Risk Factors for Peroneal Nerve Injury and Recovery in Knee Dislocation

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Abstract

Background Acute knee dislocation is rare but has a high rate of associated neurovascular injuries and potentially limb-threatening complications. These include the substantial morbidity associated with peroneal nerve injury: neuropathic pain, decreased mobility, and considerably reduced function, which not only impairs patient function but complicates treatment.

Questions/purposes We therefore identified and quantified the risks associated with specific factors for peroneal nerve injury and recovery in patients with knee dislocations.

Patients and Methods We retrospectively reviewed the charts of 26 patients, from among a cohort of all 91 knee dislocations, with a peroneal nerve palsy over a 5-year period. We then used univariable and multivariable statistics to identify risk factors predicting peroneal nerve injury and recovery.

Results Gender (odds ratio, 5.47), body mass index (odds ratio, 1.14), and fibular head fracture (odds ratio, 4.77) were associated with peroneal nerve injury. Only younger age was associated with peroneal nerve recovery.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Conclusions Knowledge of the risk factors for peroneal nerve injury and the predictors of recovery in knee dislocation allows the treating surgeon to have a better understanding of the nature of the neurologic injury and modify management based on the anticipated return of nerve function.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Acute knee dislocation is rare, although the incidence is likely greater than the reported 0.02% of musculoskeletal trauma because of an unknown number of spontaneous reductions shortly after injury, thereby increasing the rate of missed diagnoses. Because of the local anatomy and mechanisms of injury, there is a high rate of associated neurovascular injuries and potentially limb-threatening complications [6, 17, 19, 29].

The incidence of concomitant neurologic injury with knee dislocation is estimated to be from 10% to 40% with a wide discrepancy between reported series [2, 10, 18, 20, 24, 26, 27]. The most frequently injured nerve is the common peroneal nerve. Similar to the anatomy of the popliteal artery, the common peroneal nerve is constrained proximally at the fibular neck and distally at the intermuscular septum by fibrous arches that limit its ability to accommodate changes in limb position during trauma [1, 23]. In addition, when compared with other peripheral nerves, the peroneal nerve may be inherently predisposed to neuropraxic injury due to its inconsistent blood supply and lack of intraneural vessels in the segment surrounding the fibular neck [11].

The morbidity associated with posttraumatic peroneal nerve palsy is substantial. Function, neuropathic pain, and overall quality of life are all negatively affected by peroneal nerve injury [3, 4]. A patient with foot drop walks with a steppage gait and may require the use of an ankle-foot orthosis. In the setting of knee dislocation, peroneal nerve injury has widespread repercussions. The ability to have a stable, well-functioning, and pain-free knee is strongly influenced by the neurologic function of the foot and ankle. Peroneal nerve palsy is often a frustrating and debilitating problem for patients and has important implications for the timing of surgical reconstruction and ultimate knee function.

Several series [2, 10, 18, 22, 26] describe the incidence of peroneal nerve injury associated with knee dislocation, but these studies did not identify or quantify the risk factors for peroneal nerve injury and recovery. Age, gender, body mass index (BMI), mechanism of injury, and pattern of ligamentous injury are all plausible contributors to the risk of injury. These factors may also influence the ability of the peroneal nerve to spontaneously recover from injury. Despite the fact that these variables are largely nonmodifiable, an understanding of these risk factors may aid the treating orthopaedic surgeon in predicting patients who are predisposed to peroneal nerve injury. Knowledge of these factors may be useful when a patient is difficult to examine or unreliable and may be utilized in advising patients regarding their potential for neurologic recovery. Moreover, the likelihood of peroneal nerve recovery may alter the time course and specific procedures involved in surgical management.

We therefore (1) identified and quantified specific risk factors for peroneal nerve injury in acute knee dislocation

and (2) identified factors that influence the recovery of peroneal nerve injuries after a knee dislocation.

Patients and Methods

A search of hospital and surgeon database records identified all 91 patients between the ages of 16 and 60 years presenting with a diagnosis of knee dislocation between 2005 and 2010. We excluded patients who died shortly after injury or had severe head injury (three patients) from the analysis. There were 72 male patients (79%); the average age was 33.6 years (range, 16–57 years) and the average BMI was 27.7 kg/m² (range, 14.7–42.1 kg/m²). The mechanism of injury was high energy in 44 patients (48%). Fracture of the fibular head was present in 19 patients (21%), and the posterior cruciate ligament (PCL) was disrupted in 76 patients (84%). The most common ligamentous injury pattern was KD IIIL, affecting 33 patients (36%). Vascular injury requiring surgical reconstruction was present in five patients (5.5%). Overall, 74 patients (81%) were treated with ligamentous reconstruction (Table 1). Peroneal nerve injury was defined as lack of sensation over the dorsum of the foot and 0/5 motor function as graded by the Medical Research Council criteria [15]. Of the 91 patients, 26 patients (29%) had peroneal nerve injury. In this cohort of nerve-injured patients, there were 24 males (92%); the average age was 34.1 years (range, 16–52 years) and the average BMI was 32.6 kg/m² (range, 22.1–42.1 kg/m²). The mechanism of injury was high energy in 11 patients (42%). Fracture of the fibular head was present in 10 patients (39%), and the PCL was disrupted in 23 patients (89%). Vascular injury

Table 1. Baseline characteristics and univariate analysis

Variable	Knee dislocation cohort (n = 91)	Peroneal nerve cohort (n = 26)	p Value
Age (years)*	33.6 (11.1)	34.1 (13.8)	0.407
Body mass index (kg/m ²)*	27.7 (5.2)	32.6 (8.1)	0.021
Gender (male) (number)	72 (79.1%)	24 (92.3%)	0.050
Mechanism of injury (high energy)	44 (48.4%)	11 (42.3%)	0.467
Injury classification (Schenck)			
KD I	20 (22%)	3 (11.5%)	0.215
KD II	4 (4.4%)	1 (3.8%)	0.689
KD IIIL	33 (36.3%)	18 (69.2%)	< 0.001
KD IIIM	22 (24.2%)	0 (0%)	0.002
KD IV	12 (13.2%)	4 (15.4%)	0.999
KD V	0 (0%)	0 (0%)	
Fibular head fracture	19 (20.9%)	10 (38.5%)	0.009
Posterior cruciate ligament injury	76 (83.5%)	23 (88.5%)	0.420
Vascular injury	5 (5.5%)	4 (15.4%)	0.035

* Values are expressed as mean, with SD in parentheses.

requiring surgical reconstruction was present in four patients (15%). The most common ligamentous injury pattern was KD IIIL, affecting 18 patients (69%). A total of eight patients had recovery of peroneal nerve function (31%). The minimum followup was 12 months (mean, 33.2 months; range, 12–58 months). No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records. We had prior Institutional Research Ethics Board approval for the chart review for each study subject.

We created a data abstraction form to gather information regarding patient age, gender, BMI, attending surgeon, common peroneal nerve injury, common peroneal nerve recovery, mechanism of injury, and operative treatment. Mechanism of injury was stratified into low energy and high energy. We classified pattern of ligamentous injury according to the system for knee dislocations developed by Schenck [25]. Plain radiographs and MRI studies were reviewed to confirm associated fractures and ligamentous pattern of injury.

We monitored recovery of the peroneal nerve on a monthly basis by clinical examination and EMG testing. EMG testing was performed when there was lack of clinical improvement in peroneal function at 3 months postinjury. A peroneal nerve palsy was classified as “recovered” when it obtained a subjective return of light touch sensation and a Medical Research Council score of 5/5 [15]. Patients with an associated peroneal nerve injury were treated with observation ($n = 4$), neurolysis ($n = 21$), or nerve grafting ($n = 1$). The indication for neurolysis was presence of a nonlacerated peroneal nerve injury with concomitant reconstruction of the lateral/posterolateral structures of the knee. A single nerve grafting procedure was performed in the setting of an acute peroneal nerve laceration. The routine use of nerve grafting was precluded due to the broad zone of injury and mechanism (traction) in most cases. Eighteen patients had nonresolving peroneal nerve palsies, of which seven were treated with transfer of the posterior tibialis tendon and six required the use of an ankle-foot orthosis. The indication for tendon transfer was persistent peroneal nerve palsy and patient dissatisfaction with use of an orthosis.

After transfer of the posterior tibial tendon, patients had their ankle immobilized for 6 weeks, followed by enrollment in a physiotherapy program focused on restoration of ROM. Weightbearing was reintroduced at 10 to 12 weeks postoperatively as part of gait retraining. A concomitant dedicated physiotherapy program adhering to a multiligament knee reconstruction protocol was used for knee rehabilitation [16].

Data acquisition was reviewed and verified independently and in duplicate before statistical analysis. Missing data comprised less than 10% of all data and were

corrected for by the use of mean values. Means, ranges, and confidence intervals were calculated for continuous variables (age, BMI, time to followup) and compared between the peroneal nerve palsy and nonperoneal nerve palsy cohorts using Student's *t* test. We calculated frequencies for categorical variables (gender, mechanism of injury, injury classification, fibular head fracture, PCL injury, and vascular injury) and compared them using chi square or Fisher's exact tests. Using a significance level of $p < 0.05$ for factors in the univariable analyses, we identified potential variables for a multivariable logistic regression model to identify major risk factors for peroneal nerve injury. The predictor variables for the model were age, gender, BMI, mechanism of injury, presence of an injury to the PCL, and fracture of the fibular head. The outcome variable was the presence of a peroneal nerve injury. Univariable statistical techniques were used to identify factors associated with peroneal nerve recovery. The variables of interest were age, BMI, mechanism of injury, and fibular head fracture. We performed statistical analysis of data using MiniTab® 16 (MiniTab, Inc, State College, PA) computer software.

Results

Univariable analysis comparing patients with and without peroneal nerve injury showed the peroneal injury cohort to have a higher ($p = 0.0206$) BMI. In addition, there were differences in presence of fibular head fracture ($p = 0.009$) and presence of a vascular injury ($p = 0.035$). There were no differences for age, gender, mechanism of injury, or presence of PCL disruption (Table 1). Multivariate regression analysis revealed gender ($p = 0.049$; odds ratio [OR], 5.47), BMI ($p = 0.024$; OR, 1.14), and fibular head fracture ($p = 0.012$; OR, 4.77) to be predictive of peroneal nerve injury in knee dislocation (Table 2). Age, mechanism of injury, and PCL disruption did not.

Table 2. Multivariate analysis

Variable	Peroneal nerve injury		
	p Value	Odds ratio	95% confidence interval
Age (years)	0.682	0.99	0.95, 1.04
Body mass index	0.024	1.14	1.02, 1.28
Gender (male)	0.049	5.47	1.01, 29.8
Mechanism of injury (high energy)	0.880	0.92	0.33, 2.58
Fibular head fracture	0.012	4.77	1.40, 16.2
Posterior cruciate ligament injury	0.145	3.25	0.67, 15.8

Younger age ($p < 0.001$) was the sole variable associated with peroneal nerve recovery.

Discussion

Peroneal nerve injury is an important complicating factor in the setting of knee dislocation, having deleterious effects on function, neuropathic pain, and overall quality of life. The ability to identify patients who are at increased risk of peroneal nerve injury and persistent palsy may aid the treating surgeon in providing timely and appropriate surgical management. We therefore determined risk factors for peroneal nerve injury and prognostic factors for recovery in knee dislocation.

This retrospective cohort study has several limitations. First, many of the patients were referred to our tertiary care center from outside institutions. This selection bias may have resulted in a disproportionately higher number of complicated knee dislocations with neurologic abnormalities in our cohort. However, the rate of peroneal nerve injury and recovery in our cohort is comparable to that described in the literature. Second, the patients included in the study were not randomly allocated to a surgical treatment method with respect to the ligamentous pattern of injury or the presence of peroneal nerve palsy. Rather, an arbitrary decision was made based on surgeon preference. One patient, with a complete laceration of the peroneal nerve, was treated with nerve grafting (which failed), four patients were observed, and the remaining 21 patients underwent neurolysis. The specific method used for treatment may have affected neurologic recovery; however, there is no definitive evidence to support this. Third, the relatively small number of patients in our study would influence the power of the study and subject the analysis to Type II errors. However, knee dislocation is relatively uncommon and our series is relatively large with a high percentage of followup. Our study population did have similar baseline characteristics as other studies [2, 10, 18, 20, 22, 26, 30] examining peroneal nerve palsy associated with knee dislocation (Table 3). In addition, the incidence of nerve injury and nerve recovery rate was comparable. These studies validate our findings with respect to patient demographics, peroneal nerve injury rate, and peroneal nerve recovery.

We found higher BMI to predict peroneal nerve injury with knee dislocation. This finding confirms reports in the literature describing ultra-low-energy knee dislocations with neurovascular injury in morbidly obese patients [14, 21]. The supraphysiologic stress imparted to the knee and surrounding structures during injury in obese patients likely contributes to this finding. Peroneal nerve injury was also predicted by the presence of a fibular head fracture, which

Table 3. Incidence and recovery of peroneal nerve palsy in knee dislocation

Study	Incidence	Recovery
Meyers et al. [18]	14/53 (26%)	2/14 (14%)
Sisto and Warren [26]	8/20 (40%)	4/8 (50%)
Werier et al. [30]	6/38 (16%)	1/6 (17%)
Harner et al. [10]	4/31 (13%)	3/4 (75%)
Niall et al. [20]	14/55 (25%)	3/14 (21%)
Bonnevialle et al. [2]	12/67 (18%)	6/12 (50%)
Plancher and Siliski [22]	18/50 (36%)	10/18 (56%)
Peskun et al.	26/91 (29%)	8/26 (31%)

is likely a surrogate measure for disruption of the posterolateral corner of the knee. This finding confirms that of a previous study reporting a 100% rate of posterolateral corner injury in patients with peroneal nerve palsy after knee dislocation [20]. The intimate contact between the peroneal nerve and posterolateral corner of the knee makes nerve injury a frequent finding in knee dislocation. Fibular head fracture is an easily identified factor that can be seen on plain radiographs and may be particularly useful for predicting the likelihood of peroneal nerve injury in obtunded patients or those who are unable to comply with a complete neurologic examination.

The rate of peroneal nerve recovery in our study was 31%, which is comparable to that in the literature. Younger patient age was a favorable factor for peroneal nerve recovery. The average age of patients who had spontaneous recovery of peroneal nerve function was 22.7 years with only one patient older than age 30 years. These findings are consistent with basic science and clinical studies examining peripheral nerve recovery after injury [12, 13], suggesting the extent of axonal regeneration in peripheral nerve injuries decreases with age. In addition, the temporal rate of peripheral nerve recovery may be impaired with increasing age [28].

The treatment of peroneal nerve injury in the setting of knee dislocation remains challenging with inconsistent findings [5, 7–9]. The morbidity associated with peroneal nerve injury with a knee dislocation is considerable. Increased pain and lower function complicate postoperative recovery of the patient. A better understanding of the risk factors for peroneal nerve injury and the predictors of recovery may allow the treating surgeon to identify at-risk patients and to prognosticate for recovery of nerve function in these rare but challenging injuries.

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