Injury, Int. J. Care Injured xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Return to duty following combat-related multi-ligamentous knee injury

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ARTICLE INFO

Article history:
Received 27 October 2016
Received in revised form 16 January 2017
Accepted 21 February 2017

Keywords:
Multi-ligament knee injury
Combat injury
Return to duty

ABSTRACT

Introduction: This retrospective cohort study characterized injury patterns, treatment practices, and identified the return to duty (RTD) rate following combat-related multi-ligament knee injuries (MLKI).
Patients and methods: We evaluated injury characteristics and treatment methods of 46 military service members who had sustained a MLKI during combat activity. The primary clinical outcome measure was ability to return to active military duty. Secondary outcomes included subjective pain score, knee motion, knee instability, and use of ambulatory assistive device.
Results: The RTD rate was 41% (19/46). High-energy mechanism, neurovascular injury, compartment syndrome, traumatic knee arthrotomy, and intra-articular femur fracture (Orthopedic Trauma Association Classification (OTA) 33-B/C) were all more prevalent in subjects who were unable to return to duty ($p < 0.05$). Acute external fixator application and poor knee range of motion (ROM) were also associated with military separation ($p = 0.041$ and $p = 0.016$, respectively). The most common ligament injury pattern ($n = 9$; 20%) was combined disruption of the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), posterolateral corner (PLC), and medial collateral ligament (MCL). However, number of ligaments injured was not associated with RTD status.
Conclusion: MLKIs sustained in a combat setting have a high incidence of associated lower extremity injuries. Certain associated injuries, such as intra-articular femur fracture, knee arthrotomy, neurovascular injury, and compartment syndrome may be more important than the severity of the knee ligamentous injury in determining RTD outcome.

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Introduction

Multiligamentous knee injuries (MLKIs) are a potential source of long-term disability, often impairing patients' ability to return to prior functional levels [1–6]. Return to work and sport rates are commonly reported MLKI treatment outcomes [7–9]. In a military population, return to duty (RTD) rate is an objective measure of functional recovery following lower extremity injury [10–12]. In order to be considered "fit for military duty" a service member must be able to function at a physical level high enough to perform all job-specific duties as well as pass military fitness requirements. The purpose of this study is to characterize injury patterns in MLKIs sustained in a combat setting and to identify the RTD rate.

Patients and methods

After protocol approval by our Institutional Review Board, we performed a query of the Joint Theatre Trauma Registry (JTTR) to identify service members who sustained MLKI while in a deployed setting between 2003 and 2011. The query included International Classification of Disease, 9th Revision codes 836.50, 836.60 and 844.0–844.9, which returned 174 potential subjects. These patients' medical records were then queried from the Patient Administration Systems and Biostatistics Activity (PASBA) using Web Interface Scanned Patient Records (WISPR) as well as the Armed Forces Longitudinal Technology Application (AHLTA). Subjects were included in the study if their records confirmed a MLKI sustained in a combat setting. A total of 46 service members met inclusion criteria.

Knee ligament injury pattern was based upon knee magnetic resonance imaging (MRI) reports or documentation included in operative notes. MLKIs were defined as disruption of two or more ligaments of the knee, including anterior cruciate ligament (ACL),

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http://dx.doi.org/10.1016/j.injury.2017.02.019
0020-1383/Published by Elsevier Ltd.

posterior cruciate ligament (PCL), medial collateral ligament (MCL), and posterolateral corner (PLC). Injuries to the PLC were defined as disruption of the lateral collateral ligament (LCL), popliteus, and/or biceps femoris.

Injuries were further characterized based upon mechanism (high vs. low energy), ligament disruption pattern, presence of arterial and neurologic injuries, ipsilateral lower extremity fractures, traumatic arthrotomy, and other associated injuries. Treatment variables included: initial stabilization with external fixator vs removable splint, operative vs non-operative definitive management, timing of surgery (early vs delayed), and single vs. staged surgical reconstructions. Delayed treatment was defined as ligament reconstruction that occurred more than three weeks after the initial injury. Subjects who did not undergo a ligament surgery due to the decision to perform an above knee amputation (AKA) or through knee amputation (TKA) were categorized as a separate treatment cohort and were not included in either the "operative" or the "non-operative" category. Treatment outcomes were then characterized by analyzing clinical variables, including: patient reported pain at final follow-up (scale 1–10), knee range of motion (ROM), instability (either subjective instability or documentation of instability on physical exam), and required use of assistive device for ambulation.

For two subjects who sustained bilateral MLKIs, only the more severely injured extremity was included in data analysis. In these cases, severity of injury was determined based on number of knee ligaments that were disrupted.

Each patient either returned to duty directly following their treatment or was referred to a Physical Evaluation Board (PEB) for disposition and determination of disability. The PEB records were queried for the final disposition and disability rating of each patient. The PEB determines if a service member should be permanently retired, separated with severance pay, placed on the temporary disability retirement list (TDRL), or is fit for duty. We calculated the RTD rate by combining service members who returned to duty after treatment recovery with those who were found fit for duty after the PEB.

Subsets of patients, based on injury mechanism of energy and PEB disposition, were compared using two-tailed Fisher exact test for categorical variables and *Student's t* test to analyze continuous data. We then performed multivariable regression analysis to evaluate the relationship between RTD status, treatment variables (i.e. early surgery) and secondary patient outcomes (i.e. knee ROM). Statistical significance was set at $P \leq 0.05$. Statistical analysis was performed using IBM SPSS Statistics 19 software (SPSS, Chicago, Illinois).

Results

We identified 46 service members who sustained 48 MLKIs while deployed. All subjects were male and mean age was 25.9 years (range 19–44 years). Twenty three MLKIs were of the left leg and 25 were right leg. Two subjects (4%) sustained bilateral injuries. The mean time from injury to final follow-up was 63.3 months (range 19–87 months). A large majority of patients (n = 39, 85%) were injured during high-energy events. The most common cause of injury was explosion from an Improvised Explosive Device (IED) (n = 33, 72%). Other high-energy injuries included three subjects who were injured in motor vehicle accidents, two in helicopter crashes, and one fall from approximately 20 ft. The seven low-energy injuries were sustained due to a fall from less than 5 ft (n = 5) or while running (n = 2).

Table 1
Injury Characteristics by Return to Duty Status.

	RTD	Separated	*P* Value
N	19	27	
Age (yr)	27.9	24.5	0.111
Two Ligament Injury	7	11	1.000
Three Ligament Injury	9	12	0.770
Four Ligament Injury	3	6	1.000
PLC Involvement	12	18	0.754
High Energy Mechanism	13	26	**0.015**
Vascular Injury	1	9	**0.031**
Peroneal Nerve Injury	2	13	**0.010**
Knee Arthrotomy	1	10	**0.016**
Articular Femur Fracture (OTA 33-B/C)	0	7	**0.031**
Tibial Plateau Fracture (OTA 41-B/C)	4	13	0.073
Compartment Syndrome	1	9	**0.031**

PLC = posterolateral corner.

Twenty-eight subjects underwent a PEB. Final disposition among the PEB cohort included: 26 permanent disability retirements, 1 military separation with pay, and 1 subject who was retained on active duty. The overall RTD rate was 41% (n = 19). High-energy mechanism, peroneal nerve injury, vascular injury, compartment syndrome, traumatic knee arthrotomy, and intra-articular femur fracture were significantly more prevalent among service members that separated from the military ($P < 0.05$) (Table 1). Regression analysis showed that acute placement of knee spanning external fixator was also associated with military separation (P = 0.041), and mean knee ROM was significantly higher in the RTD cohort (122.1 (80–140) vs. 91.6 (10–115); (P = 0.016)) (Table 2).

The most common pattern of injury (20%) was combined disruption of the ACL, PCL, PLC, and MCL (Table 3), all of which occurred in high energy events. Disruption of the PLC was present in 32 of 48 (67%) injured knees, including two patients who required late revisions due to missed PLC injuries. Number of ligaments injured and presence of PLC injury were not different between the RTD and military separation cohorts (Table 1).

The vast majority of the MLKIs sustained in a high-energy event (n = 35, 90%) had associated ipsilateral extremity injuries, while only 29% (n = 2) of the low energy subjects had associated extremity injuries (1 peroneal nerve injury, 1 metatarsal fracture).

Table 2
Treatment and Outcome Variables by Return to Duty Status.

	RTD	Separated	*P* Value	OR	95% CI
Treatment Variables					
External Fixator (N)	4	15	**0.041**	0.213	0.048–0.94
Non-operative Treatment (N)	2	6	0.21	0.347	0.067–1.813
Early Treatment (N)	2	5	0.411	0.405	0.047–3.495
Staged Surgery (N)	1	2	0.972	0.952	0.065–13.99
Outcome Variables					
Knee ROM (deg)	122.1 (80–140)	91.6 (10–115)	**0.016**	0.005	0.001–0.009
Pain score (1–10 scale)	2.05 (0–5)	3.54 (1–10)	0.051	0.076	0–0.152
Knee Instability (N)	5	8	0.806	1.234	0.23–6.606
Assistive Device (N)	3	6	0.809	0.79	0.117–5.338

ROM = range of motion.

Please cite this article in press as: A.E. Barrow, et al., Return to duty following combat-related multi-ligamentous knee injury, Injury (2017), http://dx.doi.org/10.1016/j.injury.2017.02.019