AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

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DOI: 10.1177/1071100715575497
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Occupational Outcomes and Return to Running Following Internal Fixation of Ankle Fractures in a High-Demand Population

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Abstract

Background: Literature evaluating surgical outcomes after ankle fixation in an active patient population is limited. This study determined occupational outcomes and return to running following ankle fracture fixation in a military cohort.

Methods: All service members undergoing ankle fracture fixation at a single military hospital from August 2007 to August 2012 were reviewed. Univariate analysis determined the association between patient demographic information, type of fracture fixation, and the development of posttraumatic ankle arthritis and functional outcomes, including medical separation, return to running, and reoperation. Seventy-two primary ankle fracture fixation procedures were performed on patients with mean age of 29.1 years. The majority of patients were male (88%), were 25 years of age or older (61%), were of junior rank (57%), underwent unimalleolar fracture fixation (78%), and did not require syndesmotic fixation (54%). The average follow-up was 35.9 months.

Results: The mean time to radiographic union was 8.6 weeks. Twelve service members (17%) were medically separated from the military due to refractory pain following ankle fracture fixation with a minimum of 2-year occupational follow-up. Among military service members undergoing ankle fracture fixation, 64% returned to running. Service members with higher occupational demands had a statistical trend to return to running (odds ratio [OR] 2.49; 95% CI, 0.93-6.68). Junior enlisted rank was a risk factor for medical separation (OR 11.00; 95% CI, 1.34-90.57). Radiographic evidence of posttraumatic ankle osteoarthritis occurred in 8 (11%) service members.

Conclusions: At mean 3-year follow-up, 83% of service members undergoing ankle fracture fixation remained on active duty or successfully completed their military service, while nearly two-thirds returned to occupationally required daily running.

Level of Evidence: Level IV, retrospective case series.

Keywords: ankle fracture, fixation, surgery, occupation, outcome, running, military

Increased levels of physical activity are associated with a higher incidence of ankle injuries.[16,19] Ankle fractures constitute approximately 10% of all fractures and are the most common surgically treated orthopedic injury.[6,19] They are even more common in young athletes, contributing to 15% to 25% of sports injuries.[12,13,16,22,30] While isolated lateral malleolar fractures may be biomechanically stable and amenable to nonoperative treatment, more complex bi- and trimalleolar ankle fractures and syndesmotic injuries often require open reduction and internal fixation (ORIF) to restore the native biomechanics of the ankle and prevent premature joint degeneration.[19]

Active duty service members in the US military are required to adhere to stringent and regularly evaluated fitness requirements. Physical training is routinely required in the form of organized aerobic exercise, weight training, and performance of core military tasks, such as the ability to march at least 2 miles with an additional 40 pounds of

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military gear. Semiannual physical fitness evaluations include timed runs as well as maintenance of height and weight standards. If a military service member is unable to maintain these requirements, a medical separation from service may be initiated.

While ankle fracture fixation has been reported to significantly improve patient health status[3,7,11] and health-related quality of life[7,11] in older populations, there are inadequate clinical reports detailing the ultimate occupational outcomes and ability to return to activity in younger, high-demand cohorts. It is important to understand the return to work and impact activities among these active individuals so that they can be appropriately counseled during preoperative evaluation and postoperative rehabilitation. This study sought to determine the return to work and running rates following ORIF of ankle fractures in a cohort of military service members with at least 2 years of occupational outcome follow-up and to ascertain the significance of patient demographics and fracture characteristics in predicting subsequent medical separation. The authors hypothesized that junior enlisted rank and higher grade ankle fractures would significantly increase the risk for medical separation.

Table 1. Patient Demographics and Ankle Fracture Surgical Characteristics.

	n (%)[a]
Age, mean ± SD, y	29.1 ± 7.9
Age <25 years	28 (39)
Age 25-35 years	25 (35)
Age >35 years	19 (26)
Sex	
Male	63 (88)
Female	9 (12)
Service member population	
Junior enlisted	41 (57)
Senior enlisted/officer	31 (43)
Combat arms/support military occupation	38 (53)
Noncombat arms military occupation	34 (47)
Fracture fixation type	
Lateral malleolus only	45 (63)
Medial malleolus only	11 (15)
Bimalleolar	14 (19)
Trimalleolar	2 (2.8)
Posterior malleolar fracture involvement	19 (26)
Syndesmotic fixation required	33 (46)

[a]Age in years expressed as mean ± SD; all other values are expressed as n (%).

Methods

Following institutional review board approval, the electronic surgical scheduling system at our institution was queried for all US Army active duty service members undergoing primary ankle fracture fixation at our center from August 2007 to August 2012. Ankle fracture ORIF is routinely performed at our center for unstable bimalleolar and trimalleolar ankle fracture patterns; displaced isolated medial malleolar fracture patterns; and isolated lateral malleolar ankle fractures with preoperative radiographic manual stress testing indicating concomitant deep deltoid ligamentous or syndesmotic injury(s). Exclusion criteria were applied to patients who were not active duty service members; those with concomitant polytraumatic limb injuries; those with nonrotational, periarticular ankle fractures (eg, tibial plafond fractures), purely syndesmotic injuries without other rotational fracture pattern; and those who underwent revision ankle fracture fixation for prior malunions or nonunions.

The US Department of Defense electronic health record, Armed Forces Health Longitudinal Application (Version 3.3), was extensively reviewed for each service member previously identified to collect pertinent demographic information, including age, sex, rank, military occupational specialty, complications, and clinical outcomes. All standardized ankle radiographs were reviewed for each patient in order to classify the type of ankle fracture fixation as either unimalleolar versus bimalleolar/trimalleolar, posterior malleolar versus no posterior malleolar involvement, and syndesmotic versus no syndesmotic fixation. Similarly, the mean time to radiographic union was also assessed. Rank groups were classified into 2 categories: junior rank (junior enlisted soldiers) versus senior rank (senior enlisted noncommissioned officers, warrant officers, and commissioned officers). Military occupational specialty designations were categorized into either Combat Arms/Combat Support or Combat Service Support. Combat Arms and Combat Support military occupational specialty designates service members with typically higher functional demands than those in Combat Service Support positions. Major local complications encompassed all cases of superficial or deep wound infection, delayed union, malunion, nonunion, and posttraumatic ankle osteoarthritis. Malunion was defined as nonanatomic alignment at the time of fracture union, defined for the fibula as at least 5 degrees of external rotation, at least 2 mm of fibular shortening, or lateral translation.[28] Minor complications included superficial wound infection and symptomatic of ankle hardware necessitating surgical removal.

A total of 72 primary ankle fracture ORIF procedures were performed on active-duty US military service members. The mean age of the patient cohort was 29.1 years (range, 19.7-53.3 years). The majority of patients were male (88%), underwent unimalleolar fracture fixation (78%), were 25 years of age or older (61%), were junior rank (57%), and did not have syndesmotic fixation (54%). The average clinical follow-up from time of surgery was 35.9 months (range, 2.0-79.7 months) (Table 1).

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Each branch of military service defines similar standards for medical fitness and deployment readiness for all service members. For example, in the US Army, Army Regulation 40-501 (Headquarters, Department of the Army, Washington, DC) defines these standards.[2] Physical duty limitations are recorded in the form of Physical Profiles, which are incorporated into the electronic medical record and the Pentagon Defense Manpower Data Center database. Specific military branches maintain rigorous databases, such as the US Army Physical Agency database, and these resources were cross-referenced to identify all service members with an ankle-related medical separation at a minimum of 2 years after ankle fracture fixation surgery were identified. Cross-referencing these databases at a minimum of 2 years after ankle fracture fixation defined *occupational follow-up*, which differs from actual clinical follow-up, in the current study. The primary outcomes of interest in the current investigation included current military status, return to regular occupationally required running, reoperation other than hardware removal, and hardware removal.

Statistics

Univariate analysis was used to determine the association between patient demographic information, type of fracture fixation, and the development of posttraumatic ankle arthritis with the outcomes of a service member being medically separated, return to running, reoperation other than hardware removal, and hardware removal. Odds ratios (OR) and 95% confidence intervals (CI) were reported for the analyses. Significant independent predictor variables were determined to be those that maintained P values <.05 with OR and 95% CI exclusive of 1.0. Calculations were performed using SAS software, version 9.2 (SAS Institute, Cary, NC).

Results

The mean time to radiographic union was 8.6 weeks (range, 4.9-28.7 weeks) (Table 2). At a minimum occupational follow-up period of 2 years postoperatively, 60 (83%) military service members returned to full active duty service or fulfilled their remaining service obligations, while 12 (17%) were medical separated secondary to continued ankle disabilities. Among the military service members undergoing ankle fracture fixation, 46 (64%) returned to running to include completion of the timed 2-mile run during the semiannual Army Physical Fitness Test.

Six local perioperative complications occurred in 6 patients (8.3%). Malunion (5.5%) was the most frequent major local complication. Radiographic evidence of posttraumatic ankle osteoarthritis developed in 8 service members (11.1%), of whom 2 (25%) went on to be medically separated. Six service members (8.3%) required reoperation other than an ankle hardware removal procedure, and these procedures included 1 revision of syndesmosis malreduction, 2 lateral ligamentous reconstructions, 2 arthroscopic ankle debridements, and 1 arthroscopic treatment of an osteochondral lesion of the talus. Ankle hardware removal was performed in 31 service members (43%), although most cases were routine removal of syndesmotic screw fixation.

Table 2. Occupational Outcomes, Return to Running, Complications, and Long-Term Sequelae Following Ankle Fracture Fixation in Military Service Members.

	n (%)[a]
Outcomes	
Medical separation within 2 years	12 (17)
Return to running	46 (64)
Time to fracture radiographic union, mean ± SD, wk	8.6 ± 4.5
Local complications	
Nonunion	1 (1.4)
Malunion	4 (5.5)
Infection	1 (1.4)
Long-term sequelae	
Posttraumatic osteoarthritis	8 (11)

[a]Time to fracture union in weeks expressed as mean ± SD; all other values are expressed as n (%).

Univariate logistic regression analysis identified significant demographic and type of ankle fracture fixation risk factors for the primary outcomes of interest (Table 3). Syndesmotic fixation compared with nonsyndesmotic fixation was a significant predictor for hardware removal (OR 5.08; 95% CI, 1.85-13.93; $P = .002$). Service members with a Combat Arms or Combat Support military occupational specialty compared with those with a Combat Service Support designation had a statistical trend to return to running (OR 2.49; 95% CI, 0.93-6.68; $P = .07$). Soldiers in the junior rank group, compared with the senior rank group, had a significantly increased odds ratio for being medically separated (OR 11.00; 95% CI, 1.34-90.57; $P = .03$). A service member's age group, sex, and development of posttraumatic ankle arthritis were not significant predictors for any of the primary outcome measures.

Discussion

The current study is the first to our knowledge to directly address short-term to midterm functional and occupational outcomes following ankle fracture ORIF in a young, ubiquitously physically active patient population. Obremskey et al[20] reported short-term Short Form (SF)-36 questionnaire results in 20 patients who underwent ankle fracture ORIF and found that at 12 to 24 months, functional outcomes were similar to those of age-matched US norms, except with regard to physical functioning. However, the mean age

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Table 3. Results of Univariate/Chi-Square Analyses for the Influence of Risk Factors on Occupational Outcomes, Return to Running, Hardware Removal, and Reoperation Other Than Hardware Removal Following Ankle Fracture Fixation in Military Service Members.[a]

Risk Factor	Medical Separation Within 2 Years	Return to Running	Hardware Removal	Reoperation Other Than Hardware Removal
Age				
<25 y (vs >35 y)	4.91 (0.54-44.60) .253	1.82 (0.53-6.19) .287	3.35 (0.98-11.45) .060	3.56 (0.52-24.41) .140
25-35 y (vs >35 y)	4.50 (0.48-42.25) .347	1.09 (0.33-3.67) .680	1.02 (0.28-3.67) .271	0.24 (0.01-6.73) .181
Gender				
Male (vs female) gender	0.66 (0.12-3.65) .635	1.49 (0.36-6.13) .580	1.60 (0.37-6.97) .532	0.84 (0.09-7.93) .881
Service member population				
Junior enlisted (<E6) (vs senior enlisted [≥E6]/officer) rank	11.00 (1.34-90.57) .026	0.95 (0.36-2.52) .923	1.73 (0.67-4.51) .261	5.14 (0.59-45.15) .140
Combat arms/support (vs noncombat arms) military occupation	0.58 (0.17-2.05) .402	2.49 (0.93-6.68) .070	0.58 (0.23-1.50) .262	0.32 (0.06-1.78) .195
Fracture fixation type				
Bi- or trimalleolar (vs unimalleolar) fracture fixation	1.21 (0.28-5.11) .800	1.32 (0.40-4.33) .647	0.52 (0.16-1.71) .284	3.00 (0.60-15.09) .183
Posterior malleolar (vs no posterior malleolar) involvement	0.51 (0.10-2.55) .409	1.31 (0.43-4.01) .632	0.95 (0.33-2.74) .923	0.16 (0.01-3.14) .227
Syndesmotic (vs no syndesmotic) fixation required	0.82 (0.23-2.86) .751	0.98 (0.37-2.57) .967	5.08 (1.85-13.93) .002	0.88 (0.18-4.22) .868
Posttraumatic osteoarthritis (vs no osteoarthritis)	1.80 (0.32-10.22) .507	0.93 (0.20-4.27) .931	2.44 (0.54-11.09) .250	1.38 (0.14-13.20) .779

[a]Values presented as odds ratio (95% CI) and *P* value.

in this cohort was 52.7 years, representing a presumably lower demand patient population than the current study. In a prospective observational functional outcomes study, Bhandari et al[3] assessed 30 patients who underwent ORIF of unstable ankle fractures to determine short-term predictors of quality of life. The authors noted that lower SF-36 physical function scores at 2 years compared favorably to age-matched US norms; however, as with the aforementioned study, the mean age of 51.6 years presumably represents a lesser demand cohort than the current study, whose mean patient age was 29.1 years. A recent systematic review by Van Son et al[29] evaluated health status, health-related quality of life, and quality of life following ankle fracture fixation and determined that there are no conclusive determinants of functional outcome following ankle fracture ORIF. Furthermore, none of the 23 studies in the review assessed functional or occupational outcomes such as return to high-demand occupations or return to running. As well, few of the studies in the review by Van Son et al included follow-up of greater than 24 months.

Several authors have recently addressed return to sports in athletic patient populations following ankle fracture ORIF (Table 4). Porter et al[22] reported on 27 athletes with a mean age of 18.1 years who underwent ORIF of unstable ankle fractures; the investigators noted excellent return to athletic competition between 2 and 4 months postoperatively and 96% return to function compared with preinjury levels at latest follow-up. This study was limited by its small patient sample (n = 27), inclusion of pediatric patients (n = 4), inclusion of purely syndesmotic injuries (n = 4), and inclusion of tibial plafond fracture (n = 1). Hong et al[15] recently reported on 47 patients who underwent ORIF of unstable ankle fractures, among whom 33 patients were preinjury recreational athletes. Most patients exhibited ankle pain (55%), stiffness (62%), and swelling (45%) at 1-year follow-up. Among the recreational athletes, only 27% were able to return to preinjury levels, and 18% could not continue with any sporting activity. Notable shortcomings of this study include its limited follow-up (16 months) and higher mean patient age (>40 years) than the current study. In the largest series to address functional outcomes following ankle fracture ORIF in an athletic cohort, Colvin et al[5] noted that only 12% of competitive level athletes returned to sports at 1 year, and among both recreational and competitive athletes, overall only 24% returned to sports during the same timeframe. These results[5,15] parallel trends identified in the current study and reflect the significant disability in physically active patients following ankle

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Table 4. Other Series Assessing Return to Sports and High-Demand Activities Following Ankle Fracture Internal Fixation.

Series[a]	No. of Patients Involved in Sports/ High-Demand Activities Preoperatively	Mean Patient Age, y	Latest Reported Mean Follow-Up, mo	Fracture Severity Patterns	Study Findings
Porter et al (2008)[22]	27	18.1	29	37% bimalleolar 30% unimalleolar 15% pediatric (Salter-Harris) 15% purely syndesmotic injury 4% tibial plafond	96% return to preinjury levels at latest follow-up
Colvin et al (2009)[5]	243	NR[b]	12	NR	24% overall recreational/ competitive athletes returned to sports 12% competitive athletes returned to sports
Hong et al (2013)[15]	33	NR[b]	16	55% bimalleolar 45% trimalleolar	27% return to preinjury level 18% unable to return to sports
Current study	72	29.1	36	78% unimalleolar 22% bi- or trimalleolar	83% return to military duty 64% return to running

Abbreviation: NR, not reported.
[a]None of the prior series specifically addressed return to running, and all series included both competitive and recreational athletes.
[b]Authors reported overall mean age among all patients but did not report mean age for athletic cohorts. In both series, mean age was >40 years (vs 29.1 years in current series).

fracture ORIF. In the current study, 17% of such patients undergoing such fixation of unstable ankle fractures required medical separation from the military, and 36% were unable to continue regular occupationally required running within a mean follow-up of 3 years. Furthermore, this is the first series to report on return to regular running in such a ubiquitously highly functioning population following ankle fracture fixation.

We found that junior enlisted ranking service members were at significantly increased risk for medical separation within 2 years postoperatively. Previous epidemiological studies of lower extremity injury in military personnel have noted that junior enlisted rank serves as a proxy for lower socioeconomic status and/or education level, as junior enlisted personnel are typically younger, earn lower salaries, and more often have only secondary school educational levels prior to enlisting in the military.[21,23] Bhandari et al[3] noted that among civilian populations, less than college-level education resulted in significantly impaired physical function scores at 3 months following ankle fracture fixation and significantly lower mental well-being scores at 2 years postoperatively. Additionally, because of their lower status within the military chain of command, junior enlisted personnel are less capable of controlling their postoperative occupational demands and dictating their levels of physical activity.

The results of the current study do not indicate that fracture pattern severity was a significant predictor of functional or occupational outcomes. The authors noted no differences in return to regular occupationally required running, military retention, or reoperation other than hardware removal when comparing unimalleolar versus bi- or trimalleolar fracture patterns, presence or absence of concomitant posterior malleolar fracture, and/or need for syndesmotic fixation (Table 4). None of the aforementioned studies[5,15,22] assessing return to sports following ankle fracture fixation stratified outcomes based on fracture severity, as the current authors did. Our results contrast with some previous authors' findings in lower demand cohorts. Stufkens et al[26] and Tejwani et al[27] demonstrated poorer functional outcomes scores for bimalleolar compared with isolated unstable lateral malleolar fracture fixation; however, the authors only reported on SF-36 and Short Musculoskeletal Function Assessment (SMFA) questionnaire scores, respectively. Conversely, Colvin et al[5] reported that bimalleolar ankle fracture fixation patients were significantly more likely to return to sports at 1 year compared with unimalleolar fracture fixation patients. In the current subset, we found no difference in functional or occupational outcomes with regard to fracture severity. Only 2 authors have specifically reported the impact that a posterior malleolar fracture has on outcomes following ankle fracture ORIF.[14,32] Just as in the current study, Wikeroy et al[32] showed that presence of a posterior malleolar fracture did not affect functional outcome measures.

The current study did not demonstrate that syndesmotic fixation (46%) negatively affected military service members' ability to remain on active duty service or return to occupationally required daily running. Egol et al[10] reported on more than 300 ankle fracture ORIF patients and noted significantly improved SF-36 results at 1 year in patients

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who did not require syndesmotic fixation. Similarly, Colvin et al[5] demonstrated increased short-term return to athletics in patients who did not require syndesmotic fixation. We acknowledge that a 46% syndesmotic fixation rate appears higher than reported in prior series. In the current study, 36% (26) of the 72 ankle fractures included a suprasyndesmotic Weber type C distal fibular fracture pattern,[31] among which 85% (22) required syndesmotic fixation based on intraoperative radiographic stress testing. Among the 26 Weber type C distal fibular fractures, 23% (6) had other malleolar fracture involvement. Of the remaining 46 fractures in the current series, only 24% (11) required syndesmotic fixation. Weber type C fracture patterns, while typically not as common as more distal fracture patterns, have a known higher incidence of concomitant syndesmotic injury.[4,34] The current authors contend that the higher number of suprasyndesmotic distal fibular fracture patterns in the current series may have contributed to an unexpectedly high incidence of syndesmotic fixation. At our institution, there is no established protocol for type of syndesmotic fixation used when required. The decision to perform syndesmotic fixation is based upon careful assessment of preoperative radiographs as well as intraoperative dynamic fluoroscopic stress testing by the responsible surgeon.

The results of the current study do not indicate that age or sex was a significant predictor of functional or occupational outcomes. Most studies that have compared the relationship of age with functional outcomes and complications following ankle fracture fixation have focused on elderly patient populations.[1,7,17,18,24,25,33] As the current study analyzed a young, high-demand population with a mean age of 29.1 years, we cannot suggest comparisons between elderly and nonelderly cohorts with regard to ankle fracture ORIF. We did not note any differences in return to running, military retention, or reoperation other than hardware removal for patients among identified age groups (Table 4). Colvin et al,[5] however, did note that those patients who returned to sport at 1 year postoperatively were significantly younger than those who did not. The authors noted a 16% decreased likelihood of returning to sports for every year of increased age at 1-year follow-up. However, not all patients were young, physically active athletic patients, as an unreported number of patients were American Society of Anesthesiologists score III-IV, indicating that young healthy patients were compared with older, comorbid patients. Furthermore, the mean age in the Colvin et al[5] series was 42.5 years, compared with 29.1 in the current study. The current study included only 9 (12%) female patients, indicative of the overall demographic makeup of active duty military personnel[9]; hence, we cannot draw strong conclusions regarding the role of sex in determining functional and occupational outcomes following ankle fracture ORIF among high-demand military service members. Among athletic patients, other authors have noted increased early return to athletics among male patients compared with female patients.[5,8,11] With the sample size available, the current authors also did not demonstrate any significant differences or statistical trends in return to running, military retention, or reoperation other than hardware removal between male versus female patients.

The authors acknowledge certain strengths and weaknesses in the current series. This is a retrospective study and retains the inherent limitations of such studies, although similar series on this topic have similarly been retrospective. As well, the active duty military population is a relatively unique patient population, which may limit the external validity of the current study. However, we feel that these results can be appropriately compared with other physically active adult patient populations whose activity demands are through sports or high-demand occupational activities. The authors contend that the high-demand nature of this patient population serves as a strength of the current series, and these results represent the first functional and occupational outcomes following ankle fracture ORIF reported in such a ubiquitously high-demand adult patient cohort. As well, this is the first study to report specific return to regular running outcomes in such a patient population and, with a mean follow-up of nearly 3 years, represents the longest functional and occupational outcome data follow-up for this subset to date.

Conclusions

Operative fixation of unstable ankle fractures in a physically active patient population can result in good functional and occupational outcomes with minimal risk of local complications. At short to intermediate follow-up, however, patients should be counseled that within 3 years, more than one-third of patients will not be able to maintain regular occupationally required running expected of active duty military service members and up to 17% may require medical separation secondary to continued ankle disability. The major risk factor for medical separation from service was junior enlisted military rank, a proxy for lower socioeconomic status.

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