

Incidence of knee dislocation and concomitant vascular injury requiring surgery: A nationwide study

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BACKGROUND:	Acute knee (tibiofemoral joint) dislocation is a serious knee injury, although population-based numbers and incidence rates of knee dislocation with or without concomitant vascular injury are unknown.
METHODS:	The study covered the whole adult population of 4 million persons (aged ≥ 18 years) in Finland during the 11-year period from January 1, 1998, to December 31, 2011. Data on hospitalization caused by acute knee dislocations and concomitant vascular injuries requiring operative treatment were obtained from the nationwide National Hospital Discharge Registry.
RESULTS:	During the 14-year study period, a total of 837 patients with knee dislocation diagnosis were hospitalized in Finland. The highest incidence rates in men were in persons aged 18 years to 29 years (incidence, 29 per 1 million person-years in 2011), and the incidence decreased by age, while in women, this incidence was rather similar in all age groups. The most common injury mechanism of knee dislocation was low-energy fall at the same level (46%). The median length of hospital stay was 2 days (range, 1–109 days). In 107 cases (13%), knee dislocation required immediate open (69 cases) or closed (38 cases) reduction in the operating room. Popliteal artery injury requiring acute surgical intervention was found in 13 patients (1.6%), and amputation at the level above the tibiofemoral joint was performed for one patient (0.1%).
CONCLUSION:	This is the first study describing the population-based incidence of acute knee dislocation. Men aged 18 years to 29 years had the highest incidence rates. Half of the injuries were low-energy trauma. Popliteal artery injury requiring surgical intervention was a rare concomitant injury, but when present, the injury required immediate surgical repair to avoid dramatic consequences. (<i>J Trauma Acute Care Surg.</i> 2014;76: 715–719. Copyright © 2014 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Nationwide epidemiologic study, level I.
KEY WORDS:	Knee dislocation; popliteal artery; incidence; operative treatment; epidemiology.

Dislocation of the knee (tibiofemoral joint) is a serious knee injury with approximated occurrence of 0.02% to 0.1% of all musculoskeletal injuries.^{1,2} To our knowledge, the only study assessing the incidence rate for knee dislocation using magnetic resonance imaging (MRI) was conducted by Peltola et al.³ They suggested that the adult incidence is 1.2 per million persons-years and that dislocation of the knee usually results from a high-energy trauma, such as motor vehicle accidents. In addition to high-energy injuries, it is possible to sustain multiple ligament knee injuries and knee dislocation by low-energy injury mechanism. It has been described that up to 40% of knee dislocations can happen in overweight patients sustaining low-energy trauma, such as falling on even ground or slipping while walking.³ Nowadays, low-energy dislocations may be increasing since the prevalence of morbidly obese persons is increasing

in many countries, and severe obesity may be associated with higher risk for knee dislocation in low-energy knee injuries.⁴

In a knee dislocation classification system modified by Schenck et al.,^{5–8} knee dislocation is defined as a continuous injury pattern varying from injury to a posteromedial or posterolateral corner combined with a single cruciate injury, to fractures with bicruciate and both posterolateral and posteromedial corner injuries. The diagnostics of knee dislocation is based on clinical examination, radiographs, computed tomography, and MRI. It is however challenging to make a correct diagnosis since spontaneous relocation may occur, and thus, the severity of the ligamentous disruption may be underestimated,⁹ and the knee dislocation can be misdiagnosed as an anterior cruciate ligament injury only, for example.

There is no uniform treatment protocol established for acute knee dislocation. The main goal in the treatment of an acute knee dislocation is, however, to recognize the severity of the injury including affected ligaments and neurovascular structures sometimes requiring immediate surgical intervention. The acute phase is followed by pain management, planning for surgical reconstructions, and a well-monitored intensive rehabilitation protocol, which typically takes from few months up to 1 year.¹⁰ It is widely accepted among experts in knee surgery that surgical treatment of knee dislocation yields functional results better than those of a nonsurgical approach. However, this view is based on case series and clinical experience only, and high-quality studies are lacking.¹⁰ Modern surgical management of knee dislocation includes reconstruction or repair

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of the injured ligaments, typically in one-stage operation either soon after injury or at few months after injury, and is followed by an extensive rehabilitation program.¹¹

The most common concomitant injuries associated with knee dislocation are vascular injury, nerve injury, soft tissue affection (open dislocation), compartment syndrome, and irreducible dislocation.^{12–14} Based on several case series, the prevalence of vascular injury has been suggested to be between 7% and 32%.¹⁵ In these cases, the injury mechanism has been described to include excessive joint distension forces or mechanical contusion to the soft tissues around the knee, popliteal artery being the most vulnerable structure.^{15,16} A majority of the vascular injuries are minor and heal spontaneously. Surgical treatment options for major vascular injury include end-to-end repair or bypass vascular surgery by a graft.¹⁵ The population-based occurrence of vascular injury requiring surgical intervention following knee dislocation is not known.

The aim of this nationwide population-based register study was to assess the incidence of hospitalization caused by an acute knee dislocation as well as the incidence of surgical treatment of concomitant vascular injuries.

PATIENTS AND METHODS

The present study covered the whole adult population (≥ 18 years) in Finland during a 14-year period, from January 1, 1998, to December 31, 2011. The total number of Finnish inhabitants in this age group was 3.7 million in 1998 and 4.0 million in 2011.¹⁷ The knee dislocation data were obtained from the statutory, computer-based National Hospital Discharge Register (NHDR) of Finland including information on all patients admitted alive to any Finnish hospital (public or private) for the treatment of an acute knee dislocation. Since 1998, outpatient operations have also been coded into the register, but no such cases were found with the diagnosis of acute knee dislocation, describing the severity of the injury.

Finnish NHDR is the oldest nationwide discharge register in the world, and its coverage and accuracy are reportedly excellent.^{18–21} Medical treatment including surgery is equally available to everyone in Finland owing to the nationwide public health insurance legislated by the Finnish Ministry of Social Affairs and Health. This ensured that the hospitalization database we used had comprehensive population coverage.

The NHDR contains data on the age, sex, domicile of the subject, length of hospital stay, primary and secondary diagnosis, and operations performed during the hospital stay. The information was collected equally from all hospital categories (private, public, other). Since 1996, the diagnosis in the NHDR has been coded using the 10th revision of the International Classification of Diseases (ICD).²²

The main outcome variable for the present study was the number of patients hospitalized with a main or secondary diagnosis of knee dislocation (ICD-10 code S83.1). When describing the number and incidence of surgical treatment for knee dislocation, ICD-10 operation codes were retrieved. From 1998 to 2001, only one operative code was allowed, while after 2001, four operation codes were available. Assessment of the external cause of injury (injury mechanism) was also based on ICD-10 classification. External cause is used to indicate the

nature or origin of the injury, such as work-related, traffic injury, or sports-related accident. Approval to use the hospitalization data was obtained from the Institutional Review Board of the Ministry of Social Affairs and Health.

Statistical Analysis

To assess the incidence rates of knee dislocation and the incidence of surgical treatment, the annual midpopulation was obtained from the Official Statistics of Finland, a computer-based national population register.¹⁷ We want to emphasize that the numbers and incidence rates of knee dislocations and operations were the true, documented, and registered results concerning the whole adult population in Finland rather than cohort-based estimates, and thus, 95% confidence intervals were not calculated. Incidence rates were calculated with the Open Epi Program.

RESULTS

During the 14-year study period between 1998 and 2011, a total of 837 persons were hospitalized owing to knee dislocation as main or secondary diagnosis. Of these, 469 (56%) were male and 368 (44%) were female. The median age at the onset of injury was 33 years (range, 18–89 years) in males and 44 years (18–90 years) in females. There were altogether 1,083 hospitalization periods (median, one per person; range, one to seven). The median length of hospitalization was 2 days (range, 1–109 days). The annual number of patients with an acute knee dislocation varied between 47 (in 2003) and 77 (in 2002) per year.

The incidence of knee dislocation in the Finnish adult population is shown in Figure 1A and B. In males, the highest incidence rates were among persons aged 18 years to 29 years, and the incidence declined by age but without mentionable changes by time (Fig. 1A). In females, the incidence rates did not show age or time dependence (Fig. 1B).

Of the 837 persons with acute knee dislocation, 718 (84%) received some acute surgical intervention based on the operation codes in the NHDR. Because of the frequent multiple trauma cases including associated knee dislocation as one of the diagnoses, most of the acute operations were other than knee operations. In 107 cases (13%), the knee dislocation required immediate open (69 cases) or closed (38 cases) reduction in an operating room. Other common subsequent knee operations were arthroscopic assessment and knee debridement (100 cases), open or arthroscopic reconstruction of the ACL (50 cases), reconstruction of the PCL and/or ACL (33 cases), combined collateral ligament and cruciate ligament surgery (23 cases), as well as collateral ligament repair (16 cases). External fixator was used in nine cases, and one amputation above the level of tibiofemoral joint was performed.

Vascular injury requiring acute surgical intervention was found in 13 patients (1.6%); injury was defined as popliteal artery injury in all of the cases. The surgical procedures were bypass surgery from the femoral artery to the distal popliteal artery (nine cases), direct repair of the popliteal artery (one case), and a nonspecified bypass operation (three cases).

The most common external causes of injury (injury mechanism) of knee dislocation were fall on the same level (46%),

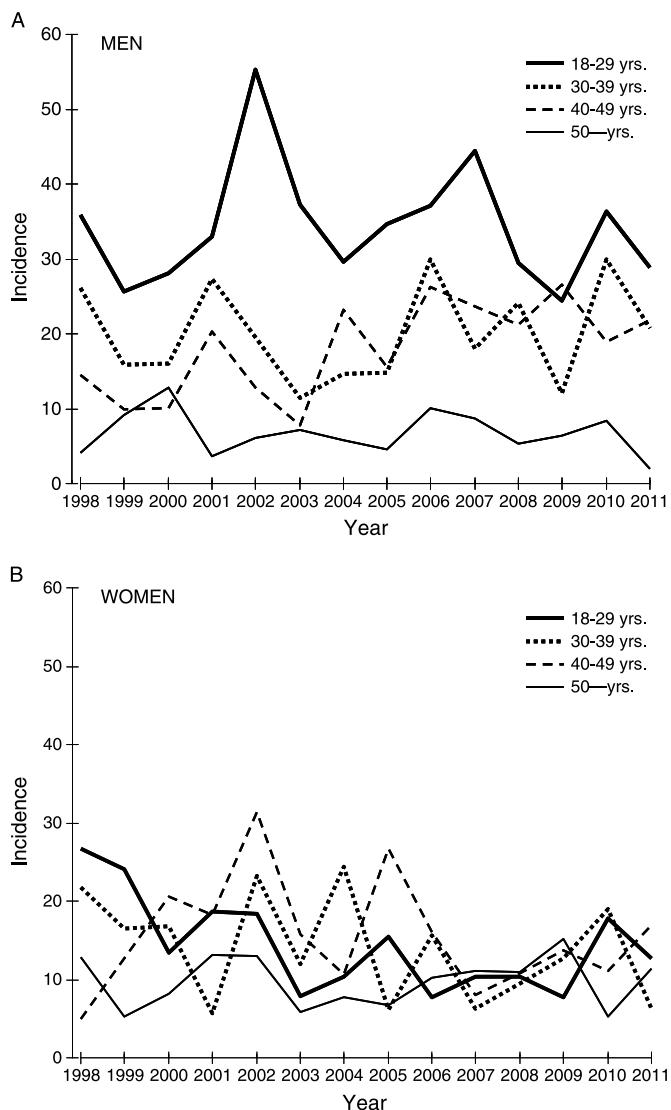


Figure 1. A, The incidence of hospitalization caused by acute knee dislocation in Finnish male adults per 1,000,000 person-years between 1998 and 2011. B, The incidence of hospitalization caused by acute knee dislocation in Finnish female adults per 1,000,000 person-years between 1998 and 2011.

higher-energy fall (16%), and traffic injuries (13%). In 20% of the patients, the external cause was unspecified knee injury.

DISCUSSION

This nationwide study is the first to assess the incidence of hospitalization caused by an acute knee dislocation. We were able to define the population-based occurrence of vascular injury requiring acute surgical intervention. On the contrary to previous case series from selected populations,^{4,23} we included each knee dislocation occurring in Finland, a European Union country of 4 million adult inhabitants, between 1998 and 2011, by a meticulous nationwide register-based analysis. Our results show that the incidence of acute knee dislocation is the highest

among men aged 18 years to 29 years (29 cases per 1 million person-years in 2011). The occurrence of popliteal artery injury requiring surgical interventions was 1.6%.

Diagnosing knee dislocation can sometimes be challenging. Because of quite frequent immediate spontaneous relocation of the tibiofemoral joint, the severity of the ligamentous injuries may be underestimated,⁹ and the knee dislocation may be misdiagnosed as an isolated cruciate ligament injury only. The severity of the injury, however, requires basically an emergency visit to a hospital (at the day of the injury event) and further diagnostic studies such as radiographs, owing to extensive signs and symptoms of major knee injury including pain, effusion, and even suspicion of vascular injury. In a case of underestimation of the knee injury severity, it has been suggested that a significant portion of subsequent isolated ligament reconstructions that have failed is caused by undiagnosed multiple ligament injury and knee dislocation.²⁴ Based on the severity of the injury, we may argue that an acute knee dislocation always results in hospital admission at some point, and since the injury diagnoses in the Finnish NHDR have been described to be reported accurate,^{1,2} we conclude that practically all of the diagnosed knee dislocations were included in our database.

Previously, the occurrence of knee dislocation has been estimated to be 0.02% to 0.1% of all musculoskeletal injuries.^{1,2} The only study assessing the injury incidence was a recent study in which the authors reviewed MRI database only and suggested the crude incidence being approximately 2.4 per million persons-years.^{1,2} Our incidence rates, which are based on a nationwide hospital discharge register and diagnosis set by an orthopedic surgeon, are significantly higher than those. A possible explanation is that our study also included the less severe knee dislocations. In addition, it has been shown that the occurrence of popliteal artery injury requiring surgical intervention is approximately 13%. This is a higher figure than that in our present study (1.6%). The discrepancy of the incidence rates could be caused by the fact that most of the previous studies are cohorts captured from trauma centers, thus including highly selected populations with possibly more severe knee dislocations (e.g., significant proportion of high-velocity traffic accidents). In the only population-based study by Peltola et al., patients were included based on single-hospital MRI archives only (and acute MRI is probably not performed in all patients in the acute phase), and thus, these patients may have had more severe injury patterns than those in our nationwide sample. Previous case series studies have shown that the occurrence of popliteal artery injury varies from 7% to 32%.¹⁵ However, they have also included conservatively treated popliteal artery injuries, while we concentrated on those requiring acute surgical interventions.

Our results, as those published previously in selected populations, show that in approximately half of the patients, the injury mechanism resulting in acute knee dislocation is a fall on the same level (low-energy dislocation).^{3,4,25} Among the patients with low-energy knee dislocations, we were not able to assess patients' body mass index from the register data, to see how many of them were morbidly obese.⁴ Low-energy knee dislocations have been suggested to be associated with severe obesity because fall on the same level, for example, very

rarely injures multiple knee ligaments in a healthy normal-weighted person. In conclusion, our findings indicate that although the classic definition of a knee dislocation has been injury associated with high-velocity trauma such as motor vehicle accidents, nowadays, the most common trauma mechanism is simply a fall on the same level.²⁵

We found that age distribution in knee dislocations varied between sexes. In males, the highest incidence figures were seen among persons aged 18 years to 29 years, the incidence declining with increasing age. Although incidence figures in general were markedly lower in females, no such decreasing incidence trend with increasing age was observed. A possible explanation is that in males, knee dislocations are caused more frequently by motor vehicle injuries, high-velocity sports, and general risk taking,²⁶ while in females, they may be associated with overweight and lower-energy trauma.

The most important limitation of this study is based on the clinical challenge in the diagnostics of a knee dislocation. It is always possible that the severity of the ligamentous injuries may be underestimated,⁹ and knee dislocation can therefore be misdiagnosed as an isolated cruciate ligament injury or a combination of single cruciate and single collateral ligament injury only. We obviously have not included these patients in our study. In addition, it is possible that we have missed a proportion of ligament reconstructive surgery performed after acute phase since the rate of surgical interventions was 84%, despite the fact that nearly all of the knee dislocations are nowadays treated with surgical repair or reconstruction, if not contraindicated because of health or age. ICD-coding suggests that S codes should be used in acute phase and T codes indicating complications and consequences of trauma thereafter. This means that it is possible that ligament reconstruction performed in subacute or chronic phase has been diagnosed with T code and thus not included in our study and that this is why our results considering frequency of ligament surgery must be interpreted with caution. In contrast, we may conclude that all acute operations performed during the first hospitalization period, such as amputations and acute vascular surgery, were accurately recorded.²⁰ Another limitation is that we were not able to assess less severe vascular injuries from the NHDR.

The strengths in our study included the fact that medical treatment, including surgery, is equally available in Finland and the study population was composed of the whole adult population of Finland. Therefore, we consider the results of this study very accurate, especially as the information in the Finnish NHDR is collected equally from public, private, and military hospitals. Previous studies have demonstrated that the accuracy and completeness of the NHDR database are excellent.^{18–20}

In summary, this population-based nationwide study was the first to assess the incidence of acute knee dislocations. Our results showed that the incidence of knee dislocation was higher than expected previously and higher in men than in women. Half of the knee dislocations were caused by low-energy trauma. The occurrence of popliteal artery injury requiring surgical interventions was 1.6%. Physicians in the emergency department should be aware of this serious injury and its vascular complications—even in patients with low-energy trauma.

AUTHORSHIP

P.J.S. has planned, conducted, and reported this research with V.M.M. and S.T.N. C.R. and L.F.-T. guided them through this process. P.K. and S.T.N. were mainly responsible for the statistical analysis. All authors have written the manuscript together and accepted the final version.

DISCLOSURE

The authors declare no conflicts of interest.

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