

# Infection reduces return-to-duty rates for soldiers with Type III open tibia fractures

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| <b>BACKGROUND:</b>        | Infection is a potentially devastating complication following severe lower extremity trauma, but its impact on the outcomes of combat casualties remains unclear. We hypothesize that orthopedic infectious complications will have a negative impact on holistic patient outcome as measured by return-to-duty (RTD) and disability ratings among wounded soldiers.                                                                                                                                                                                                                                                                                                        |
| <b>METHODS:</b>           | We reviewed the medical records for 115 wounded soldiers who sustained a Type III open tibia fracture and tabulated the prevalence of infectious complications. We searched the Physical Evaluation Board database to determine the disability ratings of soldiers with and without an infection and how many of each group was able to return to active duty service. The average percent disability rating and RTD rates between groups were compared using an unpaired <i>t</i> test and $\chi^2$ test, respectively.                                                                                                                                                    |
| <b>RESULTS:</b>           | Overall, 40% of our cohort had an infectious complication of their fractured limb. Twenty-one soldiers were able to RTD, while 94 could not and were medically retired. Of those medically retired, 44% had an infection. The average percent disability among soldiers with infection was 55%, compared with 47% for those who were not infected ( $p = 0.1407$ ). Soldiers who experienced any type of infectious complication ( $p = 0.0470$ ) and having osteomyelitis ( $p = 0.0335$ ) had a lower chance of RTD compared with those who had no infection. Having a deep soft tissue infection alone showed a strong trend toward decreased RTD rate ( $p = 0.0558$ ). |
| <b>CONCLUSION:</b>        | Infectious complications following severe lower extremity trauma significantly decrease the rate of RTD. In addition, the presence of infectious complications demonstrates a trend toward higher disability ratings in the combat wounded. ( <i>J Trauma Acute Care Surg.</i> 2014;77: S194–S197. Copyright © 2014 by Lippincott Williams & Wilkins)                                                                                                                                                                                                                                                                                                                       |
| <b>LEVEL OF EVIDENCE:</b> | Prognostic study, level III.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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Combat-related injuries have been complicated by infection throughout history.<sup>1</sup> With fractures accounting for approximately 26% of musculoskeletal combat wounds sustained during the recent conflicts in Iraq and Afghanistan and 82% of these fractures classified as open, the risk of significant infectious complications in these casualties is high.<sup>2</sup> Gustilo and Anderson classified open fractures into three types, which correlate well with the rates of infectious complications in civilian extremity trauma.<sup>3–6</sup> Of these open fractures, Type III tibial fractures have the highest infection rates, between 6% and 39%.<sup>6</sup>

A recent publication that evaluated the return to active duty service following combat sustained Type III open tibia fractures demonstrated significant disability directly related to the tibia fractures, with only 20% able to return to active duty service.<sup>7</sup> Another study in the combat wounded population with extremity injuries has suggested that extremity injuries are the cause of the greatest amount of disability among combat casualties, with an average disability rating of 42% based on the Physical Evaluation Board.<sup>8</sup> In addition, it has been documented that severe extremity injuries account for 64% of all rehospitalizations for the combat wounded, with infectious complications among the most common causes for rehospitalization.<sup>9</sup>

The Lower Extremity Assessment Project (LEAP) Study Group reported a 28% infection rate and 7.7% osteomyelitis rate in their study population, with a 23% infection rate and 9% osteomyelitis rate in the limb salvage cohort.<sup>10,11</sup> The LEAP study also found that patients who were treated for a major complication, such as infection, had significantly higher Sick-ness Impact Profile (SIP) scores than patients without a complication. Furthermore, previous studies have demonstrated that the development of infectious complications, such as deep soft tissue infection or osteomyelitis, had a significant correlation with late amputation among combat-sustained Type III open tibia fractures.<sup>6–12</sup> While these studies suggest poorer outcomes among both civilian and military patients experiencing infectious complications after severe lower extremity trauma, they have been focused mostly on limb-related outcomes. We are unaware

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This study has been presented at the Society of Military Orthopaedic Surgeons Annual Meeting, 2011, in San Diego, California, and the Limb Lengthening and Reconstruction Society Annual Meeting, 2012, in Cincinnati, Ohio.

This study was performed under the approval of the San Antonio Military Medical Center Institutional Review Board.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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of any studies that quantify the impact of such complications on the whole patient.

The purpose of this study was to characterize the impact of infectious complications on the overall disability and return to duty for wounded soldiers who sustained significant lower extremity trauma. We hypothesize that orthopedic infectious complications will have a negative impact on universal patient outcome as measured by return-to-duty (RTD) and disability ratings.

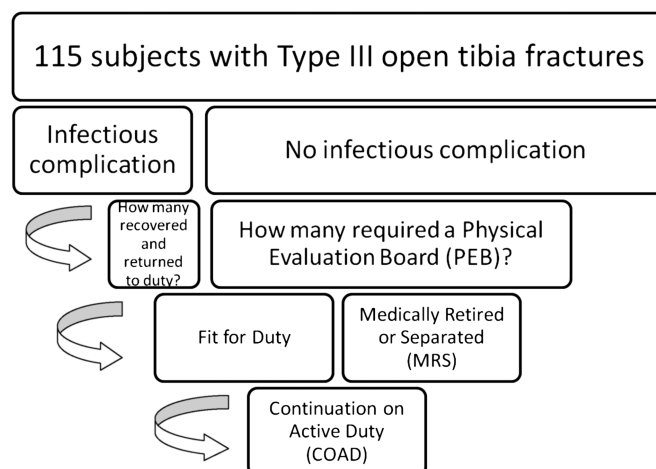
## PATIENTS AND METHODS

This retrospective study was conducted under a protocol approved by our institutional review board. We reviewed the medical records of 115 US military personnel from a previously published cohort who sustained combat-related Type III open tibia fractures.<sup>7</sup> Demographic data are presented in Table 1. Records were reviewed specifically for data on incidence of deep soft tissue infection and osteomyelitis diagnosed at any time from each soldier's initial admission to a military treatment facility following injury to the last available record. We examined culture results and tabulated surgical procedures performed specifically for the treatment of infection. Deep soft tissue infection was defined as any soft tissue infection characterized by redness, warmth, swelling, or purulence that required operative intervention. Osteomyelitis was defined as deep infection with positive bone cultures.

We then reexamined the Army Physical Evaluation Board (PEB) results for the soldiers who did and who did not have an infectious complication. The PEB determines if an injured soldier is able to physically perform an active duty job after an appropriate amount of time for recovery has passed.<sup>13–15</sup> For soldiers who are determined “unfit” for active duty service, a measure of their disability caused by an injury is assigned as a percentage<sup>16</sup> (Fig. 1). We compared the RTD rates and the average percent disabilities for soldiers with and without infectious complications. The RTD rates between soldiers with and without an infection were compared using a  $\chi^2$  method of analysis. The average percent disability rating between soldiers with and without infection was compared using an unpaired *t* test. Statistical significance level assessed at  $p \leq 0.05$ .

## RESULTS

Of the 115 soldiers, 46 (40%) had an infectious complication of their fractured limb. Forty-five soldiers (39%) had a deep soft tissue infection, and 29 (25%) had osteomyelitis. For soldiers with an infection, open wounds underwent irrigation and debridement an average of 6.8 times. An average of 5.9 irrigations and debridements were performed in soldiers who did not have an infection. The difference in number of



Return to Duty (RTD) = Recovered + Fit for Duty + COAD

**Figure 1.** Decision tree for determination of RTD.

irrigations and debridements was not statistically significant ( $p = 0.1075$ ). The number of revision surgeries for fracture fixation or eventual amputation was also not different ( $p = 0.6984$ ), as infected soldiers underwent an average of 1.6 revisions and noninfected soldiers underwent 1.5 revisions. Time for radiographic union tended to be higher for soldiers with an infection, 10.1 months for soldiers with an infection versus 9.9 months for those without ( $p = 0.9277$ ) (Table 2). Of the soldiers with an infection, 37% required a rotational or free flap coverage of their open wounds, while 33% of the noninfected soldiers required flap coverage. Infection contributed to the indication for amputation in 10 soldiers with 11 amputated limbs.

Routine skin swabs taken at admission were positive in 34 of soldiers who eventually had an infection, while 9 soldiers (26%) had no organisms on initial cultures. The most common organism isolated from skin cultures was *Acinetobacter* ( $n = 29$ ). Soldiers with an infection most commonly had *Klebsiella*, coagulase-negative *Staphylococcus aureus* and methicillin-resistant *S. aureus* as the infecting organisms based on intraoperative cultures. The isolated organism on skin swabs correlated with infectious organism 13% of the time, all as a result of *Acinetobacter* (Table 3). For soldiers who did not develop an infection, 41 (59%) had negative skin swabs at admission.

Twenty-one soldiers were able to return to active duty military service, while 94 could not and were medically retired. Of those who returned to duty, five (24%) had an infection, five deep

**TABLE 1.** Demographics of Original Cohort<sup>7</sup>

|             |            |
|-------------|------------|
| Average age | 27         |
| Median rank | Enlisted 5 |
| Male        | 94%        |
| ISS         | 13.4       |
| AIS score   | 3.5        |

**TABLE 2.** Treatment and Injury Characteristics of Infected Versus Noninfected Soldiers

|                   | Infected | Noninfected | <i>p</i> |
|-------------------|----------|-------------|----------|
| No. debridements  | 6.8      | 5.9         | 0.1075   |
| No. revisions     | 1.6      | 1.5         | 0.6984   |
| Time to union, mo | 10.1     | 9.9         | 0.9277   |
| ISS               | 14.6     | 13.5        | 0.454    |
| AIS score         | 3.7      | 3.3         | 0.1689   |

**TABLE 3.** Organisms Isolated on Routine and Intraoperative Cultures

|                                        | Routine MDR<br>Surveillance Swab, n | Injury Swab for<br>infection, n |
|----------------------------------------|-------------------------------------|---------------------------------|
| <i>Acinetobacter</i> species           | 29                                  | 7                               |
| Coagulase-negative <i>S. aureus</i>    | 4                                   | 9                               |
| <i>Escherichia coli</i>                | 0                                   | 1                               |
| <i>Enterobacter</i> species            | 0                                   | 8                               |
| <i>Enterococcus</i> species            | 1                                   | 6                               |
| <i>Klebsiella</i> species              | 2                                   | 10                              |
| Methicillin-resistant <i>S. aureus</i> | 1                                   | 8                               |
| <i>Pseudomonas aeruginosa</i>          | 0                                   | 5                               |

MDR, multi-drug resistant.

soft tissue infections and two cases of osteomyelitis (Table 4). Of those medically retired, 41 (44%) had an infection: 40 had deep tissue infections, and there were 27 cases of osteomyelitis. The average percent disability among soldiers with infection was 55%, compared with 47% for those who were not infected. This difference was not statistically significant ( $p = 0.1407$ ). Soldiers who experienced any type of infectious complication (deep soft tissue infection, osteomyelitis or deep soft tissue infection, and osteomyelitis) ( $p = 0.0470$ ) or osteomyelitis alone ( $p = 0.0335$ ) had a lower chance of returning to duty compared with those who had no infection. Having a deep soft tissue infection alone did not decrease a warrior's chance of returning to duty ( $p = 0.0558$ ) (Table 4). No soldier with an amputated limb returned to duty in our cohort.

## DISCUSSION

Infection following severe lower extremity trauma in wounded soldiers is common and is associated with RTD rates. For soldiers with and without an infection, the number of irrigations and debridements, revision surgeries, and surgeries for soft tissue coverage were not significantly different. Furthermore, Injury Severity Score (ISS) and Abbreviated Injury Scale (AIS) score were not different. These data do not indicate any predictive factors of which soldiers will have an infectious complication. The overall infection rate of 40% however is close to previous reports of infection following Type III open tibia fracture. This suggests that the injury itself is an inherent risk for infection despite the treatment factors we examined. This cohort, when examined previously, contained 25 soldiers with osteomyelitis.<sup>7</sup> Deep tissue infection was not examined during this previous report. After following the same cohort here, we have demonstrated that additional soldiers were eventually diagnosed with osteomyelitis, all of whom had an associated soft tissue infection. This is concerning that despite the aggressive nature of irrigation and debridement surgeries, osteomyelitis can still develop and present in a late fashion.

Routine skin cultures were taken for every soldier who returned from combat theater at admission to the hospital during the period that our cohort was treated. These routine skin cultures are no longer routinely obtained. At the time, these cultures were taken to identify soldiers with skin flora that may become infectious, thus imposing contact precautions on soldiers with positive cultures. *Acinetobacter*, an organism

ubiquitous in the regions of our recent military conflicts, has been implicated in infection in wounded soldiers.<sup>17</sup> However, we see here that despite the common presence of *Acinetobacter* on routine skin cultures, it is rarely the causative agent for infectious complications in this cohort, which is consistent with previous literature on open fractures.<sup>18</sup> Interestingly, soldiers with negative skin cultures had half the percentage of infectious complications. While colonization with virulent organisms has been associated with the development of infection in injured soldiers, the clinical significance of a negative routine culture or positive culture with a nonvirulent organism is unclear.<sup>19</sup>

Having an infectious complication (deep soft tissue infection, osteomyelitis or deep soft tissue infection, and osteomyelitis) or having osteomyelitis alone reduced a soldier's chance of returning to active duty service. Furthermore, having a deep soft tissue infection alone showed a strong trend toward reduced rates of RTD. The previous report on this cohort and other studies have correlated older age and higher rank with one's chance of returning to duty.<sup>7,20</sup> It was hypothesized that this correlation was related to older and higher-ranking soldiers' jobs in the military are often less physically demanding than the younger, lower-ranking enlisted individuals. While this may be so, this study adds that developing an infectious complication also contributes to return to duty despite age or rank. This may be caused by the time limitation imposed for medical treatment before PEB disposition, assuming that treatments for infected soldiers are likely longer. However, the cause of difference in RTD rates in light of similar other factors is unknown.

Overall disability within our cohort was substantial, and our study demonstrated that soldiers who experienced infectious complications following their injury had a weak trend toward higher disability ratings than those without infectious complications. This is consistent with the LEAP data, which suggested that patients who experienced major complications after severe lower extremity trauma had significantly lower validated functional outcome scores than those without complication.<sup>10</sup> Conversely, a recent publication reviewed a cohort of 33 patients with posttraumatic osteomyelitis and found that their function based on the Short Musculoskeletal Functional Assessment (SMFA) was not significantly different from that of the normal population once their infection had been eradicated.<sup>21</sup> These results suggest that our inability to identify a significantly different disability rating between the two groups in our cohort could be explained by the recent advances in the treatment of severe lower extremity trauma and associated complications, as it is possible that those patients who experienced infectious complications were cured of their infection before their PEB evaluation.<sup>6-22</sup>

**TABLE 4.** Infection Rates of Return Versus Retired Soldiers

|                       | Returned to Duty | Medically Retired | <i>p</i> |
|-----------------------|------------------|-------------------|----------|
| Any infection         | 24%              | 44%               | 0.0407   |
| Soft tissue infection | 24%              | 43%               | 0.0558   |
| Osteomyelitis         | 10%              | 29%               | 0.0335   |

There are several limitations present in the current study. This study is retrospective in nature and maintains the associated weaknesses, limitations, and potential biases inherent to the study design. In addition, the calculations of disability ratings and RTD rates were performed on data collected at one period. Because soldiers have the ability to appeal their disposition or disability rating, the PEB status used for our calculations may not reflect the final disposition or disability rating assigned. Moreover, this cohort was treated during the earlier stages of the war. As there have been advances in the management of extremity war injuries and combat-related infections since this time, these results may not be reflective of all soldiers treated throughout the current conflicts. Furthermore, if an infectious complication arises after the soldiers in this cohort left the military health care system, the effect would not be captured in this report. This is a possibility as demonstrated by the fact that additional soldiers were found to have osteomyelitis after the initial report on this cohort. Finally, our findings are representative of combat injuries sustained by active duty soldiers treated in a military medical system and may not be generalizable to the civilian trauma population.

In conclusion, soldiers with infectious complications following a Type III open tibia fracture have a significantly lower rate of returning to active duty military service than those without infectious complications. In addition, soldiers experiencing infectious complications following their severe lower extremity trauma have a trend toward higher disability ratings. Furthermore, injury and treatment factors did not predict which soldiers would have an infectious complication. These results indicate that the presence of infection contributes to a soldier's overall level of disability and likelihood of returning to duty and that the initial prevention of orthopedic infection may affect universal patient outcome. Further studies are required to further elucidate the factors that contribute to RTD and overall disability following severe lower extremity trauma so that we may better serve our wounded soldiers.

#### AUTHORSHIP

M.A.N. was involved in data analysis, manuscript preparation, and critical revision. J.C.R. was involved in the literature search, study design, data collection, manuscript preparation, and critical revision. T.C.B. was involved in the manuscript preparation and critical revision. C.K.M. was involved in the manuscript preparation and critical revision. J.C.W. was involved in the manuscript preparation and critical revision. J.R.H. was involved in the study design, manuscript preparation, and critical revision.

#### DISCLOSURE

The authors declare no conflicts of interest.

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