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Original Research

# Risk Factors for Perioperative Nerve Injury Related to Total Hip Arthroplasty

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ABSTRACT

*Background:* Nerve injury following total hip arthroplasty (THA) is a rare but serious adverse event. While prior studies have reported risk factors for nerve injury related to THA, they are limited to institutional data or small sample sizes. The current study aimed to leverage a large, national database to assess independent risk factors for sustaining nerve injury with THA.

*Methods:* The 2010-2021 PearlDiver M157 database was queried for adult THA cases. Those with nerve injury within 90 days of THA were identified. Patient age, sex, body mass index (BMI), Elixhauser comorbidity index (ECI), fracture indication, and surgery type (index vs revision) were assessed for correlation with nerve injury by multivariate analyses.

*Results:* Out of 750,695 THAs, 2659 (0.35%) had nerve injuries. Multivariate analysis revealed independent predictors of nerve injury in decreasing odds ratio (OR) order to include: revision procedure (OR: 2.13), female sex (OR 1.35), ECI (ECI 1-2 [OR 1.27], ECI 3-4 [OR 1.43], and ECI ≥5 [OR 1.59]) and age (OR 1.02 per decade decrease) ($P < .05$ for each). Pertinent negatives by multivariate analysis included underweight BMI (<20), and fracture indication. Individuals with morbidly obese BMI status (≥35) had a decreased risk of nerve injury (OR 0.84, $P = .019$).

*Conclusions:* THA-related nerve injury was found to be low at 0.35%. Factors independently associated with this adverse outcome were defined, of which the greatest risk was seen in revision procedures. These risk factors, derived from the largest cohort to date, may be helpful for risk stratification and patient counseling.



## Introduction

Total hip arthroplasty (THA) is a common and increasingly performed procedure [1,2] that is generally associated with low rates of adverse events and excellent clinical outcomes [3-7]. However, the potential for nerve injury cannot be overstated. This complication can have devastating consequences for patients and carry significant medico-legal implications [8,9]. Bokshan et al. found, in an analysis of 213 lawsuits related to total joint replacement, that nerve injury emerged as the most common complication following THA [10]. Additionally, in a national database study from the Netherlands of 516 claims related to primary THA, Zengerink et al. found that the top reason for litigation was nerve palsy [11]. Therefore, understanding the factors that may predispose patients to nerve injury following THA is critical.

In prior retrospective studies, the overall incidence of THA-related nerve injury has been reported to be low. Jacob et al. examined 12,998 THAs in a single-center retrospective cohort study and found the rate of postoperative nerve injury to be 0.72% [12]. Another retrospective cohort analysis by Shetty et al. studied 43,761 THAs and identified a postoperative nerve injury rate of 0.21% [13].

The risk of nerve injury varies depending on the surgical approach: the sciatic nerve is more commonly affected in the posterior approach [14], while the femoral nerve is at greater risk in the anterior approach [15,16]. While recovery from these injuries is variable [17-19], motor nerve palsies tend to be more severe with a

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greater impact on patient function time compared to sensory nerve palsies [8]. Additionally, posterior nerve palsies, such as those of the sciatic nerve and peroneal nerve, tend to have longer recovery than anterior femoral nerve palsies [8,17,18].

The direct anterior approach, which has gained popularity [18], poses an increased risk of injury to the lateral femoral cutaneous nerve compared to the posterior approach [19,20] However, femoral nerve palsy following direct anterior THA is rare [16,19]. Moreover, Gala et al. found that the majority of lateral femoral cutaneous nerve palsies following direct anterior approach THA tended to improve over time and did not lead to long-term functional limitations at 5-year follow-up [21].

Previous attempts to correlate THA-related injuries with clinical factors have shown that women and patients of younger age have higher odds of postoperative nerve injury, as demonstrated in a statewide retrospective analysis of 207,981 THAs by Christ et al [22]. Additionally, Shetty et al. found nerve injuries to be linked with revision procedures in a matched, retrospective single-institutional study of 43,761 THAs [13]. However, these studies are limited by their narrower geographic distribution and range of variables assessed for potential correlation.

The present study aimed to further define the incidence and risk factors associated with nerve injury following THA. A national administrative dataset was analyzed in order to produce a large sample to better examine these variables.

## Material and methods

### *Study population*

A retrospective investigation was conducted using data from the 2010-2021 M157 PearlDiver database (Colorado Springs, CO), which is a commercially available administrative United States database with a vast repository of over 157 million patient records. As data from this database is output in de-identified and aggregated form, our institutional review board found studies using this database exempt from review. Given its large volume of Health Insurance Portability and Accountability Act-compliant patient records, the PearlDiver database has been increasingly used for outcomes-based research in orthopaedics [23-28].

Patients who underwent THA were identified by Current Procedural Terminology-27130 (for primary cases) or Current Procedural Terminology-27134, 27137, and 27138 (for revision cases). Exclusion criteria were then applied, including age <18 years; surgical indications of neoplasm or infection; and a lack of minimum 90-day follow-up data. Age, sex, body mass index (BMI), Elixhauser comorbidity index (ECI, a commonly used comorbidity index) [29], and indication for fracture were abstracted from the dataset.

Patients who had a diagnosis of nerve injury within 90 days after THA were then identified by the International Classification of Diseases-9 and the International Classification of Diseases-10 codes (Supplementary Table 1). Based on preliminary analyses, the greatest category of nerve injury was identified based on unspecified codes. Given the inability to adequately separate different nerve injuries and to optimize statistical power, nerve injury codes were analyzed together.

### *Statistical analysis*

Variables related to patient demographics, comorbidities, indication, and surgery type were compared between those who experienced nerve injury within 90 days of THA and those that did not. Univariate analyses were performed using *Pearson's chi-squared test*. Multivariate logistic regression was then conducted to determine variables that may be independent predictors of sustaining nerve injury following THA. Odds ratios (ORs) and 95% confidence intervals for each variable of interest were tabulated.

All statistical tests were conducted using PearlDiver's internal software, with significance defined as $P < .05$. Figures were created using Microsoft Excel (Microsoft Corporation, Redmond, WA) and GraphPad Prism 9 (GraphPad Software, San Diego, CA).

## Results

A total of 750,695 patients who underwent THA were identified. In this cohort, 2659 (0.35%) nerve injuries following THA were identified. Univariate analysis revealed predictors of nerve injury to include age, sex, BMI status, and revision surgery. (Table 1).

Upon multivariate analyses, several independent predictors of nerve injury were identified (Figure 1). These included: younger age (per decade decrease OR 1.02, $P < .001$), female sex (OR 1.35, $P < .001$), increased ECI (relative to an ECI of zero, ECI of 1-2 [OR 1.27, $P = .003$], ECI of 3-4 [OR 1.43, $P < .001$], ECI >5 [OR 1.59, $P < .001$]), and revision procedure (OR 2.13, $P < .001$).

There were pertinent negatives for association with nerve injury by multivariate analysis. These included underweight BMI (<20) and fracture indication. Morbidly obese BMI (>30) was associated with decreased odds of nerve injury (OR 0.84, $P = .019$).

## Discussion

THA is among the most frequently conducted orthopaedic procedures in the United States [30], with projections suggesting that the annual number of surgeries will rise from 1.3 million in 2025 to 3.4 million by 2040 [31]. However, the potential for nerve injury exists, which can have severe consequences for patients. It is well established in the existing literature that nerve injury is among the top reasons for litigation following THA [9-11,32]. The current study is the largest study to date to assess incidence and independent risk factors for nerve injury following THA, drawing from 750,695 surgeries. From this population, 2659 (0.35%) nerve injuries were identified, which is in the reported range (0.22%-3.7%) from prior published literature [8,33-37].

Several independent risk factors were identified for nerve injury with THA. The greatest odds were identified for revision THA cases (OR 2.13). This aligns with existing literature, as revision surgeries often involve greater scarring and less predictable anatomy. Hasija et al. reported a nerve injury incidence of 7.6% after revision THA, significantly higher than the 0.6% to 3.7% incidence observed in primary arthroplasty [8]. In a retrospective review of 3126 THAs, Schmalzried et al. similarly found a higher prevalence of postoperative neuropathy in revision procedures compared to primary arthroplasties (3.2% vs 1.3%, $P < .01$) [37].

Younger age was also associated with nerve injury (OR 1.02 per decade decrease, $P < .001$). This may be because younger patients may have more complex hip pathologies, such as developmental hip dysplasia, which may require more extensive surgery or soft tissue releases, which can increase the risk of nerve injury. This association is supported by previous studies (12, 20). Women were at higher odds of sustaining a nerve injury after THA than men (OR 1.35). The reason for this is not clear, but it is consistent with findings from earlier studies [8,13,35]. Finally, greater comorbidity status was associated with greater odds of nerve injury in a graded fashion (ECI 1-2: OR 1.27; 3-4: OR 1.43; 5 or higher: OR 1.59). This matches prior literature, which has found that comorbidities such as diabetes, hypertension, and tobacco use were identified as risk factors for postoperative nerve injury [38].

Morbidly obese BMI (≥35) status was found to be associated with lower odds of postoperative nerve injury (OR 0.84), while

**Table 1**
Univariate and multivariate analysis of risk factors for nerve injury 90 days after THA.

| Variable | No nerve injury | % | Nerve injury | % | *P*-value | Multivariate odds ratio with 95% CI | *P*-value |
|---|---|---|---|---|---|---|---|
| Total | 7,48,036 | 99.65 | 2659 | 0.35 | | | **<.001** |
| Age (per decade decrease) | 64.83 (23 to 83) | | 63.39 (18 to 83) | | **<.001** | 1.02 (1.01, 1.02) | **<.001** |
| Sex | | | | | **<.001** | | **<.001** |
| Male | 3,27,023 | 43.72 | 977 | 36.74 | | REF | |
| Female | 4,21,013 | 56.28 | 1682 | 63.26 | | 1.35 (1.25, 1.47) | |
| BMI | | | | | **<.001** | | |
| <20 | 16,188 | 2.16 | 84 | 3.16 | | 0.90 (0.65, 1.22) | .528 |
| 20-34 | 51,725 | 6.91 | 243 | 9.14 | | REF | |
| 35+ (morbid obesity) | 1,74,075 | 23.27 | 723 | 27.19 | | 0.84 (0.72, 0.97) | **.019** |
| Comorbidities | | | | | .329 | | |
| ECI = 0 | 72,864 | 9.74 | 193 | 7.26 | | REF | |
| ECI 1-2 | 1,86,138 | 24.88 | 624 | 23.47 | | 1.27 (1.09, 1.50) | **.003** |
| ECI 3-4 | 1,62,123 | 21.67 | 620 | 23.32 | | 1.43 (1.22, 1.69) | **<.001** |
| ECI ≥ 5 | 56,420 | 7.54 | 243 | 9.14 | | 1.59 (1.32, 1.93) | **<.001** |
| Fracture indication | | | | | .078 | | .171 |
| No fracture | 7,30,911 | 97.71 | 2584 | 97.18 | | REF | |
| Fracture | 17,125 | 2.29 | 75 | 2.82 | | 1.18 (0.92, 1.47) | |
| Revision surgery | | | | | **<.001** | | **<.001** |
| Nonrevision case | 6,79,110 | 90.79 | 2182 | 82.06 | | REF | |
| Revision case | 68,926 | 9.21 | 477 | 17.94 | | 2.13 (1.93, 2.35) | |

Bold *P*-value = statistical significance at $P < .05$.
CI, confidence interval.

underweight BMI status was not found to be associated with nerve injury. Prior studies that examine this association are mixed. While some studies did not find an association between BMI range and risk of nerve injury after THA [8,13], another study of 6123 primary THA cases showed nerve palsy to occur more frequently in patients who have a lower BMI [36]. Additionally, the fracture indication for THA was not found to be associated with nerve injury. While this has not been previously assessed to our knowledge, it is reassuring that the injury itself or addressing the displaced anatomy did not seem to predispose to nerve injury.

The current study has limitations. As with other administrative database studies, it is reliant on the accuracy of administrative coding, and the specific details of patient pathology cannot be assessed. As a result, the degree (partial vs complete) and type (motor vs sensory) of nerve injury were not able to be differentiated, nor was the duration of the eventual recovery determined. Given that motor nerve palsy is a more serious concern after THA than sensory nerve palsy, which tends to have better recovery [39], the outcomes of this study should be interpreted with this in mind.

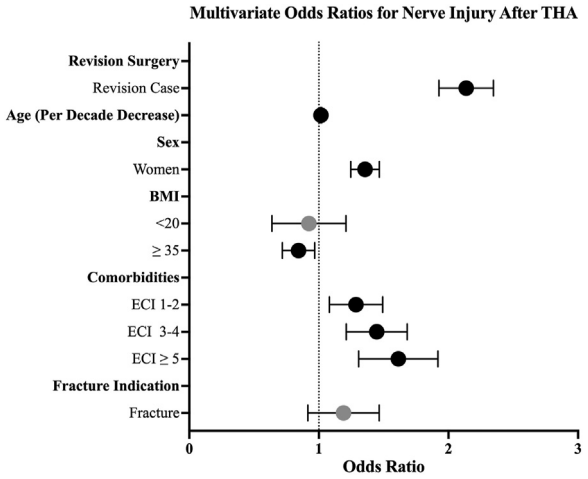


**Figure 1.** Forest plot of multivariate odds ratios for risk factors associated with nerve injury 90 days after total hip arthroplasty.

Additionally, the administrative data nature of this current study does not allow for differentiation based on surgical approach, a factor that may impact the risk of nerve injury [16,19,20]. Despite these limitations, the large patient cohorts analyzed in this current study have not been otherwise accessible in prior investigations, greatly increasing the statistical power of this current study.

## Conclusions

The current study of over 750,000 THAs is the largest study to date to examine independent risk factors for postoperative nerve injury within 90 days of surgery. The overall rate of nerve injury after THA was 0.35%. Risk factors for these injuries were identified, with revision surgery, female sex, and greater ECI score carrying the highest increase in odds of nerve damage. Understanding these risk factors is essential for risk stratification and patient counseling regarding THA.

## Uncited Figure

Figure 1.

## Conflicts of interest

J. N. Grauer is a board member and editor-in-chief of the North American Spine Society Journal. L. E. Rubin is a consultant for DePuy Synthes, Innovative Medical Products, and Thompson Surgical Instruments; receives royalties from SLACK, Inc., Johns Hopkins University Press, and Wolters Kluwer Publishers; and is an editorial board member of the Journal of Arthroplasty and Arthroplasty Today. M. J. Gouzoulis is an associate editor of the North American Spine Society Journal. All other authors declare no potential conflicts of interest.

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## CRediT authorship contribution statement

**Rahul H. Jayaram:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis,

Conceptualization. **Wesley Day:** Writing – review & editing, Writing – original draft, Investigation. **Michael J. Gouzoulis:** Writing – review & editing, Writing – original draft, Investigation. **Justin R. Zhu:** Writing – review & editing, Writing – original draft, Investigation. **Jonathan N. Grauer:** Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology, Investigation. **Lee E. Rubin:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization.

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**Supplementary Table 1**
International Classification of Diseases (ICD) Codes and Descriptions of Nerve Injuries.

| Affected nerve | ICD diagnosis code | Description |
|---|---|---|
| Sciatic nerve | ICD-9-D-3550 | Lesion of sciatic nerve |
| | ICD-9-D-9560 | Injury to sciatic nerve |
| | CD-10-D-G5700 | Lesion of sciatic nerve, unspecified lower limb |
| | ICD-10-D-G5701 | Lesion of sciatic nerve, right lower limb |
| | ICD-10-D-G5702 | Lesion of sciatic nerve, left lower limb |
| | ICD-10-D-G5703 | Lesion of sciatic nerve, bilateral lower limbs |
| | ICD-10-D-S7400XA | Injury of sciatic nerve at hip and thigh level, unspecified leg, initial encounter |
| | CD-10-D-S7400XD | Injury of sciatic nerve at hip and thigh level, unspecified leg, subsequent encounter |
| | ICD-10-D-S7400XS | Injury of sciatic nerve at hip and thigh level, unspecified leg, sequela |
| | ICD-10-D-S7401XA | Injury of sciatic nerve at hip and thigh level, right leg, initial encounter |
| | ICD-10-D-S7401XD | Injury of sciatic nerve at hip and thigh level, right leg, subsequent encounter |
| | CD-10-D-S7401XS | Injury of sciatic nerve at hip and thigh level, right leg, sequela |
| | ICD-10-D-S7402XA | Injury of sciatic nerve at hip and thigh level, left leg, initial encounter |
| | CD-10-D-S7402XD | Injury of sciatic nerve at hip and thigh level, left leg, subsequent encounter |
| | ICD-10-D-S7402XS | Injury of sciatic nerve at hip and thigh level, left leg, sequela |
| Femoral nerve | ICD-9-D-3552 | Other lesion of femoral nerve |
| | ICD-9-D-9561 | Injury to femoral nerve |
| | CD-10-D-G5720 | Lesion of femoral nerve, unspecified lower limb |
| | ICD-10-D-G5721 | Lesion of femoral nerve, right lower limb |
| | ICD-10-D-G5722 | Lesion of femoral nerve, left lower limb |
| | ICD-10-D-G5723 | Lesion of femoral nerve, bilateral lower limbs |
| | CD-10-D-S7410XA | Injury of femoral nerve at hip and thigh level, unspecified leg, initial encounter |
| | CD-10-D-S7410XD | Injury of femoral nerve at hip and thigh level, unspecified leg, subsequent encounter |
| | ICD-10-D-S7410XS | Injury of femoral nerve at hip and thigh level, unspecified leg, sequela |
| | ICD-10-D-S7411XA | Injury of femoral nerve at hip and thigh level, right leg, initial encounter |
| | CD-10-D-S7411XD | Injury of femoral nerve at hip and thigh level, right leg, subsequent encounter |
| | CD-10-D-S7411XS | Injury of femoral nerve at hip and thigh level, right leg, sequela |
| | ICD-10-D-S7412XA | Injury of femoral nerve at hip and thigh level, left leg, initial encounter |
| | ICD-10-D-S7412XD | Injury of femoral nerve at hip and thigh level, left leg, subsequent encounter |
| | ICD-10-D-S7412XS | Injury of femoral nerve at hip and thigh level, left leg, sequela |
| Cutaneous sensory nerve | ICD-9-D-9564 | Injury to cutaneous sensory nerve, lower limb |
| | ICD-10-D-S7420XA | Injury of cutaneous sensory nerve at hip and thigh level, unspecified leg, initial encounter |
| | ICD-10-D-S7420XD | Injury of cutaneous sensory nerve at hip and thigh level, unspecified leg, subsequent encounter |
| | ICD-10-D-S7420XS | Injury of cutaneous sensory nerve at hip and thigh level, unspecified leg, sequela |
| | ICD-10-D-S7421XA | Injury of cutaneous sensory nerve at hip and high level, right leg, initial encounter |
| | ICD-10-D-S7421XD | Injury of cutaneous sensory nerve at hip and high level, right leg, subsequent encounter |
| | CD-10-D-S7421XS | Injury of cutaneous sensory nerve at hip and high level, right leg, sequela |
| | ICD-10-D-S7422XA | Injury of cutaneous sensory nerve at hip and thigh level, left leg, initial encounter |
| | ICD-10-D-S7422XD | Injury of cutaneous sensory nerve at hip and thigh level, left leg, subsequent encounter |
| | ICD-10-D-S7422XS | Injury of cutaneous sensory nerve at hip and thigh level, left leg, sequela |
| Peroneal nerve | ICD-9-D-9563 | Injury to peroneal nerve |
| | ICD-10-D-S8410XA | Injury of peroneal nerve at lower leg level, unspecified leg, initial encounter |
| | CD-10-D-S8410XD | Injury of peroneal nerve at lower leg level, unspecified leg, subsequent encounter |
| | ICD-10-D-S8410XS | Injury of peroneal nerve at lower leg level, unspecified leg, sequela |
| | ICD-10-D-S8411XA | Injury of peroneal nerve at lower leg level, right leg, initial encounter |
| | ICD-10-D-S8411XD | Injury of peroneal nerve at lower leg level, right leg, subsequent encounter |
| | CD-10-D-S8411XS | Injury of peroneal nerve at lower leg level, right leg, sequela |
| | ICD-10-D-S8412XA | Injury of peroneal nerve at lower leg level, left leg, initial encounter |
| | ICD-10-D-S8412XD | Injury of peroneal nerve at lower leg level, left leg, subsequent encounter |
| | CD-10-D-S8412XS | Injury of peroneal nerve at lower leg level, left leg, sequela |
| Lateral popliteal nerve | ICD-9-D-3553 | Lesion of lateral popliteal nerve |
| | ICD-10-D-G5730 | Lesion of lateral popliteal nerve, unspecified lower limb |
| | CD-10-D-G5731 | Lesion of lateral popliteal nerve, right lower limb |
| | ICD-10-D-G5732 | Lesion of lateral popliteal nerve, left lower limb |
| Other/unspecified | ICD-9-D-7289 | Unspecified disorder of muscle, ligament, and fascia |
| | ICD-9-D-9565 | Injury to other specified nerve(s) of pelvic girdle and lower limb |
| | ICD-9-D-9568 | Injury to multiple nerves of pelvic girdle and lower limb |
| | ICD-9-D-9569 | Injury to unspecified nerve of pelvic girdle and lower limb |
| | ICD-9-D-99709 | Other nervous system complications |
| | ICD-10-D-S748X1A | Injury of other nerves at hip and thigh level, right leg, initial encounter |
| | ICD-10-D-S748X1D | Injury of other nerves at hip and thigh level, right leg, subsequent encounter |
| | ICD-10-D-S748X1S | Injury of other nerves at hip and thigh level, right leg, sequela |
| | ICD-10-D-S748X2A | Injury of other nerves at hip and thigh level, left leg, initial encounter |
| | ICD-10-D-S748X2D | Injury of other nerves at hip and thigh level, left leg, subsequent encounter |
| | ICD-10-D-S748X2S | Injury of other nerves at hip and thigh level, left leg, sequela |
| | ICD-10-D-S748X9A | Injury of other nerves at hip and thigh level, unspecified leg, initial encounter |
| | ICD-10-D-S748X9D | Injury of other nerves at hip and thigh level, unspecified leg, subsequent encounter |
| | ICD-10-D-S748X9S | Injury of other nerves at hip and thigh level, unspecified leg, sequela |
| | ICD-10-D-S7490XA | Injury of unspecified nerve at hip and thigh level, unspecified leg, initial encounter |
| | ICD-10-D-S7490XD | Injury of unspecified nerve at hip and thigh level, unspecified leg, subsequent encounter |
| | ICD-10-D-S7490XS | Injury of unspecified nerve at hip and thigh level, unspecified leg, sequela |
| | ICD-10-D-S7491XA | Injury of unspecified nerve at hip and thigh level, right leg, initial encounter |
| | ICD-10-D-S7491XD | Injury of unspecified nerve at hip and thigh level, right leg, subsequent encounter |

(*continued on next page*)

**Supplementary Table 1** (*continued*)

| Affected nerve | ICD diagnosis code | Description |
|---|---|---|
| | ICD-10-D-S7491XS | Injury of unspecified nerve at hip and thigh level, right leg, sequela |
| | ICD-10-D-S7492XA | Injury of unspecified nerve at hip and thigh level, left leg, initial encounter |
| | ICD-10-D-S7492XD | Injury of unspecified nerve at hip and thigh level, left leg, subsequent encounter |
| | ICD-10-D-S7492XS | Injury of unspecified nerve at hip and thigh level, left leg, sequela |