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No effect of dislocation status at arrival in emergency department on outcome of knee joint dislocations

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Abstract

Purpose: Knee dislocation is a rare but severe injury of the lower extremities. The aim of this study was to report on the epidemiology, diagnostics and treatment of such injuries and to identify negative predictors of clinical outcomes.

Methods: This retrospective analysis included all knee dislocations treated at a Level I Trauma Centre in Germany between 2009 and 2021. Medical records were categorised, collected and analysed in a standardised manner. A follow-up visit 1 year after the injury focused on limitations in knee mobility.

Results: A total of 120 knee dislocations were included in the study. 29.3% of patients presented to the emergency department with a dislocated joint, and 17.5% ($n = 21$) had a neurovascular lesion. At follow-up 12 months after the injury, 65.8% of the patients reported limitations in the range of motion, and 11.7% ($n = 14$) reported severe limitations in daily activities. Site infections due to surgery occurred in 3.3% of patients. Increased body weight ($r = 0.294$; $p < 0.001$ and $r = 0.259$; $p = 0.004$), an increased body mass index above 25 kg/m^2 (body mass index, $r = 0.296$; $p < 0.001$ and $r = 0.264$; $p = 0.004$) and deficits in peripheral perfusion as well as sensory and motor function ($r = 0.231$; $p = 0.040$ and $r = -0.192$; $p = 0.036$) were found to be negative predictive factors for clinical outcome. For post-traumatic neurovascular injury, lack of peripheral perfusion, insufficient sensory and motor function ($r = -0.683$; $p < 0.0001$), as well as a higher Schenck grade ($r = 0.320$; $p = 0.037$), were identified as independent risk factors. The status of dislocation at the site of the accident and on arrival at the emergency department had no impact on the outcome or neurovascular injury.

Conclusion: Knee dislocation is a rare injury with a high rate of severe complications such as neurovascular lesions. In particular, the initial status of neurovascular structures and injury classification showed a relevant negative correlation with the posttraumatic status of nerves and vessels. In particular, patients with these characteristics need close monitoring to prevent negative long-term consequences.

Abbreviations: ACL, anterior cruciate ligament; BMI, body mass index; CT, computed tomography; ED, emergency department; LCL, lateral collateral ligament; MCL, medical collateral ligament; MRI, magnetic resonance imaging; PCL, posterior cruciate ligament; ROM, range of motion; SD, standard derivation.

Level of Evidence: Level III.

KEYWORDS
ACL, complex knee injury, knee dislocation, PCL, Schenck classification

INTRODUCTION

Knee dislocation is a rare but serious injury that may result in significantly increased morbidity and disability. Knee dislocations occur when the surrounding soft tissues of the knee joint are severely displaced from their normal position, resulting in damage to the ligaments, tendons, nerves and blood vessels that support the joint [3, 15, 19, 30]. Injuries are graded according to the classification by Schenck et al. and include cruciate and collateral ligament injuries as well as fractures [7, 31, 33]. Knee dislocations may result from a variety of traumatic events, including sports-related injuries, motor vehicle accidents and fall from height. The current literature suggests that up to 60% of dislocations are caused by high-impact injuries, while low-energy traumas are associated with female sex and obesity [5, 7, 25].

The incidence of knee dislocation is relatively low, estimated to range between 0.02 and 0.2 per 100,000 people per year [12, 25, 32]. However, the incidence is higher in certain subgroups, such as athletes and young men, who have an increased risk of sustaining traumatic injuries [32]. Complications associated with knee dislocation include neurovascular injury, compartment syndrome and posttraumatic arthritis. In a systematic review, Medina et al. reported up to 18% of vascular injuries and up to 25% of nerve injuries [19]. Treatment guidelines for knee dislocation typically include reduction of the knee joint, stabilisation with external or internal fixation, reconstruction of injured neurovascular and ligamentous structures and rehabilitation procedures to restore joint function [12, 15, 24, 28, 37].

Due to the low incidence of these injuries, research on this topic is limited. In particular, patient- and injury-related risk factors and their evaluation are lacking in the current literature. The aim of our investigation was to describe (1) the characteristics of knee dislocations as well as (2) their treatment and complications. At the same time, (3) factors influencing the outcome of knee dislocations were identified.

MATERIALS AND METHODS

The study design was approved by the Ethics Committee of the University of Regensburg (ID: 24-3634-104). This retrospective analysis included all knee dislocations treated at a Level I Trauma Centre in Germany between 2009 and 2021. Injury data, diagnostics, treatment and complications were analysed in a standardised manner. Initially, all patients with a diagnosed knee dislocation were included in the data analysis. Knee dislocation was diagnosed according to existing and commonly used definitions with disruption of at least two of the six major ligamentous or cartilaginous structures [7, 18, 31]. Twelve months after the injury, patients were contacted for a standardised follow-up assessment of limitations in their daily activities and range of motion (ROM).

All patients with knee dislocation were invited to participate in this data analysis. Informed consent was obtained from all participating patients. After discharge from the hospital, all clinical records were screened in a standardised manner and entered into a database. In addition to the anthropometric data of the injured patients, the mechanism of injury and the previous history of knee injury were recorded. The preclinical dislocation status and the status on arrival at the emergency department were also recorded. Data records also included the diagnostic procedures performed, any concomitant injuries present and the surgical therapy conducted as well as the time between the injury and the first, second and third surgery. All injuries were graded according to the Schenck classification for knee dislocation published in 1994 [7, 31]. Twelve months after the injury, postinjury complications were analysed in terms of limitations in daily activities and motion and the presence of arthrofibrosis or infection. Limitations in daily activities were classified according to the *International Knee Documentation Committee* [13]. ROM was measured using a goniometer. Injury- and patient-specific characteristics were correlated with outcome parameters to identify risk factors for a worse outcome.

Patients without informed consent or under 18 years of age and patients with concomitant diseases in the ipsilateral leg were excluded from the analysis. Patients with insufficient data or without follow-up were also excluded from the study.

Statistical analysis

Categorical data are expressed as frequency counts (%) and continuous data as mean ± standard deviation (SD). Proportions between groups were compared with Fisher's exact test and continuous variables with the *t* test. The Phi test and Cramer *V* test were used to

TABLE 1 Demographic data.

	Mean ± SD (min; max)
Age in years	45.2 ± 15.2 (15; 90)
Height in cm	176.3 ± 17.9 (153; 205)
Weight in kg	90.8 ± 21.3 (55; 173)
BMI in kg/m^2	28.8 ± 6.5 (18; 53)
Sex = male (%)	96 (80.0)
Affected side, *n* (%)	
Left knee	62 (51.7)
Right knee	58 (48.3)

Abbreviation: BMI, body mass index.

calculate the correlation between nominal variables, and Spearman's test to correlate metric variables with ordinal variables. The sample size was not calculated because the aim of the study was to recruit as many patients with injuries as possible. The study office used the RedCap System for data management and IBM SPSS Statistics, version 26.0, for data analysis (IBM Corp.) GraphPad Prism (version 8.0, GraphPad Software) was used for graphical presentation.

A post hoc power analysis was performed by using statistical software (G*Power, v 3.1.9.2; Heinrich-Heine-Universität) and revealed that with an alpha of 0.05 and a sample size of 120, a power of 0.91 was achieved.

RESULTS

This study included 120 patients with knee dislocation treated between 2009 and 2021. Patient and injury characteristics are summarised below (Table 1, Figures 1 and 2). Of all participants, 23 (19.2%) reported a previous injury to the ipsilateral knee. The most common injuries were cartilage lesions in 10 (8.3%) and meniscal lesions in seven cases (5.8%). Ten patients (8.3%) had previously undergone surgery on the affected knee joint.

On arrival at the emergency department, 35 patients (29.3%) still had a dislocated knee. Overall, 21 (17.5%) had deficits in peripheral perfusion as well as in sensory and motor function. The most common nerve injury was to the peroneal nerve in 21 patients (17.5%), while the most common vascular injury was to the popliteal artery in seven patients (5.8%) (Table 2).

All patients received standardised radiographs of the knee joint (anterior–posterior and lateral views, 100%), while 74 patients additionally (62.0%) underwent computed tomography (CT) and 20 patients CT angiography (16.7%). Vascular ultrasound was conducted in 58 cases (48.3%), magnetic resonance

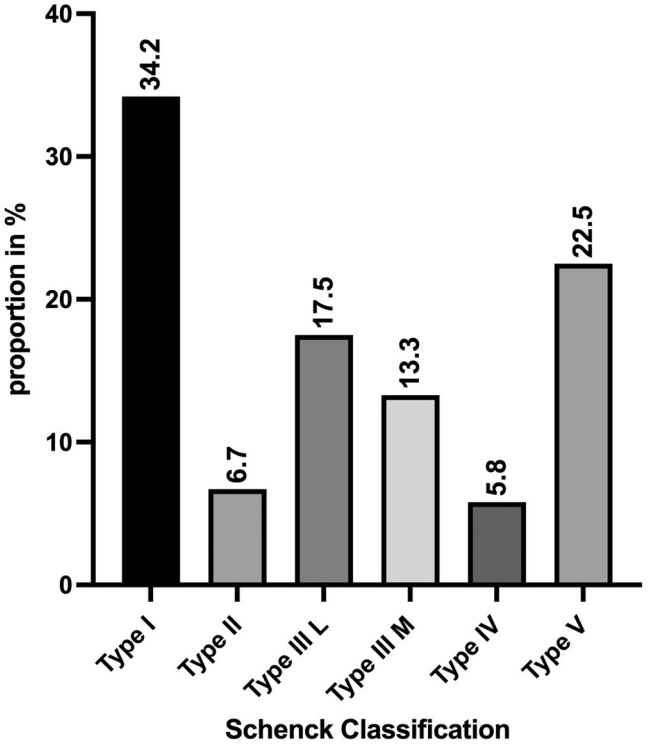

FIGURE 1 Proportion of Schenck classification of included knee dislocations.

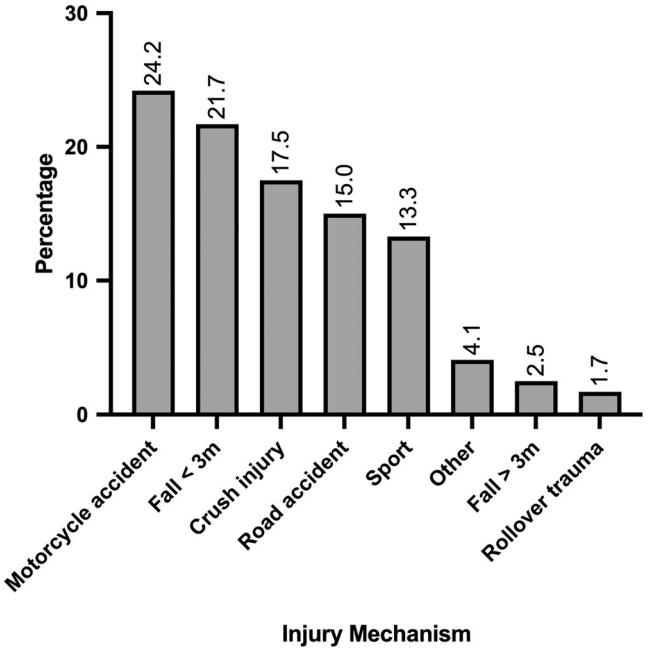

FIGURE 2 Reported injury mechanism of knee dislocation.

imaging (MRI) scan in 94 patients (78.3%) and MRI angiography in 12 patients (10.0%). Cross-sectional imaging was performed in 97.5% of the patients, with specific vessel imaging in 24.2%.

Meniscus injuries occurred in 71 patients (57.3%); the medial meniscus was involved in 31 patients

TABLE 2 Dislocation status, status of neurovascular structures and initial treatment of knee dislocation.

	n (%)
Dislocation on arrival at the emergency department	35 (29.2)
Spontaneous reposition at the site of the accident	80 (66.7)
Reposition through preclinical first responder	10 (8.3)
Peripheral perfusion, sensory or motor function	21 (17.5)
Neurovascular lesion	21 (17.5)
Peroneal nerve	21 (17.5)
Tibial nerve	3 (2.5)
Sciatic nerve	1 (0.8)
Femoral nerve	0 (0.0)
Popliteal artery	7 (5.8)
Tibial artery	0 (0.0)
Initial treatment	
External fixator without ligament bracing	100 (83.3)
External fixator with ligament bracing	15 (12.5)

TABLE 3 Time between injury and first, second and third surgical treatment.

	Median ± SD (min; max)
Time between injury and first treatment	9 days ± 181.6 (min: 0; max: 1464)
Second surgery *n* (%)	68 (56.7)
Time between injury and second surgery	194 days ± 351.1 (min: 5; max: 1939)
Third injury *n* (%)	18 (15.0)
Time between injury and third surgery	295 days ± 376.6 (min: 13; max: 1288)

(25.8%) and the lateral meniscus in 27 patients (22.5%). Both menisci were injured in 16 patients (13.3%). An osteochondral lesion occurred in 45 patients (37.5%), while a compartment syndrome was reported in only four patients (3.3%). Excluding emergency surgery due to compartment syndrome or vascular injury, the first surgery was performed after a median time of 9 days (SD: 181.6 days). A second operation was required by 68 patients (56.7%) (Table 3).

Twelve months after the injury, 60 patients reported abnormal knee function with limitations in activities of daily living (50%), and 28 reported limitations in ROM (23.6%); 28 reported a flexion deficit of <110° (23.6%), 21 a flexion deficit of <100° (17.5%) and 11 a flexion deficit of 90° and less (9.2%). Extension was limited by 10° and more in seven of all patients (5.8%), whereas one had a limitation of more than 20° (0.8%). Surgical site infection occurred in four patients (3.3%) (Table 4).

TABLE 4 Complications during the treatment of knee dislocation.

	n (%)
Surgical site infection	4 (3.3)
Posttraumatic cartilage lesion	50 (41.7)
Posttraumatic neurovascular injury	16 (13.3)
Arthrofibrosis	6 (5.0)
Regular pain medication	11 (9.2)
Minor limitations in everyday life	60 (50.0)
Severe limitations in everyday life	14 (11.7)
Limitation in ROM	28 (23.6)

Abbreviation: ROM, range of motion.

Correlations between complications and patient- and injury-specific factors were calculated to evaluate influencing factors. Correlation analysis identified weight ($r = 0.294$; $p < 0.001$ and $r = 0.259$; $p = 0.004$), body mass index (BMI) ($r = 0.296$; $p < 0.001$ and $r = 0.264$; $p = 0.004$) and the status of peripheral perfusion as well as sensory and motor function ($r = 0.231$; $p = 0.040$ and $r = -0.192$; $p = 0.036$) as influencing factor for worse outcome in limitations in everyday life and ROM. Posttraumatic neurovascular injuries showed a lack of peripheral perfusion and insufficient sensory and motor function ($r = -0.683$; $p < 0.0001$), as well as a higher Schenck grade ($r = 0.320$; $p = 0.037$). Previous knee injury, dislocation status at the emergency department and at the site of the accident, age and sex had no impact on a worse outcome (Table 5).

DISCUSSION

The most important findings of this retrospective cohort study on 120 knee dislocations were the detection of weight, the status of peripheral perfusion, as well as insufficient sensory and motor function as significant risk factors for worse clinical outcomes in terms of limitations in daily activities and ROM. Factors associated with posttraumatic neurovascular injury included poor peripheral perfusion, insufficient sensory and motor function and a higher Schenck classification.

The basic anthropometric data of our study population were comparable to those already published in the literature. In our population, with a male-to-female ratio of 80%, knee dislocation was predominantly seen in men. This result is in line with published epidemiological data describing a male-to-female ratio of 80%, with the majority of patients being young men [30]. This high ratio is consistent with the mechanism of trauma,

TABLE 5 Risk factor analysis for limitations in everyday life, range of motion (ROM) and neurovascular injury.

	Limitation in everyday life		Limitation in ROM		Posttraumatic neurovascular injury	
	r	*p* Value	*r*	*p* Value	*r*	*p* Value
Sex	0.098	n.s.	0.035	n.s.	0.019	n.s.
Weight	0.294	<0.001*	0.259	0.004*	0.571	n.s.
BMI	0.296	<0.001*	0.264	0.004*	0.417	n.s.
Age	0.990	n.s.	0.709	n.s.	0.576	n.s.
Previous knee injury	0.292	n.s.	0.268	n.s.	0.159	n.s.
Dislocation on arrival at ED	0.118	n.s.	−0.007	n.s.	0.025	n.s.
Dislocation at the site of the accident	0.100	n.s.	0.094	n.s.	0.106	n.s.
Peripheral perfusion, sensory and motor function	0.231	0.040*	−0.192	0.036*	−0.683	<0.0001*
Schenck classification	0.321	n.s.	0.246	n.s.	0.320	0.037*

Note: * indicate a significant result by using a significance level ≤ 0.03.

Abbreviations: BMI, body mass index; ED, emergency department; n.s., nonsignificant; ROM, range of motion.

in which mainly high-impact injuries have been reported. Sports and road traffic accidents involving cars or motorcycles accounted for more than half of all dislocations in our patient collective. In their review, Robertson et al. also reported mainly road traffic accidents and sports injuries as the predominant mechanisms of knee dislocation [30]. Interestingly, 26 of all injuries (21.7%) could be classified as low-impact trauma with falls from less than 3 m.

The most commonly used classification of knee dislocations was introduced by Schenck et al. [31]. In our population, type I lesions (rupture of the isolated anterior cruciate ligament [ACL] or posterior cruciate ligament [PCL]) were the most common, with 34.2%. Schenck type V lesions were reported in 22.5% (knee fracture dislocation), and type III lesions in 17.5% (ACL + PCL + lateral collateral ligament). Anterior–posterior dislocations account for more than 70.0% of injuries and cause lesions of the cruciate ligament structures. In case of additional valgus or varus stress, knee dislocations result in injuries to the lateral or medial collateral ligaments [30]. Type III lesions are the most common injury pattern described in the literature, accounting for up to 41% of knee dislocations [19, 30].

Concurrent with the number of higher Schenck grades, a dislocated status was presented to the emergency department in 35 of all knee dislocations in our population (29.2%). At the first assessment, a neurovascular lesion was reported in 21 patients (17.5%). In our study, the peroneal nerve was most commonly affected. Nerve injury is a serious complication and is associated with a high rate of neurological sequelae. In patients with a complete lesion of the peroneal nerve, only 38% recovered motor strength greater than three out of five, according to the Janda strength scale. In partial lesions, up to 87% of patients achieved motor strength greater than three out of five on the Janda scale after full rehabilitation [36]. Nerve injury after knee dislocation is reported in up to 48% of patients, depending on the severity of the dislocation [1, 2, 14, 27]. Lesions of the peroneal nerve are most common due to the anatomic site on the lateral aspect of the knee [19]. Niall et al. found peroneal nerve injury in 25% of patients with knee dislocation. Particularly in patients with lesions on ACL, PCL, and the (postero-) lateral structures (Schenck III-L), knee joint nerve injuries were common with up to 41% [21].

While conservative treatment showed inferior results, primary stabilisation of highly unstable knee joints with an external fixator or primary ligament bracing showed significantly better results [9, 12, 15, 24]. A meta-analysis published by Frosch et al. comparing ligament bracing and reconstruction of the ACL and/or PCL showed comparable results, including dislocation of Schenck II and higher dislocations [4].

Neurovascular injury is a feared complication in patients with knee dislocation due to the mechanism of the trauma. Analysis of factors associated with posttraumatic neurovascular injury in our collective showed deficits in peripheral perfusion as well as sensory and motor function at first assessment ($r = -0.683$; $p < 0.0001$) and Schenck classification ($r = 0.320$; n.s.) as significant risk factors. The status of knee dislocation at the site of the accident (n.s.) or on arrival at the emergency department (n.s.) did not influence the occurrence of posttraumatic neurovascular injury. Based on this result, it can be assumed that the time of dislocation, at least between the accident and arrival at the hospital, does not influence the rate of neurovascular injury, but the trauma itself does. In

particular, knee dislocations with higher Schenck grades, that is, with more injured structures and, therefore, a higher grade of dislocation, are responsible for the development of lesions of vessels and nerves [3, 23, 27, 29]. In a meta-analysis by Medina et al., vascular injuries were commonly reported in knee dislocations of Schenck type III and higher [19]. Focusing on the direction of dislocation according to the Kennedy classification, posterior joint dislocations are most commonly associated with lesions of vascular injury (25.0%) [19].

The rate of surgical site infections in our collective was rather low at 3.3%. Data on infections associated with knee dislocation are scarce in the literature, but existing data also report a low rate of infection [10]. However, the rate of surgical site infections is increasing with regard to secondary surgical treatments and potential bony, vascular or nerve interventions and can reach rates of up to 10%, depending on patient- and treatment-related risk factors [20, 22]. A higher percentage was reported for posttraumatic cartilage lesions, with 41.7% ($n = 50$) in our data set. The site of the cartilage lesion depends on the direction of the dislocation; however, the prevalence has been reported in previously published literature to be almost 50.0%, which matches our data [16]. Concurrent meniscal tears have been reported in 55.0% of all knee dislocations [16]. In particular, the complexity of knee dislocations and the rupture of multiple ligaments is associated with posttraumatic cartilage lesions and subsequent posttraumatic osteoarthritis of the knee joint. A multiple-increased odds ratio has been reported [35].

Limitations in daily activities were reported by half of the patients, while only 14 (11.7%) had severe problems. However, limitations in ROM were more common, reported by 28 (23.6%) of the study population. Despite new treatment strategies and surgical techniques, the severe soft-tissue damage caused by knee dislocation results in a high rate of knee disability [30]. Only 40% of patients reported normal knee function after knee dislocation, while the majority reported abnormal and severely abnormal function [6, 17, 26, 34]. Significant stiffness of the knee joint with limitations in ROM has been described in up to 21% of the patients in the literature, with surgical intervention required by 14% [8].

Significant risk factors for the development of limitations in activities of daily living and limitations in ROM were weight, BMI, lack of peripheral perfusion as well as insufficient sensory and motor function. Interestingly, the status of dislocation or the severity of the injury (graded according to the Schenck classification) had no impact on limitations in ROM or in activities of daily living. Hanley et al. also showed the number of injured and surgically treated ligaments as a risk factor for the development of posttraumatic knee stiffness ($p = 0.04$). In contrast to our data, which did not show any statistically significant correlation between dislocation at admission to the hospital or at the site of the accident, Hanley et al. also reported the status of knee dislocation at hospital admission as a risk factor ($p = 0.04$) [8].

Patients exhibiting these specific characteristics, as mentioned above, require vigilant and thorough monitoring to mitigate the risk of experiencing adverse long-term outcomes. This necessitates regular and attentive observation, sufficient rehabilitation coupled with potential proactive intervention strategies aimed at minimising the potential negative consequences associated with their condition over an extended period. Early rehabilitation and early physiotherapy in patients with knee dislocation have shown benefits in a small study population and need to be confirmed in a larger population. However, this approach seems to decrease the development of knee stiffness and limitations in ROM and should be implemented in clinical routine [11].

Despite the strength of this study, some limitations need to be mentioned. Its main limitation is the retrospective design, but it has the benefit of a larger study population. Another limitation is the lack of standardised functional scores. However, we collected data on persisting complications at a follow-up visit 12 months after the injury, and patients were asked to fill in a standardised questionnaire on persisting limitations and postoperative issues.

CONCLUSION

Knee dislocation is a rare injury with a high rate of severe complications such as neurovascular lesions. The status of the dislocation at the site of the accident and on arrival at the emergency department had no impact on posttraumatic neurovascular injury or outcome. Significant risk factors for limitations in activities of daily living and ROM were weight, the status of peripheral perfusion as well as insufficient sensory and motor function. Patients with knee dislocation require frequent follow-ups to identify and treat potential complications at an early stage.

AUTHOR CONTRIBUTIONS

Dominik Szymski, Lorenz Huber and Johannes Weber drafted the manuscript, performed statistical analysis and conceived the study. Markus Rupp, Volker Alt and Johannes Weber supervised the study. Dominik Szymski, Johannes Weber, Lorenz Huber and Markus Rupp conceived of the study and participated in its design and coordination and helped to draft the manuscript. Lorenz Huber, Dominik Szymski, Markus Rupp and Johannes Weber are responsible for data assessment and databank management. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT
The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
Data are available on request.

ETHICS STATEMENT
The study design was approved by the Ethics Committee of the University of Regensburg. Informed consent was obtained from all participants.

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