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Iatrogenic superior gluteal nerve stretch in surgical fixation of acetabular fractures through a Kocher-Langenbeck approach: a cadaveric study

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Abstract

Objectives Fixation of posterior column fractures through a Kocher–Langenbeck approach requires retraction of the gluteus medius and minimus and, therefore, the superior gluteal nerve (SGN). Iatrogenic nerve injury is a concern that may result in hip abductor weakness and altered gait patterns. The purpose of this study was to measure the amount of stretch to the SGN relative to common placement of a retractor during a posterior approach to the acetabulum for fracture fixation.

Methods An IRB-approved cadaveric study was performed. The Kocher–Langenbeck approach was performed on ten hips from five cadaveric donors. The superior gluteal nerve was reproducibly identified and isolated, exiting the greater sciatic notch (GSN) and traversing between the gluteus minimus and medius. The length of the nerve was measured with a caliper between the GSN and its insertion into the gluteus medius, along its longest segment. An acetabular retractor was placed anterior to the gluteal pillar, and the length of the SGN was measured with the retractor positioned 30 and 60 degrees relative to the horizontal. The measurements were completed both with the leg in the neutral position and with the leg in 15 degrees of abduction. Interobserver reliability was measured. The percent change in the length of the SGN relative to retractor position was calculated.

Results The SGN was consistently found exiting the most proximal aspect of the GSN. The length of the SGN from the GSN to the muscular insertion was 29.3 mm (+/- 7.4 mm). The nerve stretched 28% of its length at 30 degrees of retraction and 56.9% at 60 degrees of retraction. The nerve was stretched over a short segment and tethered at the level of the GSN. The intraclass correlation coefficient (ICC) was excellent between the two observers (0.92 [0.87–0.95]). Significant changes in the length of the nerve were found in four hips with the retractor at 30 degrees and all ten hips at 60 degrees.

Conclusions The superior gluteal nerve is subjected to significant stretching during anterior retraction of the gluteal muscles during acetabular fracture fixation through a Kocher–Langenbeck approach. A clinical study with electrodiagnostic studies and gait analysis is needed to determine whether iatrogenic nerve stretch is consequential.

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Keywords Superior gluteal nerve, Iatrogenic injury, Acetabulum fracture, Kocher–Langenbeck approach

Introduction

The Kocher–Langenbeck approach is a commonly used surgical approach to the acetabulum for the fixation of fractures involving the posterior column or posterior wall (1, 2). Adequate fracture exposure and visualization require retraction of the gluteus medius and minimus and, therefore, the superior gluteal neurovascular bundle (2, 3).

The course of the superior gluteal nerve (SGN) has been well described, including a safe zone 3–5 cm proximal to the tip of the greater trochanter (4, 5, 6). However, significant variability in the course of the SGN has been demonstrated, with adjacent blood vessels traversing within 1 cm from the acetabular rim (4, 6).

While the sciatic and femoral nerves have been well studied in both the trauma and arthroplasty literature, the SGN often lacks consideration. Nerve conduction studies of the SGN have compared surgical approaches in total hip arthroplasty but are lacking in the setting of acetabular fracture surgery (7, 8). Functional deficits, including abductor weakness and altered gait patterns, can be difficult to diagnose in the trauma setting, as patients are often prescribed non-weight bearing for up to three months post-operatively. However, multiple studies report ongoing gait disturbance and gluteal weakness at 12 month follow up (9, 10).

Peripheral nerves are sensitive to changes in length. Changes in nerve conduction velocity and amplitude resulting from nerve strain of as little as 4–21% have been demonstrated (11, 12). Yet the prognosis of elastic stretch injuries is favorable in animal models compared to crush or inelastic stretch injuries (13).

Routine placement of surgical retractors via the Kocher–Langenbeck approach may result in significant stretching to the SGN (Fig. 1). Iatrogenic nerve stretch may lead to long-term functional limitations, including weakness in hip abductor strength and altered gait patterns (14, 15, 16). Several clinical studies have concluded that hip abductor strength deficits are related to posterior surgical exposure of the hip and that functional deficits can be measured beyond two years post-operatively (14, 15). Dickinson et al. reported up to 50% weakness in hip abductor strength at a mean of 21 months following a posterior approach for acetabular fracture fixation (9).

We hypothesize that the superior gluteal nerve is subject to significant iatrogenic stretch during acetabular fracture fixation via the Kocher–Langenbeck approach, which may be related to long-term postoperative functional deficits. This study aims to quantify the extent to which the SGN is stretched as a result of retractor positioning.

Methods

Study design

This is an IRB-approved anatomical cadaveric study evaluating the iatrogenic stretch of the superior gluteal nerve during the fixation of acetabular fractures via the Kocher–Langenbeck approach. We performed ten standardized approaches on five full body, formalin-embeded cadavers (3 male, 2 female) at room temperature. Specimens were provided by the University of Ottawa Division of Clinical and Functional Anatomy. Institutional ethics approval was obtained. The cadavers that were included in the study were free of any previous surgical intervention to the pelvis or hip. The approaches were completed by one fellowship-trained orthopedic surgeon assisted by an orthopedic resident.

Surgical approach

The samples were placed in the lateral decubitus position, secured with sandbag bolsters. The operative leg was placed in zero degrees of extension. A standard incision was made from the posterior superior iliac spine, which curved anteriorly over the greater trochanter following the posterior aspect of the femoral shaft. Superficial dissection was carried down to the gluteal fascia and iliotibial band. The iliotibial band was split along the posterior aspect of the femur and curved in line with the gluteus maximus fibers. The gluteus maximus tendon was released from the femur. The piriformis tendon was isolated and released 1 cm from its insertion on the greater trochanter. The conjoined tendon of the obturator internus and superior and inferior gemelli muscles was then identified and released in a similar fashion. The sciatic nerve was identified and traced to the greater sciatic notch. A retractor was placed in the lesser sciatic notch. The gluteus minimus was elevated off the capsule. The minimum amount of gluteus minimus was debrided to isolate the superior gluteal nerve at the most cranial aspect of the GSN. The main branch was followed deep to the gluteus medius up to its muscular insertion. A Hohmann retractor was then placed anterior to the gluteal pillar, 2 cm proximal to the hip joint (Fig. 2).

Measurements

Using a caliper and goniometer, two independent surgeons measured the length of the nerve from its exit of the greater sciatic notch until its insertion into the gluteus muscles in the absence of tension or retraction (Fig. 3). The gluteus medius was then retracted via a sharp Hohmann retractor anterior to the gluteal pillar in a standardized fashion. The retractor was then positioned at 30 and 60 degrees from the horizontal, as confirmed

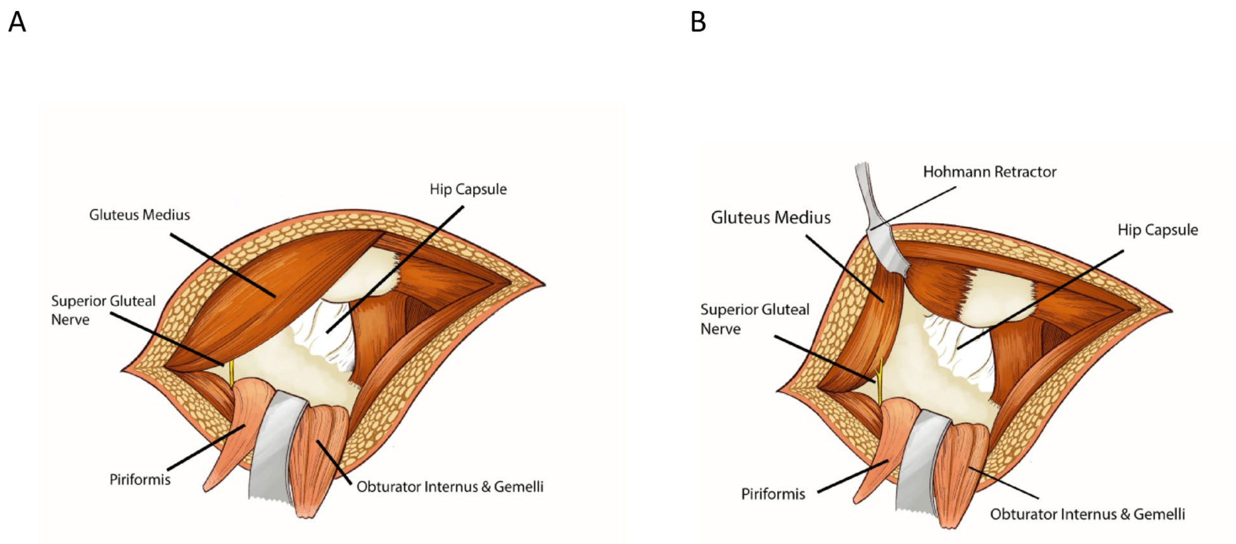

Fig. 1 **A** Illustration of Superior Gluteal Nerve without Hohmann retractor present; **B** Placement of Hohmann retractor anteriorly resulting in stretch of SGN

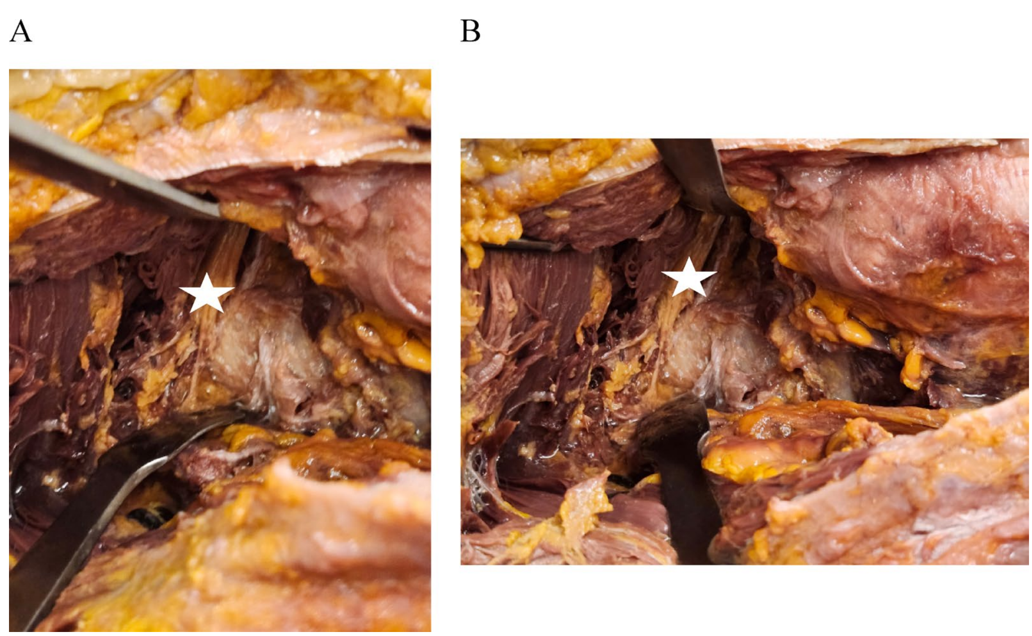

Fig. 2 **A** Visualization of SGN with retractor 30 degrees from horizontal and Fig. 1 **B**: Visualization of SGN with retractor 60 degrees from horizontal

with a goniometer, and nerve length was again recorded for each retractor position. The most distal aspect of the nerve was marked to demonstrate that the nerve was elongated over a short distance (Fig. 4). Each measurement was then repeated by a second independent surgeon. The operative leg was then abducted 15 degrees using an extremity bump, and all measurements were repeated.

Statistical analysis

Absolute and relative changes in nerve length were calculated. A resting nerve length with no retractor present was used as the control for each sample. Descriptive statistics are presented. A significant stretch of the SGN is defined as a 20% change in the original length or more based on previous work by Rickett et al. (14). The intraclass correlation coefficient (ICC) with a 95% confidence interval (95% CI) was calculated for reliability analysis. All analyses were performed via SAS version 9.4 for Windows (SAS Institute Inc., Cary, NC, USA).).

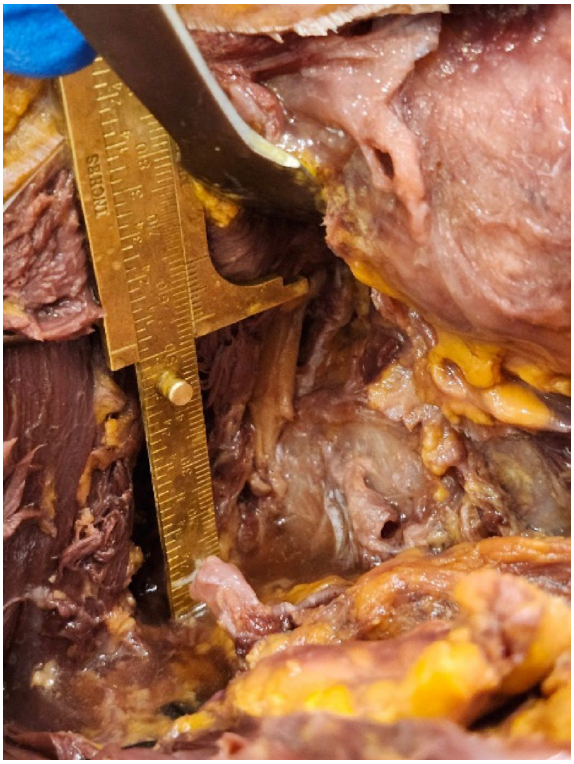

Fig. 3 Demonstration of caliper measurement of SGN from greater sciatic notch to muscular insertion into gluteus medius

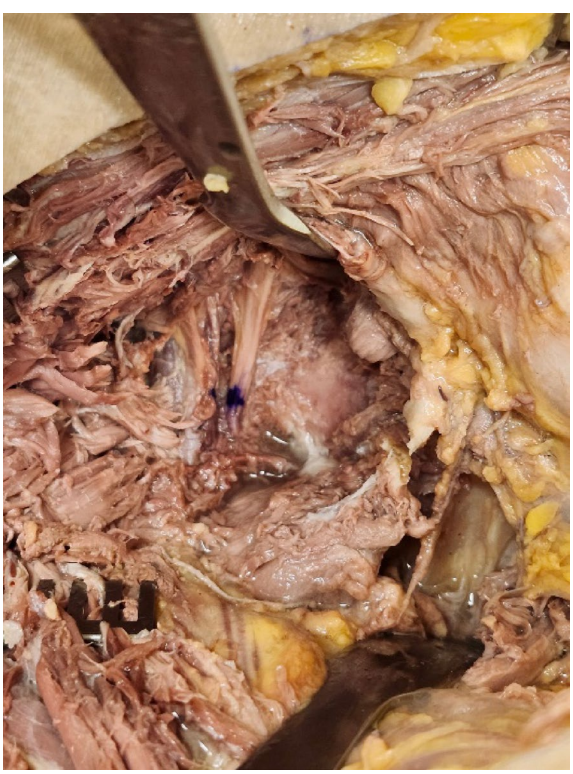

Fig. 4 The caudal portion of the SGN was marked prior to retractor placement. The limited translation of the mark indicates the nerve is elongated over a short distance

Table 1 Absolute and relative change of nerve length with the leg in neutral vs. abducted position

Mean resting length of nerve	Leg neutral (SD)	Leg abducted (SD)
	29.3 mm (7.4)	**31.9 mm (6.7)**
Mean length of nerve with retractor at 30 degrees	36.6 mm (6.3)	38.4 mm (5.4)
Mean length of nerve with retractor at 60 degrees	44.7 mm (6.8)	47.2 mm (7.4)
% change in length 0–30	28.0% (15.8)	22.3% (11.7)
% change in length 0–60	56.9% (21.1)	49.8% (12.1)

Results

With the leg in the neutral position, the absolute resting mean length of the SGN was 29.3 mm (+/- 7.4 mm). With the retractor 30 and 60 degrees from the horizontal direction, the mean lengths of the SGN were 36.6 mm and 44.7 mm, respectively. The mean relative changes in nerve length with retractor placement were 28.0% and 56.9% at 30 and 60 degrees, respectively.

Hip abduction reduced the relative change in nerve length by 5.7% from 0 to 30 degrees and 7.1% from 0 to 60 degrees (Table 1).

Significant stretch was defined as a relative change in nerve length greater than 20%. The change in nerve length with the retractor at 30 degrees was significant in all four samples. All ten nerves stretched greater than 20% with the retractor at 60 degrees. Hip abduction did not significantly affect the outcome.

The intraclass correlation coefficient (ICC) was excellent between the two observers (0.92 [0.87–0.95]).

Discussion

We demonstrate significant stretching to the superior gluteal nerve with routine placement of acetabular retractors during the Kocher–Langenbeck approach in acetabular fracture surgery. The nerve elongates by greater than 50% over a short segment rather than translating through the greater sciatic notch.

The clinical implications of acute stretching to the SGN have not yet been established but could manifest as prolonged hip abductor weakness and measurable changes in gait and kinematic analyses (16). The diagnosis of SGN injury is a clinical challenge. Some hip abductor weakness and limp may be expected findings in the short-term follow-up of patients treated with acetabular fractures, as the postoperative course often involves a period of limited weight bearing for up to three months. The resulting abductor muscle disuse atrophy may mask an underlying nerve lesion. Furthermore, the superior gluteal nerve has no terminal sensory innervation. The absence of distal sensory disturbance may also mask nerve injury.

The treatment of fractures involving the posterior column or wall typically requires exposure via a posterior approach. The Kocher–Langenbeck approach is the workhorse approach for accessing the posterior acetabulum. Unlike many other surgical approaches in orthopedics, this approach does not exploit an intermuscular, internervous plane. Rather, the hip abductors are retracted en block away from the origin of the innervating superior gluteal nerve. Hip abductor weakness has been reported more commonly in the management of transverse-pattern acetabular fractures than in the management of isolated posterior wall fractures; this finding is likely related to the degree of soft tissue retraction required to visualize and plate more cranial injury patterns.

While cadaveric studies remain an important element of anatomic research, we recognize that embalmed cadaveric tissue does not have the same elasticity as live tissue, specifically as it relates to neural kinematics. However, tissue stiffness and loss of elasticity likely results in an underestimation of nerve stretch with increased retraction, as the resting tissue length is more affected than it is under tension.

Other surgical approaches have been described that may limit strain to the superior gluteal neurovascular bundle. Struder et al. reported on the Adelaide approach, which involves dissecting out the SGNB and working through windows on either side of the neurovascular structures (17). They reported symmetric abductor power to all 22 patients at one-year post-surgery. Other benefits of this approach include selective hemorrhage control related to superior gluteal artery injury and avoiding complications associated with nonselective large vessel angioembolization in the context of massive injury-related bleeding. Further surgical techniques, such as the Gibson approach plus or minus trochanteric osteotomy, may allow access to more cranial injury patterns while limiting nerve retraction.

Future directions will involve clinical nerve conduction testing to measure SGN function at multiple postoperative timepoints after the Kocher–Langenbeck approach.

Limitations.

The primary limitation of this study is the use of cadaveric specimens to measure changes in soft tissues. Although formalin-embalmed specimens are commonly used for anatomic studies, there is a nonreversible effect on tissue elasticity with multiple repeated measurements. Compared to fresh frozen cadavers, embalmed specimens may not preserve neural kinematics to the same degree. Furthermore, in vivo, there may be a larger component of nerve translation through the greater sciatic notch rather than isolated elongation over a short segment.

Conclusion

When Kocher–Langerbeck is used in the management of posterior acetabular fractures, the superior gluteal nerve is at risk of significant lengthening secondary to retractor placement. This could lead to superior gluteal nerve dysfunction and ultimately abductor weakness, affecting patient outcomes. Retractors should be placed cautiously, and intermittent relaxation is recommended when possible. Further studies on the clinical significance of these findings are needed to corroborate this concern.

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Author contributions

MN and NT were involved in data acquisition and wrote the manuscript. AL prepared the figures. MN, BS, AL, GW and SP were involved in study design and methodology. All authors reviewed the manuscript.

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Data availability

Original data has been attached as a separate file.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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