves to line A–C (mean°/range°)	Number of nerves injured		
							Posterior MIS	Anterolateral MIS	Standard lateral
	1	L	M	1025	6	48.8 (18–78)	3	0	6
	2	R	M	885	5	59.8 (40–74)	3	1	3
	3	L	M	910	6	50.3 (18–75)	4	1	5
	4	R	M	885	7	57.1 (20–81)	3	0	3
	5	L	M	880	7	54.3 (35–82)	4	1	5
	6	L	F	850	5	54.6 (15–90)	3	0	4
	7	R	F	850	7	53.6 (26–85)	4	0	5
	8	L	F	885	7	65.1 (32–100)	3	3	5
	9	R	F	870	7	54.1 (13–75)	3	0	5
	10	R	F	840	7	49.1 (22–63)	4	0	7
	11	L	F	840	8	50.6 (14–78)	5	0	7
	12	L	M	930	7	54.4 (28–98)	4	0	6
	13	R	M	890	6	63.3 (55–75)	3	0	5
	14	R	M	890	9	59.3 (29–82)	5	2	6
	15	L	M	900	6	62.3 (45–85)	3	1	3
Total	15	7R	6F	13330	100		54	9	72
Mean (range)				888.7 (840–1025)	6.7 (5–9)	55.7 (13–100)	3.6 (3 – 5)	0.6 (0–3)	5 (3–7)

The path of each nerve branch was extrapolated to the line A–C. The angle the nerve branch made to the line A–C was measured. When the skin flap was replaced, it was possible to identify and count which nerve branches would be divided by each of the surgical approaches. All reference points and measurements were taken by one of the authors (SSJ).

The data were initially analysed with the Friedman test to establish significant differences between the three groups. The Wilcoxon signed ranks test was then used to compare the number of nerve branches divided by each incision.

Results

Dissection was performed on 8 left hips and 7 right hips. The mean limb length (A–B) was 889 mm (range, 840–1025 mm). Results are summarised in Table 1.

In total, 100 nerve branches were found, mean 6.7 (range, 5–9) branches per thigh. The mean departure angle of these branches from the main trunk (the angle from line A–C) in the lateral thigh was 55.7° (range, 12–100°).

The mean number of nerve branches divided in the SLA was 5.0 (range, 3–7) compared with 3.6 (range, 3–5) in the PA (mean difference, 1.4; 95% confidence interval [CI],

1.0–1.8; $P = 0.0005$) and 0.6 (range, 0–3) for the ALA (mean difference, 4.4; 95% CI, 3.56–5.24; $P < 0.0001$). When the two MIS incisions were compared, the mean difference was 3 (95% CI, 2.8–3.2; $P = 0.0001$).

Discussion

THA through a SLA is a successful operation with good pain relief, excellent functional improvement and a low complication rate. MIS THA has potential benefits. However, smaller incisions can compromise visualisation and result in a paradoxical increase in soft tissue damage from excessive retractor forces.⁵ Poor implant fixation and malposition can lead to early implant failure, and new techniques must also be learnt and perfected by the surgeon.¹

From the results presented here, division of cutaneous nerve branches is common in the SLA and the PA. Studies have reported better patient outcome following knee arthroscopy and arthroscopic ACL reconstruction when the incision lines are placed horizontally (parallel to the infra-genicular branch of the saphenous nerve) rather than vertically, across the path of the nerve.¹² Similarly, symptoms

(pain and numbness) after harvesting of bone from the posterior iliac crest are reduced when incisions are made parallel to the nerves, rather than perpendicular to them.¹⁵

There is conflicting evidence for the benefits of MIS in the literature. Many studies show no benefit.^{5,21–25} Szendroi *et al.*² showed that patients had less pain in the postoperative period, and were happier with the cosmetic result after a shorter incision. However, patients selected for MIS had a significantly lower body mass index and there were significantly higher numbers of patients with malpositioning of the acetabular cup. There were no statistically significant differences in intra-operative blood loss and postoperative recovery.¹ Another study showed the only benefit to be cosmetic.²⁴

The posterior approach to the hip is popular among orthopaedic surgeons. However, the posterior MIS approach still carries the same risk of dislocation.^{6,25} When the standard posterior approach was compared to the MIS posterior approach, there were significant increases in wound infection rates and component malposition,⁵ but lower intra-operative blood loss, length of stay and use of walking aids in the MIS group.^{26,27} Other studies have shown no significant differences in component placement, transfusion rates, pain control, length of stay, return to walking and function at 6 weeks.^{28,29}

Of the published literature comparing anterolateral MIS incisions with the standard approach, MIS patients have a quicker recovery and a reduction in intra-operative blood loss.^{30,31}

We acknowledge the limitations of our study. Wound pain and paraesthesia may be seen in clinic but we found little evidence in the published literature concerning this complication. However, injury to cutaneous nerves is likely to contribute to postoperative pain, numbness and patient dissatisfaction.^{8–10} The small number of cadavers and their LFCN branching pattern may not have been representative of our surgical population group. However, the distribution of nerves compared favourably with that described previously;¹⁶ therefore, we feel conclusions drawn from this study are valid. All the cadavers used had been embalmed; the position of the hip at rigor mortis may have influenced the position of cutaneous nerves. However, unlike nerves around the knee where joint movement can influence nerve position markedly,¹² the hip position during dissection was similar to the intra-operative position at the time of skin incision for THA. There is also a risk of inter-observer bias as the dissections were performed by two of the authors independently. Finally, an assumption is made that nerve branches supply a certain area of skin and, for the purposes of this study, each area is equal. This is clearly not the case; the diameter of nerves cut and area of skin supplied is variable and it is quite possible that small nerve branches were inadvertently removed during dissection and were, therefore, not included in the study, despite careful dissection.

Ultimately, selecting an approach for hip arthroplasty depends on many considerations – the muscle plane to dissect, adequate joint access, complication rate, and design of prosthesis and instrumentation. Comparisons between MIS approaches are difficult to find in the published literature and, in the absence of any significant benefits of one over another, the most familiar approach should be used. In this study, we have shown that the ALA divides significantly fewer cutaneous nerves than the PA, which in turn divides significantly fewer than the SLA. We suggest that an incision aligned parallel to the branches of the LFCN, similar to the ALA will preserve more cutaneous nerves and may result in less thigh pain and paraesthesia, and improved patient satisfaction. These results need corroboration with clinical outcomes to determine their significance for MIS.

Acknowledgements

The authors would like to thank the staff of the Anatomy and Clinical Skills Department, Newcastle University, for their assistance in performing this study, and to Dr Nick Steen (Newcastle University) for performing the statistical analysis.

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