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# Knee dislocation with popliteal artery disruption: A nationwide analysis from 2005 to 2013

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ABSTRACT

*Objective:* Few have compared short-term outcomes following knee dislocations with or without concomitant popliteal artery disruption (PAD).
*Methods:* The Nationwide Inpatient Sample was used to identify 2175 patients admitted for knee dislocation from 2005 to 2013 (concomitant PAD: n = 210/9.7%; without: n = 1965/90.3%).
*Results:* Patients with PAD were younger, more often male, Black and Hispanic, and with Medicaid (all $p \leq 0.013$). PADs were associated with 11.0-times higher odds of increased LOS (95%CI, 6.6–18.4) and 2.8-times higher odds of experiencing any complication (95%CI, 2.03–3.92). Female sex was a protective factor against increased LOS, (OR = 0.65; 95%CI, 0.48–0.88).
*Conclusion:* High suspicion index should be maintained for concomitant vascular injuries following knee dislocations.

## 1. Introduction

Dislocation of the knee constitutes an orthopaedic emergency that is associated with concomitant soft-tissue and vascular injuries. Dislocation is most often secondary to high-energy “dashboard” injuries in motor vehicle accidents,[1–4] although low-energy falls and athletic injuries can lead to dislocation.[2–6] Upon presentation, patient evaluation includes immediate knee reduction, followed by lower extremity neurovascular examination and imaging studies to assess the reduction and evaluate vascular and soft-tissue integrity.[7–11] Most knee dislocations are managed operatively with external fixation, which has been found to have superior functional outcomes compared to conservative therapy.[12–14] Popliteal artery disruption occurs in an estimated 30% of knee dislocations following high-energy injuries,[4–7,15–27] and prompt diagnosis and treatment is critically important, as a delay in revascularization beyond 8 h[27–30] can potentially lead to limb ischemia, necrosis, and ultimately surgical amputation.[27,29]

Currently, the data is sparse on short-term outcomes of patients with knee dislocations and concomitant popliteal artery disruption. To address this knowledge gap, we used the Nationwide Inpatient Sample (NIS), a large, nationwide US inpatient database, to identify all knee dislocations in the United States between 2005 and 2013. Specifically, we compared the following metrics among knee dislocation patients with and without popliteal artery disruption: (1) patient factors (incidence and demographics); (2) perioperative factors (medical and surgical complications, length of stay [LOS], and hospital charges).

## 2. Materials and methods

### 2.1. Study population

The NIS contains a 20% representative sample of annual hospital admissions in the United States.[27] It contains demographic and clinical variables for each admission, including International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes. Additionally, a data-weighting variable, which is based on the size and location of the hospital where each admission occurred, allows statistical models to calculate nationwide estimates of

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patient discharges. The NIS is publicly available to researchers and contains de-identified data. Therefore, this study did not meet human subject research criteria and was exempt from institutional review.

### 2.2. Patient factors

Utilizing ICD-9-CM diagnosis codes, all patients between 2005 and 2013 who were admitted with a closed knee dislocation (836.5x) were identified. Patients who had a popliteal artery disruption were identified using the ICD-9-CM diagnosis code 904.41. For each patient, data on demographics, as they were recorded, was collected, including age (continuous, in years), sex (male, female), race (White, Black, Hispanic, Asian or Pacific Islander, or Other), insurance (government, private, other), and year of hospital admission (2005–2013). Comorbidities were calculated from diagnosis codes using Charlson and Deyo's method,[31] and patients were distributed into comorbidity score categories of 0, 1, and ≥2 points.

### 2.3. Perioperative factors

For each patient, data on perioperative complications, length of stay, and hospital charges were collected. Perioperative complications were calculated using ICD-9-CM diagnosis codes, as described previously.[15] Medical complications included hematoma, altered mental status, acute myocardial infarction (MI), pulmonary distress, pneumonia, gastrointestinal upset, urinary tract infection (UTI), acute renal failure (ARF), sepsis, pulmonary embolism (PE), or deep vein thrombosis (DVT). Surgical complications included wound infection, wound dehiscence, or blood transfusion.

### 2.4. Statistical analysis

Patients were stratified into two groups, those with vascular injury and those without (the reference group). To compare differences in demographics between patients who had vascular injury and the reference group, regression modeling was employed to predict the chance that a patient had a vascular injury based on each demographic variable. To compare the risk of complication between patients who had a vascular injury and the reference group, logistic regression was utilized to calculate the Odds Ratio (OR) of having a perioperative (any, medical, surgical) complication. To compare differences in length of stay, length of stay was dichotomized by defining an increased length of stay as greater than 0.5 standard deviations (SD) from the mean. Subsequently, a logistic regression was used to calculate the OR as previously described. All regression models included the following covariates: age, sex, race, and Deyo comorbidity score.

Weighting variables were utilized in all analyses to simulate nationwide United States rates of admission for knee dislocation. All analyses were performed with SPSS version 24 (IBM Corp., Armonk, New York). Figures were created with Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington). An alpha level of 0.05 was selected as the threshold for statistical significance.

## 3. Results

### 3.1. Patient factors

The analysis identified 2,175 patients who had a knee dislocation between 2005 and 2013 in the United States. A diagnosis of popliteal artery injury was documented for 210 (9.7%) patients, while the other 1,965 (90.3%) patients did not have an arterial injury. Patients with popliteal artery disruptions were younger (35 vs. 44 years, $p < 0.001$) and were more often male relative to patients without vascular injury (72.9% vs. 56.2% male, $p < 0.001$). Patients with popliteal artery disruption were more often Black and Hispanic, with an increased frequency of Medicaid, private insurance, and self-pay as the primary payer (all $p \le 0.013$) (Table 1).

**Table 1**
Demographic information for patients with and without popliteal artery injury from the Nationwide Inpatient Sample (NIS) between 2005 and 2013.

| Patients (n) | | No Disruption | Disruption | p Value |
|---|---|---|---|---|
| | | 1,965 | 210 | – |
| Age (years) | | 44 | 35 | **0.001** |
| **Sex (%)** | *Male* | 56.20 | 72.90 | **0.001** |
| | *Female* | 43.80 | 27.10 | |
| **Primary Payer (%)** | *Medicare* | 20.50 | 5.70 | **0.001** |
| | *Medicaid* | 13.30 | 18.70 | |
| | *Private Insurance* | 42.70 | 44.00 | |
| | *Self-Pay* | 11.90 | 12.90 | |
| | *No-Charge* | 1.30 | 2.40 | |
| | *Other* | 10.30 | 16.30 | |
| **Race (%)** | *White* | 63.70 | 52.20 | **0.013** |
| | *Black* | 18.20 | 24.40 | |
| | *Hispanic* | 12.10 | 17.80 | |
| | *Asian or Pacific Islander* | 1.30 | 0.00 | |
| | *Native American* | 1.20 | 2.20 | |
| | *Other* | 3.50 | 3.30 | |

Chi-square analysis revealed that the percentage of popliteal artery disruptions in patients with knee dislocations did not vary significantly from 2005 to 2013 (Fig. 1). The rate of vascular injury fluctuated between 7.8 and 11.1%.

### 3.2. Perioperative factors

Among medical complications, patients with popliteal disruptions had significantly higher rates of hematoma, UTI, ARF, PE, DVT ($p \le 0.049$). Among surgical complications, the popliteal disruption population had significantly higher rates of wound infection and blood transfusion when compared to patients with knee dislocations without popliteal disruption ($p < 0.001$). Furthermore, LOS and total charges were increased in the popliteal disruption patients ($p < 0.001$.) (Table 2).

After adjusting for the potential confounding effects (covariates) of race, sex, age, and Deyo Index, binary logistic regression revealed that the odds of developing at least one medical or surgical complication was 2.8 times higher (95% CI, 2.03–3.92, $p < 0.001$) among patients with popliteal artery disruption compared to the reference group. Similarly, the odds of having an increased length of stay was 11.0 times higher (95% CI, 6.6–18.4, $p < 0.001$) in patients with popliteal artery disruption, while female sex was associated with a 0.65 lower odds (95% CI, 0.48–0.88, $p = 0.005$) (Table 3).

## 4. Discussion

Although knee dislocations are considered rare injuries, they are surgical emergencies due to the potential neurovascular complications.[32] This study utilized the NIS database to assess the risks and burdens associated with knee dislocation and analyzed frequency trends over time, stratified by age, sex, race, and Deyo comorbidity index, to determine the incidence of knee dislocations and the associated complications. In knee dislocation patients, popliteal artery injury occurred in 7.8–11.1% of cases. Specifically, knee dislocation patients with concomitant vascular injury were found to be younger and more often male. Additionally, race may have a role in the rate of vascular injury, as Black and Hispanic patients more often incurred a vascular complication rather than a purely anatomical dislocation. Furthermore, vascular injury patients were more likely to experience secondary medical and surgical complications, including hematoma, UTI, ARF, PE, DVT, and wound infection and were also more likely to experience an increased length and cost of stay. Of note, patient

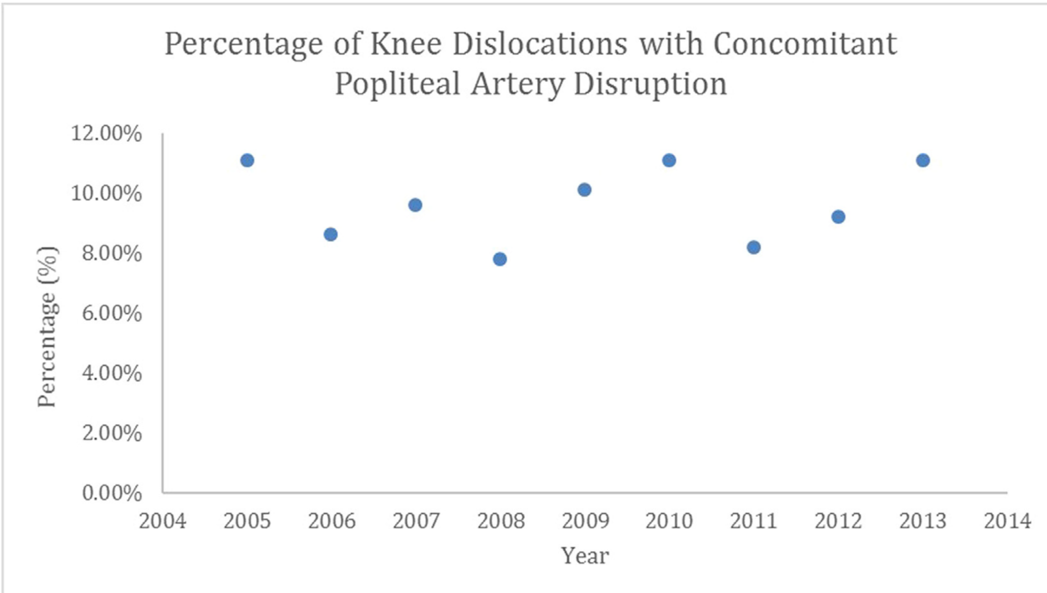


**Fig. 1.** Percentage of knee dislocations with concomitant popliteal artery disruptions from 2005 to 2013.

**Table 2**
Medical and surgical complication rates, length of stay, and total hospital charges in knee dislocation patients with and without popliteal artery disruption.

| | No Disruption | Disruption | P-value |
|---|---|---|---|
| **Length of Stay (days)** | 6.84 | 13.94 | **0.001** |
| **Total Charges (US Dollars)** | $70,756 | $147,425 | **0.001** |
| **Medical Complications (%)** | | | |
| *Hematoma* | 0.90 | 4.30 | **0.001** |
| *Altered Mental Status* | 0.20 | 0 | 0.513 |
| *Acute Myocardial Infarction* | 0.30 | 0 | 0.423 |
| *Pulmonary Distress* | 1.20 | 1.40 | 0.744 |
| *Pneumonia* | 1.90 | 1.40 | 0.609 |
| *Gastrointestinal Complications* | 0.20 | 0.50 | 0.298 |
| *Urinary Tract Infection* | 0.40 | 1.40 | **0.047** |
| *Acute Renal Failure* | 2.00 | 4.30 | **0.037** |
| *Sepsis* | 0.70 | 1.90 | 0.052 |
| *Pulmonary Embolism* | 0.90 | 2.40 | **0.049** |
| *Deep Vein Thrombosis* | 2.40 | 5.20 | **0.018** |
| **Surgical Complications (%)** | | | |
| *Transfusion of Blood* | 10.80 | 19.00 | **0.001** |
| *Wound Infection* | 3.50 | 8.60 | **0.001** |
| *Wound Dehiscence* | 0.80 | 1.90 | 0.116 |

comorbidities did not significantly influence the rate of vascular complications following knee dislocation ($p = 0.268$).

The findings from this study were in agreement with other works with regards to the incidence of vascular injury following knee dislocation. A multicenter prospective study by Boisrenoult et al.[33] found that of the 67 knee dislocation patients, 12% incurred a vascular injury. Similarly, Medina et al.[34] showed that of 826 patients with a knee dislocation, 171 (18%) experienced vascular complications. This investigation produced similar results to the aforementioned studies and highlight that, while knee dislocations may be rare, there were high enough rates of vascular complications following knee dislocation emphasize the need for careful examination.

However, while this study pointed to a high incidence of vascular injury following knee dislocation, other studies have reported different injury rates. In a national 14-year prospective study conducted in Finland by Sillanpää et al.,[35] of the 837 patients included in the study, only 13 (1.6%) experienced vascular injury. Likewise, using a large private insurance database, Natsuhara et al.[36] reported that among the 8050 limbs reviewed, only 267 (3.3%) experienced a vascular injury. Several factors may account for the differences found between these studies and the present one. Different patient populations may alter study results. Specifically, as there is a higher incidence of traffic accidents in the USA compared with most other countries,[37,38] and since high-energy mechanisms are more likely to be associated with vascular injuries,[17] this can potentially impact incidence rates. Likewise, the use of a private insurance database may potentially limit variations in the patient population included in the study. Moreover, patient body mass index (BMI) might influence injury biomechanics and alter patient presentation. In a retrospective cohort study, Johnson et al.[39] reported a slightly lower vascular injury rate of 5.63% following knee dislocation compared to our results. However, their rate increased to 7.2% in obese patients and 11.3% among morbidly obese patients, indicating that BMI may influence the rates of vascular injury. The importance of these findings becomes apparent when considering the role that angiography plays in detecting vascular injury. Angiography is an invasive and expensive modality with the potential for allergic reactions, renal damage, and vascular injury.[25] If the rates of vascular injury are in fact lower than what is presented in the current study, more stringent patient selection criteria for angiography is justified.

There were several limitations to the current study. Performing retrospective analysis with the use of large administrative encompasses inherit limitations. As databases were not maintained by study personnel, there exists the potential to introduce bias with data entry and errors in reporting diagnosis codes. Additionally, as hospitals operate under various regulations, the reporting of vascular injury may be reported under different codes depending on that particular institute's reporting protocol. As such, the true incidence of vascular injury may be either over or underestimated. Despite these limitations, we believe that the results of the present study are significant and valid.

## 5. Conclusions

It is critical to accurately diagnose and assess knee dislocations, as they are associated with significant patient morbidity. This study reported on a significant proportion of patients that incurred popliteal artery injury following a knee dislocation. Importantly, these patients with concomitant popliteal injury were also more likely to experience secondary complications, experience longer hospital stays, and incur greater healthcare costs. Diagnostic diligence is vital, as a proper neurovascular and ligamentous examination may accurately identify soft

**Table 3**
Logistic Regression of Factors Independently Associated with the occurrence of Any Medical or Surgical Complication, or a Length of Stay (LOS) 0.5 SD greater than the mean.

| | | Odds Ratio | 95% Confidence Interval | | p-value |
|---|---|---|---|---|---|
| **Any Complication** | ***Popliteal Disruption*** | **2.819** | **2.030** | **3.915** | **0.001** |
| | *Female Sex* | 0.841 | 0.666 | 1.061 | 0.144 |
| | *African American* | 1.005 | 0.744 | 1.360 | 0.972 |
| | *Hispanic* | 1.240 | 0.888 | 1.731 | 0.207 |
| | *Asian or Pacific Islander* | 1.079 | 0.387 | 3.008 | 0.885 |
| | *Native American* | 1.495 | 0.598 | 3.740 | 0.390 |
| | *Other* | 1.179 | 0.649 | 2.144 | 0.589 |
| | *Deyo Index* | 1.073 | 0.947 | 1.215 | 0.268 |
| | ***Age in years at admission*** | **1.016** | **1.010** | **1.022** | **0.001** |
| | | **Odds Ratio** | **95% Confidence Interval** | | **p-value** |
| **Increased Length of Stay ( > 0.5 SD)** | ***Popliteal Disruption*** | **11.040** | **6.622** | **18.404** | **0.001** |
| | ***Female Sex*** | **0.650** | **0.480** | **0.881** | **0.005** |
| | *African American* | 1.006 | 0.685 | 1.478 | 0.976 |
| | *Hispanic* | 1.330 | 0.857 | 2.062 | 0.203 |
| | *Asian or Pacific Islander* | 1.267 | 0.383 | 4.194 | 0.698 |
| | *Native American* | 1.185 | 0.374 | 3.758 | 0.773 |
| | *Other* | 1.182 | 0.586 | 2.383 | 0.640 |
| | *Deyo Index* | 0.902 | 0.717 | 1.135 | 0.380 |
| | *Age in years at admission* | 1.004 | 0.996 | 1.013 | 0.326 |

tissue and neurovascular complications and may decrease patient morbidity.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jor.2018.08.006.

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## Conflicts of interest

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