Distal peroneal nerve decompression after sciatic nerve injury secondary to total hip arthroplasty

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OBJECTIVE The sciatic nerve, particularly its peroneal division, is at risk for injury during total hip arthroplasty (THA), especially when a posterior approach is used. The majority of the morbidity results from the loss of peroneal nerve–innervated muscle function. Approximately one-third of patients recover spontaneously. The objectives of this study were to report the outcomes of distal decompression of the peroneal nerve at the fibular tunnel following sciatic nerve injury secondary to THA and to attempt to identify predictors of a positive surgical outcome.

METHODS A retrospective study of all patients who underwent peroneal decompression for the indication of sciatic nerve injury following THA at the Mayo Clinic or Washington University School of Medicine in St. Louis was performed. Patients with less than 6 months of postoperative follow-up were excluded. The primary outcome was dorsiflexion strength at latest follow-up. Univariate and multivariate logistic regression analyses were performed to assess the ability of the independent variables to predict a good surgical outcome.

RESULTS The total included cohort consisted of 37 patients. The median preoperative dorsiflexion grade at the time of peroneal decompression was 0. Dorsiflexion at latest follow-up was Medical Research Council (MRC) ≥ 4 for 15 (41%) patients. In multivariate logistic regression analysis, motor unit potentials in the tibialis anterior (OR 19.84, 95% CI 2.44–364.05; p = 0.004) and in the peroneus longus (OR 8.68, 95% CI 1.05–135.53; p = 0.04) on preoperative electromyography were significant predictors of a good surgical outcome.

CONCLUSIONS After performing peroneal nerve decompression at the fibular tunnel, 65% of the patients in this study recovered dorsiflexion strength of MRC ≥ 3 at latest follow-up, potentially representing a significant improvement over the natural history.

https://thejns.org/doi/abs/10.3171/2017.8.JNS171260

KEY WORDS sciatic nerve; peroneal nerve; total hip arthroplasty; nerve injury; fibular tunnel; peripheral nerve
with the tibial division, is more susceptible to stretch injury and less likely to recover. This is thought to be due to the shorter distance between relative points of fixation—the piriformis muscle proximally and fibular tunnel distally for the peroneal division, versus the piriformis muscle proximally and the tarsal tunnel distally for the tibial division.\textsuperscript{4,8} In addition to peroneal-predominant sciatic nerve palsy being more common than the tibial-predominant type, peroneal-related symptoms and deficits account for the majority of the morbidity associated with sciatic nerve injuries after THA. For these reasons, recovery of peroneal nerve function is the focus.

For those patients who do not spontaneously recover, some centers have performed sciatic neurolysis for both treatment of neuropathic pain and in an effort to foster motor recovery. The results are limited to small series but in general have shown benefit in comparison with conservative management.\textsuperscript{3,9,14} An alternative or potentially complementary strategy is to consider decompression of the peroneal nerve at the fibular tunnel. The fibular tunnel is a known area of nerve entrapment and may represent a barrier to continued nerve regeneration, and it may also be a site of conduction block.\textsuperscript{10} The objective of this study was to report the outcomes of decompression of the peroneal nerve at the fibular tunnel following sciatic nerve injury secondary to THA and to attempt to identify predictors of a positive surgical outcome.

Methods

Study Design and Patient Selection

This retrospective study was approved by the Mayo Clinic’s institutional review board. The medical records from the Mayo Clinic and Washington University School of Medicine in St. Louis were queried to identify all patients who underwent peroneal nerve decompression at the fibular tunnel between January 1, 2004, and July 1, 2016, for the Mayo Clinic and between January 1, 2008, and July 1, 2015, for Washington University School of Medicine in St. Louis. The medical records were then reviewed to identify the cohort of patients who underwent peroneal nerve decompression for the indication of sciatic nerve injury following THA. Patients with less than 6 months of postoperative follow-up were excluded.

Variables of Interest

For the patient cohort, the following data were abstracted from the medical record: sex, age at THA, date of THA, date of peroneal nerve decompression, body mass index (BMI), height, and date of each pre- and postoperative examination. Results of the neurological examination at each pre- and postoperative examination—including dorsiflexion, plantar flexion, eversion, and inversion motor grading and the presence of Tinel’s sign anywhere along the course of the sciatic nerve or peroneal nerve and its branches—were collected, along with results of each preoperative electromyogram (EMG), including motor unit potentials (MUPs) in the short head of the biceps (SHB), tibialis anterior (TA), and peroneus longus (PL).

Operational Definitions

Motor grading was performed according to the Medical Research Council (MRC) grading scale. If there were any detectable MUPs, regardless of how minimal or abnormal, they were considered to be present. MUPs for the TA, SHB, and PL were treated as dichotomous variables: present or absent.

Primary Outcome

The primary outcome was dorsiflexion strength at latest follow-up. For the main analyses, dorsiflexion strength was treated as a dichotomous outcome: MRC ≥ 3 versus MRC < 3.

Statistical Analysis

Commercially available software (JMP version 10.0) was used to perform all statistical analyses. Univariate and multivariate logistic regression analyses were performed to assess the ability of the independent variables to predict a good surgical outcome, defined as dorsiflexion MRC ≥ 3. We planned a priori to include all variables with p values < 0.20 in the univariate analysis in subsequent multivariate analyses. Statistical significance was considered to be p < 0.05.

Results

Total Patient Cohort

A total of 53 patients underwent peroneal nerve decompression at the fibular tunnel for sciatic nerve injury following THA during the study period. Due to insufficient follow-up, 16 were excluded, leaving 37 patients in the analyzed cohort. Table 1 summarizes the cohort. The average age was 61 years. The median time from THA and sciatic nerve injury to peroneal nerve decompression was slightly more than 1 year (397 days). The average patient

<table>
<thead>
<tr>
<th>Variable Value</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Total cohort</td>
<td>37</td>
</tr>
<tr>
<td>Average age at THA, in yrs (SD)</td>
<td>61 (13)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16 (43%)</td>
</tr>
<tr>
<td>Female</td>
<td>21 (57%)</td>
</tr>
<tr>
<td>Average height in cm (SD)</td>
<td>169 (11)</td>
</tr>
<tr>
<td>Average BMI in kg/m² (SD)</td>
<td>30 (6)</td>
</tr>
<tr>
<td>Median time from THA to peroneal decompression, in days (range)</td>
<td>397 (30–980)</td>
</tr>
<tr>
<td>Preop findings</td>
<td></td>
</tr>
<tr>
<td>Tinel’s sign at fibular neck</td>
<td>27 (73%)</td>
</tr>
<tr>
<td>SHB MUPs</td>
<td>29 (76%)</td>
</tr>
<tr>
<td>TA MUPs</td>
<td>14 (38%)</td>
</tr>
<tr>
<td>PL MUPs</td>
<td>13 (35%)</td>
</tr>
<tr>
<td>Median preop dorsiflexion grade (range)</td>
<td>0 (0–3)</td>
</tr>
<tr>
<td>Median postop follow-up from peroneal decompression, in days (range)</td>
<td>438 (201–2452)</td>
</tr>
</tbody>
</table>

| Table 1. Summary of the included cohort |
was obese (BMI 30 kg/m²). Preoperatively, the majority of patients had Tinel’s sign at the fibular neck (73%) and MUPs in the SHB on the EMG (78%), whereas a minority had MUPs in the TA (38%) and PL (35%). The median preoperative dorsiflexion grade at the time of peroneal decompression was 0. Postoperative follow-up from the peroneal decompression ranged from 201 to 2452 days, with the median being 438 days.

### Dorsiflexion Outcome

Dorsiflexion at latest follow-up was MRC ≥ 3 for 24 (65%) patients. Dorsiflexion recovered to MRC ≥ 4–5 for 15 (41%) patients. The median dorsiflexion grade at latest follow-up was 3 (range 0–5).

Among the subgroup with at least 12 months of follow-up after the peroneal decompression (n = 28), dorsiflexion at latest follow-up was MRC ≥ 3 for 19 (68%) patients. Dorsiflexion recovered to MRC ≥ 4–5 for 11 (39%) patients. The median dorsiflexion grade at latest follow-up was 3 (range 0–5).

### Predictors of Good Surgical Outcome

In univariate logistic regression (Table 2), the presence of TA MUPs on the preoperative EMG was predictive of dorsiflexion recovery to MRC ≥ 3 (OR 5.45, 95% CI 1.12–40.89; p = 0.03), as was the presence of PL MUPs (OR 5.00, 95% CI 1.03–30.14; p = 0.04). Follow-up duration also had a p value < 0.20, so it was included in the multivariate analysis. In the multivariate analysis, both TA (OR 19.84, 95% CI 2.44–364.05; p = 0.004) and PL (OR 8.68, 95% CI 1.05–135.53; p = 0.04) MUPs on the preoperative EMG remained significant predictors, whereas follow-up duration remained nonsignificant.

### Postoperative Complications

No patient had worsening of neurological function postoperatively. One (3%) patient developed postoperative superficial cellulitis requiring oral antibiotic therapy.

### Discussion

Sciatic nerve injury complicates approximately 0.5% of all THAs, with revisions having a higher rate of nerve injury. The peroneal division is more sensitive to injury in these circumstances, resulting in weakness of dorsiflexion and eversion and often requiring the use of an ankle-foot orthosis. Chughtai and colleagues performed a systematic review and found that 33% of the patients in the reported literature who were managed conservatively demonstrated recovery. Individual studies included in the systematic review have reported as high as 50% recovery. In comparison, we found that 65% of patients regained dorsiflexion strength of MRC ≥ 3 with peroneal decompression at the fibular tunnel.

Although there is no direct comparison with a nonoperative group in our study, our data suggest that peroneal decompression at the fibular tunnel may improve recovery over the natural history, based on the historical data. The data may be even more impressive considering that we probably have a biased sample. Park et al. reported that the average time to full recovery is 1.5 years for complete lesions and 1 year for partial lesions. They also reported that obesity was the only identifiable negative prognostic factor. The average patient included in our study was obese and slightly more than 1 year out from their THA with sciatic nerve injury, and had not recovered any dorsiflexion. Thus, based on the historical data, our cohort is probably biased toward a population with a lower likelihood of spontaneous recovery. Despite that, our patients had a higher rate of dorsiflexion recovery than those receiving conservative management in the literature.

The concept of performing distal decompression of the peroneal nerve following sciatic nerve injury is based on several hypotheses. We explain that there is a known entrapment point of the peroneal nerve at the fibular tunnel and that the nerve takes a tortuous course around the fibular head from behind to in front of the knee over a short distance. We also suggest that paralysis due to nerve injury increases the likelihood of leg swelling, which in turn makes the entrapment point tighter. Disruption of axoplasmic flow as a result of the nerve injury may also enlarge the nerve, further exacerbating potential compression at known sites of entrapment. Thus, the nerve may be bigger and the tunnel tighter, creating both an impediment to continued nerve regeneration and a site of

### TABLE 2. Univariate and multivariate logistic regression analyses predicting dorsiflexion recovery (MRC ≥ 3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate OR (95% CI)</th>
<th>Univariate p Value</th>
<th>Multivariate OR (95% CI)</th>
<th>Multivariate p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.02 (0.97–1.09)</td>
<td>0.34</td>
<td></td>
<td></td>
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<tr>
<td>Female sex</td>
<td>1.94 (0.50–7.92)</td>
<td>0.34</td>
<td></td>
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<tr>
<td>Time from THA to peroneal</td>
<td>1.00 (1.00–1.00)</td>
<td>0.88</td>
<td></td>
<td></td>
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<tr>
<td>BMI</td>
<td>1.02 (0.91–1.15)</td>
<td>0.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>1.04 (0.97–1.11)</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up duration</td>
<td>1.00 (1.00–1.00)</td>
<td>0.18</td>
<td>1.00 (1.00–1.00)</td>
<td>0.11</td>
</tr>
<tr>
<td>Preop Tinel’s sign</td>
<td>1.37 (0.30–7.49)</td>
<td>0.69</td>
<td></td>
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</tr>
<tr>
<td>Preop SHB MUPs</td>
<td>0.45 (0.09–2.28)</td>
<td>0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preop TA MUPs</td>
<td>5.45 (1.12–40.89)</td>
<td>0.03</td>
<td>19.84 (2.44–364.05)</td>
<td>0.004</td>
</tr>
<tr>
<td>Preop PL MUPs</td>
<td>5.00 (1.03–30.14)</td>
<td>0.04</td>
<td>8.68 (1.05–135.53)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

The value shown for each variable is the nonreference value.
conduction block at the fibular tunnel. It was this concept on which Millesi based the idea of performing decompression of the peroneal nerve at the fibular tunnel following sciatic nerve repair.\textsuperscript{13} Besides compression, we discuss tension on a nerve as detrimental to function and recovery, and the fact that if preoperative range of motion is decreased because of hip pain, nerves may lose their ability to tolerate the range of motion needed during surgery to manipulate the leg to facilitate the total hip replacement. In the future, preoperative assessment of nerve glide may become part of the assessment. Decompression of the peroneal nerve at the fibular tunnel may then also improve nerve glide and lessen tension, promoting potential recovery.

Both of the senior authors (S.E.M. and R.J.S.) have used Tinel’s sign at the fibular tunnel as a potential positive prognostic factor for surgical decompression. Similarly, MUPs in the SHB may suggest that nerve regeneration has progressed to that point but is now stuck at the fibular tunnel. Although conceptually these ideas make sense, we did not find that either Tinel’s sign at the fibular neck or MUPs in the SHB were predictors of surgical outcome. However, because both senior authors use these factors as loose indications for surgery, the sample was biased. Among the cohort, 73\% had Tinel’s sign at the fibular neck and 78\% had MUPs in the SHB. If all comers had been included and these factors had not been used as an indication for surgery, making the cohort more evenly distributed between the presence and absence of these factors, we may have seen that they were in fact predictive. In fact, 20 of the 24 patients who recovered dorsiflexion strength of MRC ≥ 3 had MUPs in the SHB, suggesting its potential importance as a prognostic factor. Thus, while the current study does not support the value of Tinel’s sign at the fibular neck or MUPs in the SHB, this may be due to a biased sample, and we will continue to use these when determining whether operative management is appropriate. The scratch collapse test is also used by the Washington University group to diagnose common and superficial peroneal nerve compression, as well as proximal sciatic nerve injury in this patient population.\textsuperscript{2,6}

The significant positive predictors of surgical outcome were the presence of MUPs in the TA or PL on the preoperative EMG. If MUPs were present in the TA, the odds of recovering dorsiflexion strength of MRC ≥ 3 with peroneal decompression were nearly 20 times those if MUPs were absent. If MUPs were present in the PL, the odds of recovering dorsiflexion strength of MRC ≥ 3 with peroneal decompression were nearly 9 times those if MUPs were absent. Thus, the strongest predictor was the presence of MUPs in the TA. One could argue that the presence of MUPs in the TA or PL suggests that these patients may have gone on to recover spontaneously anyway. The historical data and lack of recovery more than 1 year from the injury (on average) suggest otherwise. We would encourage surgeons to consider these as positive indications for peroneal decompression, rather than signs of probable spontaneous recovery.

There are several weaknesses of the study. First, 16 patients, representing nearly one-third of the identified cohort, had insufficient follow-up to be included. This may bias the cohort in either direction. However, it seems more likely that this would bias the sample against surgery. Patients who are doing well and recovering are less likely in general to continue to seek medical care and to continue with long-term follow-up. Conversely, patients who are not recovering and are doing poorly are more likely to continue to seek medical care to explore additional options. For this reason, the data presented in this study may be even stronger if all patients had had adequate follow-up to be included. We cannot prove this, however, making this a weakness of the study. Second, this is a retrospective study, with all of the limitations and potential biases associated with a study of this nature. Third, there is no conservative management cohort to allow direct comparison. We are relying on historical data to compare with our pure surgical cohort. The conclusions of this study would be strengthened if there were a nonoperative group available for direct comparison. Finally, as mentioned previously, the surgical indications used by both senior authors introduce some biases into the cohort that make identifying prognostic factors difficult.

Conclusions
Sciatic nerve injury is a known complication of THA, with the majority of the morbidity being associated with the deficits of the peroneal nerve–innervated muscles. For those patients who do not spontaneously recover, the goal is to recover enough dorsiflexion to allow the patient to be free from an ankle-foot orthosis. By performing peroneal nerve decompression at the fibular tunnel, 65\% of the patients in this study recovered dorsiflexion strength of MRC ≥ 3 at latest follow-up, potentially representing a significant improvement over the natural history. We identified MUPs in the TA or PL on the preoperative EMG as positive predictors of a good surgical outcome. We encourage surgeons to consider MUPs in the TA or PL as potential indications for surgical decompression of the peroneal nerve, rather than signs of probable spontaneous recovery. We will continue to use MUPs in the TA, PL, and SHB, along with Tinel’s sign at the fibular neck and/or positive scratch collapse test as indications for peroneal nerve decompression in those patients who do not spontaneously recover.

References

Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: Spinner, Mackinnon. Acquisition of data: Wilson, Kleiber. Analysis and interpretation of data: all authors. Drafting the article: Spinner, Wilson, Mackinnon. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Spinner. Statistical analysis: Wilson. Study supervision: Spinner.

Supplemental Information
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