Original Article

Position of the sciatic nerve and effect of gluteus maximus release during hip arthroplasty

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ABSTRACT

Eight Thiel embalmed hips were dissected. The distance between the sciatic nerve and the femoral neck was measured before and after hip dislocation, and before and after release of the gluteus maximus tendon. There was a significant reduction in the mean distance between the neck of femur and the sciatic nerve in both the gluteus maximus tendon release and the unreleased groups at 60° and 90° of hip flexion, $p < 0.05$. The mean distance between the neck of femur and sciatic nerve was greater in the release group for all positions.

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1. Introduction

The aetiology of sciatic nerve injury after total hip arthroplasty is a poorly understood phenomenon, which is associated with considerable morbidity. During total hip arthroplasty the anatomy of the gluteal region becomes distorted, particularly following dislocation of the hip and positioning during femoral preparation and implant insertion. Our previous study showed that during the posterior approach to the hip, following hip dislocation and femoral neck osteotomy, the sciatic nerve moves significantly closer to the femoral neck with progressively increasing hip flexion.¹ The use of formalin-embalmed cadavers, with stiffness requiring gluteus maximus tendon release to facilitate hip dislocation, may have had an uncertain impact on these results. It is not known whether the relationship demonstrated between the femoral neck and the sciatic nerve predisposes to an increased risk of nerve injury. This relationship may be significant given that the cause of the sciatic nerve palsy after THA in approximately one half of patients is unknown.²

To supplement our previous study, the aim of current study is to determine the effect gluteus maximus tendon release on the position of the sciatic nerve during the posterior approach to the hip. This study also differs from our previous study in that it utilises cadavers that are embalmed using Thiel's method which have tissue-handling characteristics similar to living subjects.³

2. Material and Methods

We obtained four cadavers, which had been embalmed using Thiel's method, giving a total of eight hips, of which six were male and two were female.

None of the specimens had prior leg, hip or spine pathology. They were placed in the lateral position and a classical posterior approach was performed with a curved incision over the posterior aspect of the greater trochanter. The fascia lata and gluteus maximus muscle were incised in line with the skin incision. A Charnley self-retaining retractor was used to retract the fascia lata and gluteus maximus muscle. The sciatic nerve was identified from the lower border of the piriformis to the upper border of the gluteus maximus tendon. The fat surrounding the nerve was removed to enable visualisation, but the nerve itself was not mobilised and the surrounding loose connective tissue and local anatomy were otherwise undisturbed. Two independent observers (AK, PL) conducted serial measurements using digital calipers, with measurements made to the nearest millimetre (Figs. 1–3). The mean values of these measurements were recorded for statistical analysis. The anatomy and each measurement was recorded with still digital photography. The short external rotators of the hip and posterior capsule were detached from the proximal femur. Measurements at each position were taken from the closest identifiable margin of the nerve to the closest identifiable edge of the medial femoral cortex, one centimeter proximal to the lesser trochanter. The measurements which were made before the hip was dislocated were performed with the hip in 0° of flexion (0° F), 0° of abduction (0° Ab) and neutral rotation. The hip was dislocated

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Fig. 1. a) Photograph and b) diagram of the left posterior gluteal region demonstrating how measurements between the femoral neck and sciatic nerve were taken in one representative specimen. The fat around the sciatic nerve has been removed. The hip is dislocated posteriorly and positioned at 90° internal rotation and 0° flexion. The gluteus maximus tendon is intact. The sciatic nerve was measured to be 34.9 mm from the femoral neck.

and the limb was maintained at 0° Ab and 90° of internal rotation (90° IR) from this point onwards. Further measurements were taken with the hip in 0° F (Fig. 1), then flexed to 30°, 60° and 90° (30° F, 60° F and 90° F, respectively) (Fig. 2). The femoral neck was osteotomized one centimeter proximal to the lesser trochanter at an angle of 45° to the femoral shaft. The osteotomy was performed with 90° IR and 60° F because the femoral head came into contact with the nerve and obscured its position at this stage. The knee was maintained flexed in 90° F following dislocation. The gluteus maximus tendon released one centimeter from its insertion point at the gluteal tuberosity, and repeat measurements were taken at 0° F, 30° F, 60° F and 90° F (Fig. 3).

Statistical analysis was performed using SPSS version 23.0 software (IBM-SPSS, Armonk, New York). Student's *t*-test for independent and paired samples was used for statistical calculations with a *p*-value <0.05 considered significant. All data are summarised as means with standard deviations (SD).

3. Results

The mean distance between the femoral neck and the sciatic nerve at the pre-dislocation starting position was 31.0 ± 5.4 mm. After dislocation, the distance between the neck of femur and the sciatic nerve distance was a mean of 32.5 ± 3.8 mm, 25.6 ± 3.9 mm, 17.4 ± 5.5 mm, and 8.8 ± 3.8 mm, with 0° F, 30° F, 60° F and 90° F respectively, whilst maintaining 90° IR (Table 1, Figs. 1 and 2). The closest distance between the sciatic nerve and the femoral neck was 3 mm at 90° IR and 90° F before gluteus maximus release (Graph 1).

After the release of gluteus maximus was performed, the mean distance between the femoral neck and the sciatic nerve was 34.8 ± 6.5 mm, 27.5 ± 8.0 mm, 21.0 ± 6.5 mm, and 13.2 ± 6 mm at 0° F, 30° F, 60° F and 90° F respectively, while maintaining 90° IR (Fig. 3). The closest distance between the sciatic nerve and the femoral neck was 8 mm at 90° IR and 90° F after gluteus maximus release (Graph 1).

Fig. 2. a) Photograph and b) diagram of the left posterior gluteal region (the same specimen as Fig 1). The hip is dislocated posteriorly, and positioned in 90° of flexion and 90° of internal rotation. The gluteus maximus tendon is intact. The distance between the nerve and the femoral neck was 4.28 mm.

When compared with the pre-dislocation starting position, there was a significant difference in the distance between the neck of femur and the sciatic nerve in both the gluteus maximus tendon release and the unreleased groups at 60° F and 90° F, $p < 0.05$. This corresponded to a mean decrease in distance between the sciatic nerve and the femoral neck of 13.6 ± 8.5 mm and 22.3 ± 7.0 mm at 60° F and 90° F before release, and 10 ± 6.2 mm and 17.8 ± 6.1 mm at 60° F and 90° F after release.

When the gluteus maximus tendon release group was compared to the unreleased group directly, there was a mean greater distance maintained between the neck of femur and the sciatic nerve in the gluteus maximus tendon release group for all positions, which was statistically significant at 90° F with a mean increase of 4.5 ± 4.3 mm, $p = 0.021$ (Graph 1).

There was no significant difference between the measurements obtained for the right and left hips and the male and female hips for all parameters (Table 1).

4. Discussion

The aetiology of sciatic nerve palsy after THA is not well understood or described, and its cause is likely to be multifactorial.⁴ In the setting of primary THA, the incidence of sciatic nerve palsy is between 0.28% to 3.0%, and in revision THA the incidence is between 2.6% to 7.6%.² Approximately one-half of patients who demonstrate sciatic nerve palsy after THA have no clear etiology.⁵ Risk factors for sciatic nerve palsy during THA include a pre-operative diagnosis of developmental dysplasia of the hip, the

Fig. 3. a) Photograph and b) diagram of the left posterior gluteal region (the same specimen as Fig 1). The hip is dislocated posteriorly, and positioned in 90° of flexion and 90° of internal rotation. The gluteus maximus tendon has been released. The piriformis tendon has been placed anteriorly. The distance between the nerve and the femoral neck was 10.68 mm.

Table 1

Comparison of sciatic nerve to femoral neck distances for male and female and left and right specimens (n = 8).

Hip position	Mean distance between the neck of the femur and the sciatic nerve (mm)						
	Right	Left	P value	Male	Female	P value	Total
Pre-dislocation	33.8 ± 2.1	28.3 ± 6.8	0.203	32.2 ± 5.5	27.5 ± 4.9	0.334	31.0 ± 5.4
0° of flexion	32.8 ± 5.5	32.3 ± 1.7	0.868	33.7 ± 3.6	29.0 ± 1.4	0.139	32.5 ± 3.8
30° of flexion	24.8 ± 5.6	26.5 ± 1	0.581	26.2 ± 4.2	24.0 ± 2.8	0.533	25.6 ± 3.9
60° of flexion	18.8 ± 6.7	16 ± 4.7	0.524	17.8 ± 6.2	16.0 ± 4.2	0.717	17.4 ± 5.5
90° of flexion	10.5 ± 3.7	7.0 ± 3.5	0.216	9.2 ± 4.3	7.5 ± 2.1	0.630	8.8 ± 3.8
0° of flexion, gluteus maximus released	36.3 ± 8.4	33.3 ± 4.9	0.558	37.8 ± 3.7	25.5 ± 2.1	0.005	34.8 ± 6.5
30° of flexion, gluteus maximus released	30.0 ± 9.6	25.0 ± 6.4	0.418	30.3 ± 6.9	19.0 ± 4.2	0.077	27.5 ± 8.0
60° of flexion, gluteus maximus released	25.0 ± 6.4	17.0 ± 4.1	0.079	23.2 ± 6.0	14.5 ± 2.1	0.106	21.0 ± 6.5
90° of flexion, gluteus maximus released	16.5 ± 7.3	10.0 ± 1.6	0.173	15.0 ± 6.0	8.0 ± 0.0	0.169	13.2 ± 6

Data are presented as means ± SDs.

Graph 1. The distance difference between the femoral neck and the sciatic nerve in gluteus maximus tendon unreleased and released groups with progressive hip flexion.

performance of revision THA, female sex, post-traumatic arthritis, the use of the posterior approach and cementless femoral fixation.⁶ In our previous study we demonstrated that the sciatic nerve becomes closer to the femoral neck with internal rotation and progressive hip flexion as performed during hip arthroplasty using the posterior approach.¹ It is not unknown whether the described hip flexion intra-operatively predisposes to an increased risk of nerve injury, however we believe that this positioning may be part of the cause for patients with sciatic nerve palsy after THA with no clear etiology.² Our previous study had several weaknesses, including the use of formalin-embalmed specimens and the need for gluteus maximus release to facilitate dislocation due to increased stiffness of the cadaveric joints.¹

We have repeated our findings in this study using Thiel embalming which has tissue properties closer to live patients than specimens embalmed in formalin. Thiel embalming results in soft and flexible cadavers with almost natural colours³ (Figs. 1–3). Thiel-embalmed cadavers have been shown to have joint flexibility comparable to fresh tissue.⁷ This allowed us to dislocate the hips in the current study with similar ease to hips in vivo, without any soft tissue releases. This in turn allowed us to examine to effect of gluteus maximus release on the position of the sciatic nerve during the posterior approach to THA.

Gay et al.⁸ measured the pressure on the sciatic nerve in cadavers during a posterior approach for total hip resurfacing before and after the gluteus maximus release.⁸ The sciatic nerve can potentially be caught between the intact gluteus maximus tendon and ischial tuberosity during the hip flexion and internal rotation that occurs during total hip resurfacing or THA. Gay et al. found that during acetabular exposure the pressure placed on the sciatic nerve increased above the critical value of 400 mmHg thought to cause endoneurial oedema. Release of the gluteal sling resulted in reduced pressure below the critical value. During femoral preparation, release of the gluteal sling also reduced pressure on the nerve, however the difference was not significant, and pressures did not exceed the critical value. Our results demonstrate that there is a statistically significant increase in the distance between the femoral neck and the sciatic nerve after

gluteus maximus release with 90° of hip flexion. This change in distance may reflect a reduction in mechanical pressure on the nerve, which is consistent with the findings of Gay et al.

Hurd et al. described the clinical and MRI relationships between the gluteus maximus tendon and the sciatic nerve.⁹ They presented two sciatic nerve palsies after primary THA with MRI confirmation of damage to the sciatic nerve at a point adjacent to the ischial tuberosity. They hypothesized that the sciatic nerve is compressed between the gluteus maximus tendon and the ischial tuberosity during femoral preparation, and that release of the gluteus maximus tendon would prevent this compression. There were no cases of sciatic nerve palsy demonstrated in a study group of 752 patients undergoing primary THA with routine release of the gluteus maximus tendon, compared to three patients with sciatic nerve palsy out of 804 patients who underwent THA with the gluteus maximus tendon left intact. In gluteus maximus tendon release group, the tendon was fully released and then repaired at the end of the procedure with the hip reduced. Repair of the tendon was considered to not worsen risk of sciatic nerve injury because the risk of injury was believed to occur intra-operatively during extreme limb positioning. For this reason the authors did not recommended a second operation to release the tendon if sciatic nerve palsy occurred without release during the primary operation. Hurd et al. suggest the occurrence of a compressive injury to the sciatic nerve between the gluteal sling and ischial tuberosity, whilst our study demonstrates movement of the sciatic nerve closer to the femoral neck. This may in turn increase the risk of direct injury to the sciatic nerve around the femoral neck or the ischial tuberosity. To maintain standardization, the entire gluteus maximus tendon was released in all specimens in our study. We acknowledge that partial releases are all that is necessary in operative cases. Therefore, our results can only be applied to cases where the entire tendon has been release.

Our study shows that there is a statistically significant increase in the distance between the sciatic nerve and femoral neck in the gluteus maximus tendon release group at 90° F (Table 3). As in our previous study, for all specimens the sciatic nerve became progressively closer to the femoral neck with increasing hip

flexion.¹ We believe that our relatively small sample size contributed to some values not reaching statistical significance, however we are constrained by the finite resources of our teaching institution. We have demonstrated the relationship between the sciatic nerve and the femoral neck with hip flexion and gluteal tendon release in cadaveric specimens, however our results will require further testing in the clinical environment to clarify the risk and benefit of gluteal tendon release as a protective measure against sciatic nerve injury.

5. Conclusions

We recommend that if there is any concern regarding risk to the sciatic nerve during the posterior approach to THA, such as in developmental dysplasia of the hip or revision THA, the gluteus maximus tendon should be released before dislocation and flexion of the osteotomized femur. This will increase the distance between the sciatic nerve and the femoral neck, particularly at 90° F. We maintain that the femoral neck be osteotomised and femoral neck retractors be placed under the femoral neck with the hip positioned in <0° F, as described in our previous study, to avoid direct damage to the sciatic nerve by crushing or laceration.

Conflict of interest

The authors have none to declare.

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References

1. Kanawati AJ, Narulla RS, Lorentzos P, Facchetti G, Smith A, Stewart F. The change in position of the sciatic nerve during the posterior approach to the hip. *The bone & joint journal*. 2015;97-B:1056–1062.
2. Park JH, Hozack B, Kim P, et al. Common peroneal nerve palsy following total hip arthroplasty: prognostic factors for recovery. *The Journal of bone and joint surgery American*. 2013;95:e551–5.
3. Brenner E. Human body preservation—old and new techniques. *Journal of anatomy*. 2014;224:316–344.
4. Schmalzried TP, Noordin S, Amstutz HC. Update on nerve palsy associated with total hip replacement. *Clinical orthopaedics and related research*. 1997;188–206.
5. Johanson NA, Pellicci PM, Tsairis P, Salvati EA. Nerve injury in total hip arthroplasty. *Clinical orthopaedics and related research*. 1983;214–222.
6. Farrell CM, Springer BD, Haidukewych GJ, Morrey BF. Motor nerve palsy following primary total hip arthroplasty. *The Journal of bone and joint surgery American*. 2005;87:2619–2625.
7. Jaung R, Cook P, Blyth P. A comparison of embalming fluids for use in surgical workshops. *Clinical anatomy*. 2011;24:155–161.
8. Gay DP, Desser DR, Parks BG, Boucher HR. Sciatic nerve injury in total hip resurfacing: a biomechanical analysis. *The Journal of arthroplasty*. 2010;25:1295–1300.
9. Hurd JL, Potter HG, Dua V, Ranawat CS. Sciatic nerve palsy after primary total hip arthroplasty: a new perspective. *The Journal of arthroplasty*. 2006;21:796–802.