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Management of acute knee dislocation with vascular injury: the use of the external fixator. A systematic review

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Abstract

Introduction Vascular injuries after traumatic knee dislocation pose a potential limb threat for the patient. The benefits of external fixation have been described by many authors. However, the usefulness of the external fixator during acute management of knee dislocations with vascular injuries is a controversial aspect that has no consensus in the literature. The purpose of the present study was to provide data from the current literature on the utility of the external fixator and to investigate the percentage of knee dislocations with vascular injuries treated with an external fixator, the timing between external fixator and vascular repair, and the total time of external fixator.

Material and methods The present systematic review was conducted according to the PRISMA checklist. MEDLINE (Pubmed), Web of Science, and SCOPUS databases were searched for articles from 1 January 2000 to 6 February 2019. Studies reporting outcomes of treatment of knee dislocations with vascular injuries were included. Exclusion criteria included studies investigating chronic knee dislocations, knee arthroplasties, editorials, case reports, and expert opinions. Two authors independently extracted data and appraised the quality of evidence and risk of bias using the Methodological quality and synthesis of case series and case reports.

Results Descriptive statistics were used to report the outcome of our findings. Seven studies related to the usefulness of the external fixator during acute management of knee dislocations with vascular injuries were included. The external fixator had been used in the majority of knee dislocations with vascular lesions (72%). Timing between external fixator and vascular repair was reported on four studies (57%), two studies performed external fixation before vascular repair, and two studies performed external fixation after vascular repair. Total time of external fixator was only reported on three studies, ranging from 3 weeks to 3 months. These studies reported acute management, without referring to long-term results and without comparative groups.

Conclusions External fixator was used in the majority of knee dislocations with vascular injuries but the justification for its use remained unclear. Larger studies are needed to fully understand the merit of the external fixator in knee dislocations with vascular injuries. Joint protocols between vascular surgeons and trauma surgeons are necessary to agree on the aspects related to the management of knee dislocations with vascular injuries.

Level of evidence IV.

Keywords Knee dislocation · Vascular injury · External fixator · Multiligament knee injury

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Abbreviation

MLIK Multiple ligament injured knee

Introduction

Knee dislocation is a rare injury, accounting for less than 0.02% of orthopaedic injuries [1–6]. It is defined as the disruption of the integrity of the tibiofemoral joint, while a multiple ligament injured knee (MLIK) is defined as the rupture of at least two of the main four knee ligament stabilizer

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groups. Because of the high incidence of spontaneous reduction before the physician's arrival, every MLIK should be treated immediately as a true knee dislocation until proven otherwise [1, 4, 7–12]. Recent publications describe that the presence of a periarticular fracture predicts significantly worse clinical outcomes in the setting of MLKI, without significanct differences in age, gender, BMI, follow-up time, time till surgery, the staging of surgery, or incidence of ligamentous, vascular, or nerve injury patterns between patients with or without a concomitant periarticular fracture [13] In recent studies, the incidence of vascular lesions during knee dislocation ranged from 3 to 18% [1, 3, 7, 8, 14–18]. The need for repair of vascular lesions in knee dislocation has been quoted to range from 13 to 80% [7, 8, 14–17]. Rapid identification and repair of vascular injury are critical, as vascular injuries are potentially limb threatening and can result in the possible need for an amputation [7, 8, 16, 19]. The benefits of post-reconstructive spanning external fixation have been described by many authors [9, 20–22]. However, the usefulness of the external fixator during acute management of knee dislocations with vascular injuries is a controversial aspect that has no consensus in the literature [23, 24]. Therefore, a systematic review of current evidence was performed. The purpose of the present study was to provide data from the current literature on the utility of the external fixator and to investigate the percentage of knee dislocations with vascular injuries treated with an external fixator, the timing between external fixator and vascular repair, and the total time of external fixator.

Material and methods

Search strategy

The present systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [25].

Literature search

A comprehensive search was performed on MEDLINE (Pubmed), Web of Science, and SCOPUS databases from 1 January 2000 to 6 February 2019. The aim was to include only the most recent papers using modern techniques. Randomised and non-randomised clinical trials, case series, multicenter studies, reviews, systematic reviews and meta-analyses were included. There were no limitations on the chosen cultural/language criteria.

Search strategies are shown in Table 1. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies and assessed using the inclusion and exclusion criteria.

Eligibility criteria

Eligible studies for the present systematic review included those investigating the treatment of knee dislocations with vascular injuries. Primary screening of the titles and abstracts was performed, and all studies of any level of evidence were included. Exclusion criteria included studies investigating chronic knee dislocations, knee arthroplasties, editorials, case reports, and expert opinions. We excluded all duplicates. Additionally, we excluded studies in which data about treatment was not accessible, missing or not well-reported.

Outcomes of interest

Two authors independently extracted data from selected studies and the data collected was compared to verify the agreement. All data were extracted from article texts, tables, figures, and the Population, Intervention, Comparison and Outcome (PICO) framework, which included title, year of publication, study design, sample size, study population, patient characteristics, intervention and comparator (if

Table 1 Search strategies: February 6, 2019

Database	Search term	Search result
Pubmed	("Knee Dislocation"[Mesh] OR "Knee Joint"[Mesh] OR "Knee Injuries"[Mesh] OR "Joint Instability"[Mesh] OR Knee joint* [tiab] OR knee dislocation [tiab] OR "Ligaments, Articular/surgery"[MAJR] OR "Ligaments, Articular/injuries"[MAJR]) AND ("Popliteal Artery"[Mesh] OR "Vascular System Injuries"[Mesh] OR "Vascular Diseases"[Mesh] OR Popliteal vascular [tiab] OR Vascular system injur*[tiab] OR Popliteal arter*[tiab])	2427
Scopus	INDEXTERMS ("Knee Dislocation") OR INDEXTERMS ("Knee Joint") OR INDEXTERMS ("Knee Injuries") OR INDEXTERMS ("Joint Instability") OR TITLE-ABS("knee dislocation") OR ALL ("ligaments") AND INDEXTERMS ("Popliteal Artery") OR INDEXTERMS ("Vascular System Injuries") OR INDEXTERMS ("Vascular Diseases") OR TITLE-ABS("Popliteal vascular") OR TITLE-ABS("Vascular system injury") OR TITLE-ABS("Popliteal artery")	1448
Web of science	(TS = (knee dislocation) OR TS = (knee joint) OR TS = (knee injuries) OR TS = (joint instability) OR TI = (knee dislocation) OR TS = (ligaments)) AND (TS = (popliteal artery) OR TS = (vascular system) OR TS = (vascular diseases) OR TI = (popliteal vascular) OR TI = (vascular system injury) OR TI = (popliteal artery))	7362

applicable), outcomes, funding, and conclusions. The outcomes of interest were the percentage of knee dislocations with vascular injuries treated with an external fixator, the timing between external fixator and vascular repair, and the total time of external fixator.

Methodological quality assessment

The quality of evidence and risk of bias was assessed using the Methodological quality and synthesis of case series and case reports [26]. This assessment used eight items that can be categorized into four domains (selection, ascertainment, causality, and reporting). We presented the main findings of the review in Table 2.

Results

Search results

Descriptive statistics were used to report the outcome of our findings. A total of 11,237 records were collected from MEDLINE (Pubmed), Web of Science, and SCOPUS databases using the aforementioned inclusion and exclusion criteria. We located one additional record not found in the initial search using bibliographies of the retrieved records. Overall, 11,238 papers were screened through the reading of the abstracts and titles. After reading the full texts and checking the reference lists, we selected seven articles for analysis in our systematic review. A PRISMA flow chart of the selection process and screening is provided in Fig. 1. The study design, patient demographics, outcomes and main findings are summarized in Table 3.

Methodological quality assessment

Methodological quality and synthesis of case series and case reports [26] were used to assess the quality of evidence and risk of bias. We presented the main findings of the review in Table 2. The quality of evidence and risk of bias was good.

Outcomes of interest

The study design, patient demographics, outcomes and main findings are summarized in Table 3. The external fixator had been used in the majority of knee dislocations with vascular lesions (34/47 = 72%). No comparative results of knee dislocation with vascular injury treated by external fixation versus non-external fixation were found. Timing between external fixator and vascular repair was reported on four studies (57%), two studies performed external fixation before vascular repair, and two studies performed external fixation after vascular repair. No comparative results between timing between external fixator and vascular repair were found. Total time of external fixator was only reported on three studies, ranging from 3 weeks to 3 months. No comparative results between the total time of external fixator were found.

Selected articles

Engebresten et al. [2] published a prospective cohort study of 85 knee dislocations. The aim of the study was to document knee function and knee osteoarthritis at a minimum of 2 years of follow-up after knee dislocation. Five patients (6%) sustained injuries to the popliteal artery and underwent surgical bypass or embolectomy with temporary external fixation (100%) followed by ligament reconstruction 3–6 months later. Based on their results, the presence or absence of a neurovascular injury did not have an effect on the outcomes in their study. Bonnevialle et al. [27] published a retrospective study of 14 knee dislocations with popliteal vascular disruption. The dislocation was stabilized by an external fixator in nine (64%) patients (current cases) and by a cruropedious cast in five (36%) patients (old cases). In all cases, external fixation was performed before vascular repair. Mean duration of the external fixator was 3.4 months. They described the superiority of the external fixator against the cruropedious cast, facilitating the care of traumatic wounds and aponeuroses and making it easier to monitor limb revascularization by direct access to pulse palpation sites. López-Hualda et al. [28] conducted a retrospective study of 10 acute knee dislocations. They described three popliteal artery injuries requiring repair of the vessels and application

Table 2 Study quality assessment

References	1	2	3	4	5	6	7	8
Engebresten et al. [2]	Yes	Yes	Yes	No	No	No	Yes	Yes
Bonnevialle et al. [27]	Yes	Yes	Yes	No	No	No	Yes	Yes
López-Hualda et al. [28]	Yes	Yes	Yes	No	No	No	No	Yes
Levy et al. [23]	Yes	Yes	Yes	No	No	No	Yes	Yes
Kupczik et al. [8]	Yes	Yes	Yes	No	No	No	No	Yes
Liu et al. [29]	Yes	Yes	Yes	No	No	No	Yes	Yes
Sanders et al. [30]	Yes	Yes	Yes	No	No	No	Yes	Yes

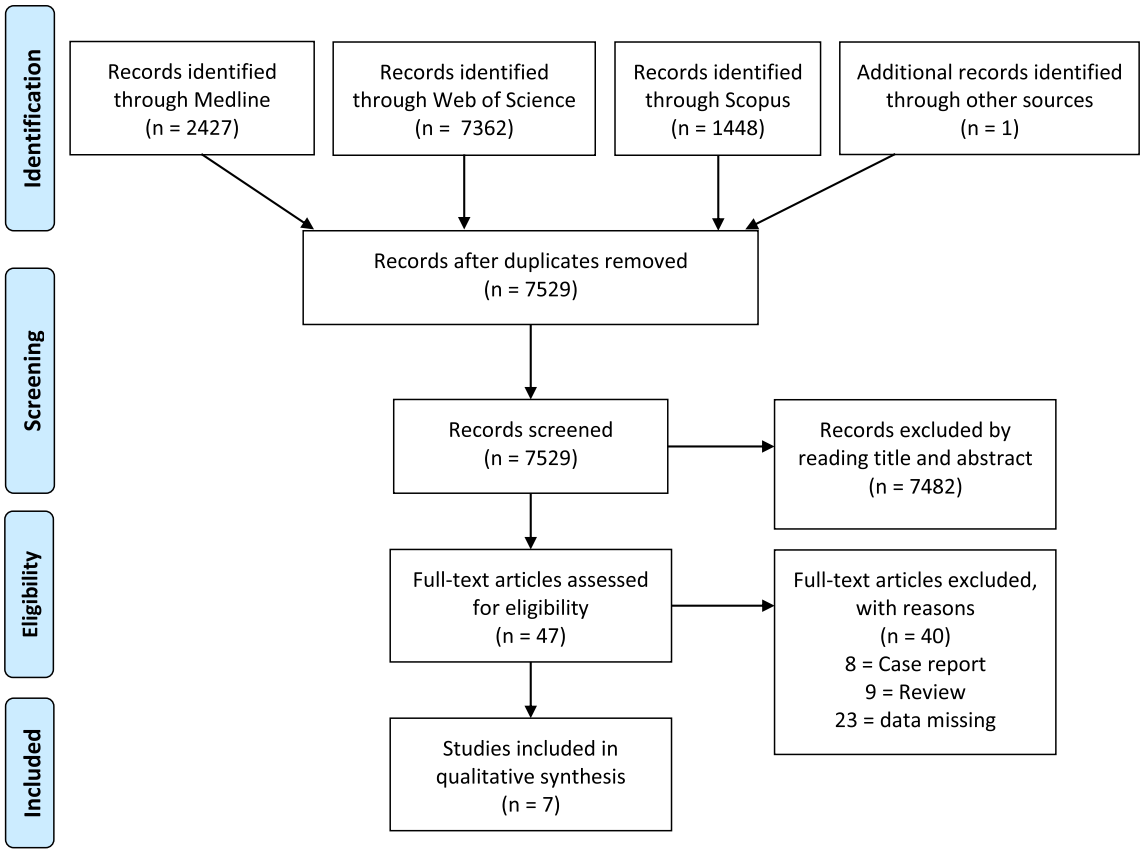

Fig. 1 PRISMA flowchart of the systematic literature review

of an external fixator (100%) without complications. Levy et al. [23] described clinical and functional outcomes for nine patients who received initial spanning external fixation for the treatment of knee dislocations. The main indications for spanning external fixation included significant vascular injury (22%) regardless of whether the vascular injury requires surgical intervention, gross instability on examination with failure to maintain joint reduction (44%), open knee dislocation (22%), and inability to tolerate mobilization in a brace (11%). All fixators were removed approximately 3–4 weeks after placement, at which point all patients were transferred to a hinged knee brace. They concluded that the treatment algorithm utilized in this series for management of the dislocated knee demonstrated satisfactory clinical and functional outcomes. Kupczik et al. [8] described the management of 23 knee dislocations, including 15% with an arterial injury. The initial treatment consisted of joint reduction and stable fixation using a transarticular external fixator in all the patients (100%), which promoted better soft tissue control, maintaining joint reduction and facilitating patient management with regard to angiographic studies and nursing care. In all cases, the vascular repair was performed after placement of the external fixator. Liu et al. [29] reported the clinical and functional results of 15 patients who underwent surgical management for posterior knee dislocations associated with extensor apparatus rupture. For the four patients with associated vascular injuries, a hinged external fixator or tibial tubercle tractor was applied after vessel exploration and repair to immobilize the knee (100%). All fixators were removed approximately 6 weeks after placement. The conclusion was that patients who sustained posterior knee dislocations with associated vascular injuries needed immediate assessment and revascularization, with postponed extensor apparatus repair and multiple ligament reconstruction. Sanders et al. [30] published a matched cohort analysis to compare knee function after multi-ligament knee injury between patients with a vascular injury requiring popliteal artery bypass grafting ($n=16$) and patients without vascular involvement ($n=32$). In the vascular cohort, seven patients (43%) had placement of a temporary spanning external fixator after the vascular procedure but prior to the ligament surgery using Levy's protocol [23]. The conclusion was that patients who sustained a multi-ligament knee injury with an associated popliteal artery injury requiring bypass grafting had significantly lower knee function scores than patients without vascular involvement. They suggested that it may be related to prolonged limb ischemia, the mechanism of injury, reperfusion consequences, associated injuries, or

Table 3 Summary of outcomes of interest of the studies included

References	Study design	Patient demographics	Outcomes	Conclusion
Engebresten et al. [2]	Prospective cohort	Knee dislocation $n=85$ Vascular injuries $n=5$ (6%) Treatment with Ext.Fix $n=5$ (100%)	Timing Ext. Fix vs vascular repair: not reported Total time of external fixator: not reported	The presence or absence of a neurovascular injury did not have an effect on the knee function and osteoarthritis at a minimum 2 years follow-up
Bonnevialle et al. [27]	Retrospective cohort	Knee dislocation $n=37$ Vascular injuries $n=14$ (38%) Treatment with Ext.Fix $n=9$ (64%)	External Fixator before vascular repair total time of external fixator: 3.4 months	Superiority of external fixator against cruropedious cast, facilitating the care of traumatic wounds and aponeurotics and making easier to monitor limb revascularization
López-Hualda et al. [28]	Retrospective cohort	Knee dislocation $n=10$ Vascular injuries $n=3$ (30%) Treatment with Ext.Fix $n=3$ (100%)	Timing Ext. Fix vs vascular repair: not reported total time of external fixator: not reported	The systematic use of the protocol has avoided consequences of late diagnosis and has drastically reduced the abusive use of invasive tests
Levy et al. [23]	Retrospective cohort	Knee dislocation $n=9$ Vascular injuries $n=2$ (22%) Treatment with Ext.Fix $n=2$ (100%)	Timing Ext. Fix vs vascular repair: not reported total time of external fixator: 3–4 weeks	A staged protocol involving initial spanning external fixation provided comparable clinical and functional outcomes with the current standard of care
Kupczik et al. [8]	Retrospective cohort	Knee dislocation $n=23$ Vascular injuries $n=3$ (15%) Treatment with Ext.Fix $n=3$ (100%)	External Fixator before vascular repair total time of external fixator: not reported	External fixator provides good soft-tissue control, maintining the joint reduction
Liu et al. [29]	Retrospective cohort	Knee dislocation $n=15$ Vascular injuries $n=4$ (26%) Treatment with Ext.Fix $n=5$ (100%)	External Fixator after Vascular Repair Total time of external fixator: 6 weeks	Patients with posterior knee dislocation associated with vascular injuries need immediate assessment and revascularization, with a postponed extensor apparatus repair and multiple ligament reconstruction
Sanders et al. [30]	Retrospective matched-cohort	Knee dislocation $n=48$ (32/16) Vascular injuries $n=16$ (33%) Treatment with Ext.Fix $n=7$ (43%)	External fixator after vascular repair total time of external fixator: not reported	Patients who sustain an MLKI with an associated popliteal artery injury requiring bypass grafting have significantly lower knee function scores than patients without vascular involvement

concomitant tissue damage requiring external fixation or fasciotomy. In the control cohort, five patients (16%) were treated with an external fixator. However, no data were provided between patients with vascular injuries treated with an external fixator and those not treated with an external fixator (cast or without immobilization).

Discussion

According to the main findings of the present systematic review, the external fixator had been used in the majority of knee dislocations with vascular lesions (72%). Only three studies indicated the duration of external fixation (from 3 weeks to 3 months). Timing between external fixator and vascular repair was reported on four studies (57%), two studies performed external fixation before vascular repair, and two studies performed external fixation after vascular repair.

The indication concerning immobilization with an external fixator in knee dislocation with vascular injury is clearly accepted among specialists. Maslaris et al. [9] concluded that indications for the initial application of an external fixation after knee dislocations were open major trauma, vascular injury, compartment syndrome, unstable dislocated joint fractures, polytrauma patients during damage control, and practical difficulties or insufficient stability after bracing. Levy et al. [23] concluded that the main indications for initial spanning external fixation were significant vascular injury, gross instability on examination with failure to maintain joint reduction, open knee dislocation, and inability to tolerate mobilization in a brace whether due to pain or noncompliance. With regard to vascular injury, they concluded that the recommendation for initial spanning external fixation applies regardless of whether the vascular injury requires surgical intervention because the rationale for external stabilization is to protect against further vascular trauma when the arterial injury does not require surgery and to stabilize the vascular repair when the injury does require surgery. Compared with casts, the external fixator offers monitoring of the soft tissues and neurovascular status and better stability. The disadvantages of the external fixator include the invasiveness of the procedure, risk of pin infections, potential damage to the extensor mechanism of the knee, and joint rigidity, although the severity of injury alone appears to be a predisposing factor to joint stiffness [9].

The timing between vascular reconstruction and the placement of an external fixator remained controversial. Some authors recommended the placement of an external fixator after vascular exploration or repair. This decreases the ischemia time and allows knee flexion, which is critical for medial popliteal exposure by the vascular surgery team [31, 32]. However, other authors recommended the use of external fixation before definitive arterial repair and the presence of a vascular surgeon to assist with planning the placement of external fixation, as improperly located hardware may hamper surgical exposure during revascularization [33].

There were no recommendations in protocols about the best time to remove the external fixator in cases with vascular injury.

Limitations

The major limitation of this systematic review is the quality of the included studies. Most of the included studies were retrospective case series without control groups and without clinical and functional outcomes.

Conclusion

According to the main findings of the present systematic review, an external fixator was used in the majority of knee dislocations with vascular injuries but the justification for its use remained unclear. Larger studies are needed to fully understand the merit of the external fixator in knee dislocations with vascular injuries. Joint protocols between vascular surgeons and trauma surgeons are necessary to agree on the aspects related to the management of knee dislocations with vascular injuries.

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Compliance with ethical standards

Conflict of interest The authors report no conflicts of interest or sources of funding with regard to the present study. Eduard Ramírez Bermejo, Pablo Gelber, Nicolas Pujol.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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