

# Surgical Treatment of Chronic Exertional Compartment Syndrome of the Leg

## Failure Rates and Postoperative Disability in an Active Patient Population

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**Background:** Chronic exertional compartment syndrome of the leg is a frequent source of lower-extremity pain in military personnel, competitive athletes, and runners. We are not aware of any previous study in which the authors rigorously evaluated the rates of return to full activity, persistent disability, and surgical revision after operative management of chronic exertional compartment syndrome of the leg in a large, physically active population.

**Methods:** Individuals who had undergone surgical fasciotomy of the anterior, lateral, and/or posterior compartments (Current Procedural Terminology [CPT] codes 27600, 27601, and 27602) for nontraumatic compartment syndrome of the lower extremity (International Classification of Diseases, Ninth Revision [ICD-9] code 729.72) between 2003 and 2010 were identified from the Military Health System Management Analysis and Reporting Tool (M2). Demographic variables including age, sex, and rank were extracted, and rates of postoperative complications, activity limitations, and revision surgery or medical discharge were obtained from the electronic medical record and U.S. Army Physical Disability Agency database.

**Results:** A total of 611 patients underwent 754 surgical procedures. The average patient age was 28.0 years, and 91.8% of the patients were male. Of the surgical procedures, 77.4% involved only anterior and lateral compartment releases; 19.4% addressed the anterior, lateral, and posterior compartments; and 2.2% addressed the posterior compartments alone. Symptom recurrence was reported by 44.7% of the patients, and 27.7% were unable to return to full activity. Surgical complications were documented for 15.7% of the patients, 5.9% underwent surgical revision, and 17.3% were referred for medical discharge because of chronic exertional compartment syndrome. Univariate analysis of prognostic factors revealed that surgical failure was associated with bilateral involvement (odds ratio [OR], 1.64), perioperative complications (OR, 2.12), activity limitations (OR, 4.41), and persistence of preoperative symptoms (OR, 8.46). Multi-variable analysis confirmed significant associations between surgical failure and perioperative complications (OR, 1.72), activity limitations (OR, 2.23), and persistence of preoperative symptoms (OR, 5.47), whereas other factors were not significantly associated with surgical failure.

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**Disclosure:** None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.

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A commentary by Keith M. Baumgarten, MD, is linked to the online version of this article at [jbj.s.org](http://jbj.s.org).

**Conclusions:** Chronic exertional compartment syndrome is a substantial contributor to lower-extremity disability in the military population. Nearly half of all service members undergoing fasciotomy reported persistent symptoms, and one in five individuals had unsuccessful surgical treatment.

**Level of Evidence:** Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Since it was first described in 1956<sup>1</sup>, chronic exertional compartment syndrome of the lower extremity has become an established source of exercise-induced leg pain in active patient populations, particularly competitive athletes and military recruits. Conservative management is ineffective without restrictions on activity, whereas surgical treatment has demonstrated success in multiple limited case series<sup>2-4</sup>. However, we are not aware of any large-scale, population-based studies on the long-term outcomes and rates of disability after elective fasciotomy for chronic exertional compartment syndrome.

The purpose of this study was to retrospectively review the clinical results of surgical management of chronic exertional compartment syndrome of the leg in military personnel. We hypothesized that a considerable subset of this military cohort would experience incomplete resolution of symptoms and be unable to return to full military duty after surgery.

### Materials and Methods

All active U.S. military service members who had undergone elective surgical fasciotomy of the anterior, lateral, and/or posterior compartments (Current Procedural Terminology [CPT] codes 27600, 27601, and 27602) for nontraumatic compartment syndrome of the lower extremity (International Classification of Diseases, Ninth Revision [ICD-9] code 729.72) between 2003 and 2010 were identified from the Military Health System Management Analysis and Reporting Tool (M2). Demographic variables including age (in years), sex, and military rank were extracted. Laterality, compartment involvement, medical comorbidities, tobacco use, perioperative complications, activity limitations, and rates of revision surgery or medical discharge were among the variables recorded from the electronic medical record and U.S. Army Physical Disability Agency database. For this study, surgical failure was defined as either the requirement for subsequent revision surgery or a medical disability discharge due to persistent lower-extremity symptoms.

### Statistical Analysis

We calculated standard descriptive statistics including means and standard deviations (SD) for continuous variables and counts and frequencies for categorical variables. Initially, we evaluated the importance of factors associated with failure using univariate t tests and chi-square tests for continuous (e.g., age) and categorical variables, respectively. Of note, categorical variables such as laterality (i.e., unilateral versus bilateral), medical comorbidity (i.e., yes versus no), tobacco use, perioperative complications, postoperative activity limitations, and symptom recurrence were organized under a binary system. Risk factors that maintained a p value of <0.2 following univariate testing were then carried forward into a multivariable logistic regression model with surgical failure as the primary outcome. Odds ratios (OR) and 95% confidence intervals (CI) were calculated and reported for the variables of interest. All statistical analyses were performed with use of STATA/SE software (version 10.1; Stata-Corp, College Station, Texas).

### Source of Funding

No outside funding was received for this study.

## Results

### Descriptive Analysis

A total of 1022 total entries were reviewed, and 268 were excluded because they were duplicate entries or coding errors. A total of 611 patients underwent 754 elective fasciotomies for chronic exertional compartment syndrome during the study period. The average patient age was 28.0 years; 91.8% (561) of the patients were male and 8.2% (fifty) were female. With regard to military rank, 60.9% were junior enlisted (E1-E4) service members, 23.6% were senior enlisted (E5-E8) service members, and 15.5% were commissioned or warrant officers (O1-O5; CW1-CW4). Of the surgical procedures, 77.4% were combined anterior and lateral compartment releases only, 19.4% were performed on all four compartments, 2.2% involved the posterior (i.e., superficial and deep) compartments only, 0.9% involved the lateral compartment only, and 0.13% involved the anterior compartment only.

### Clinical Outcomes

Symptoms recurred after the fasciotomy in 44.7% of the patients, and 27.7% of the patients were unable to return to full activity. Thirty-six patients (5.9%) underwent revision surgery after an unsuccessful initial fasciotomy, and seven of these patients required bilateral revision surgery. The indications for the surgical revisions included one or more of the following: recurrence of preoperative symptoms (n = 35), superficial peroneal neuritis (n = 4), and untreated compartments (n = 1). After the revision surgery, only 14% of the patients experienced complete resolution of symptoms and only 67% returned to full activity. One hundred and six patients (17.3%) received a medical discharge, including ninety-seven (16.9%) of the 575 patients treated with the index procedure only and nine (25%) of the thirty-six patients who had revision. This represents a cumulative surgical failure rate of 21.8% (n = 133).

**TABLE I** Complication Profile After Elective Fasciotomy for Chronic Exertional Compartment Syndrome

Complication	No.	Discharge (no. [%])	Secondary Surgery (no.)
Infection	50	10 (20%)	2
Neurological	26	7 (27%)	3
Wound dehiscence	16	2 (13%)	5
Seroma/hematoma	12	4 (33%)	6
Miscellaneous	4	1 (25%)	0
Total	108	24 (22%)	16

**TABLE II Results of Univariate Logistic Regression Analyses of Surgical Failure**

Variable	OR	95% CI	P Value
Sex*	1.32	0.68, 2.57	0.411
Age†	0.95	0.91, 0.98	0.002
Bilateral involvement‡	1.64	1.08, 2.48	0.020
Compartment involvement			
Anterior	1.00	—	—
Posterior	1.64	0.14, 19.39	0.696
Anterior and lateral	1.24	0.15, 10.40	0.844
Four-compartment	0.66	0.07, 5.90	0.711
Persistent symptoms§	8.46	5.05, 14.19	<0.001
Activity limitations§	4.41	2.93, 6.63	<0.001
Psychiatric comorbidity§	1.39	0.92, 2.09	0.117
Tobacco use§	1.20	0.81, 1.78	0.369
Perioperative complication§	2.12	1.30, 3.45	0.003

\*Females are the referent group. †Age in years when age is considered as a continuous variable. ‡Unilateral involvement is the referent group. §The referent group is the absence of the given variable.

**TABLE III Results of Multivariable Logistic Regression Analysis of Surgical Failure**

Variable	OR*	95% CI	P Value
Age	0.97	0.93, 1.01	0.130
Bilateral involvement	1.29	0.82, 2.04	0.274
Persistent symptoms	5.47	3.14, 9.54	<0.001
Activity limitations	2.23	1.41, 3.53	0.001
Psychiatric comorbidity	1.14	0.72, 1.79	0.584
Perioperative complication	1.72	1.00, 2.99	0.050

\*Odds ratios are adjusted for all other variables listed in the table.

### Complications

A total of 108 complications occurred in ninety-six patients (15.7%), with twelve patients experiencing two complications (Table I). Complications were classified as infection (fifty), neurological (twenty-six), wound dehiscence (sixteen), seroma or hematoma formation (twelve), or miscellaneous (four). The patients with complications required a total of nineteen single or concomitant procedures during sixteen operations. The secondary surgical procedures, included irrigation and debridement/repeat closure (thirteen), neuroplasty (three), split-thickness skin grafting (two), and tendon transfer (one). Twenty-four (22%) of the 108 complications were in patients who subsequently received a medical discharge; these twenty-four complications included ten infections, seven neurological

complications, four cases of seroma or hematoma formation, two cases of dehiscence, and one miscellaneous complication (deep vein thrombosis).

### Risk Factors

Univariate analysis of prognostic factors revealed that surgical failure was associated with age (OR, 0.95), bilateral involvement (OR, 1.64), perioperative complications (OR, 2.12), activity limitations (OR, 4.41), and persistence of preoperative symptoms (OR, 8.46), whereas sex, tobacco use, psychiatric comorbidity, and four-compartment fasciotomy were not significantly associated with surgical failure (Table II). Multivariable analysis (Table III) showed perioperative complications (OR, 1.72), activity limitations (OR, 2.23), and persistence of preoperative symptoms (OR, 5.47) to be independently associated with surgical failure whereas other factors were not significantly associated with surgical failure.

### Discussion

Chronic exertional compartment syndrome of the leg is an important source of disability in physically active military populations. Vogt first alluded to exertional compartment syndrome with his description of “march gangrene” in 1943<sup>5</sup>. Subsequent authors have chronicled the burden of exertional compartment syndrome in the military and established initial optimism for surgical management<sup>6,7</sup>. Almdahl and Samdal reported favorable outcomes in 73% of thirty-four military patients who had had a fasciotomy for the treatment of anterior tibial compartment syndrome<sup>8</sup>. The current study reveals that 78.2% of 611 military service members experienced successful outcomes, as defined by the aforementioned study criteria, after fasciotomy for chronic exertional compartment syndrome. However, nearly one in five individuals experienced surgical failure after elective fasciotomy, and approximately a quarter of all patients were unable to return to full activity in the military.

Prior reports of surgical treatment for chronic exertional compartment syndrome in the civilian population have shown favorable results. Detmer et al. reported that 90% of 100 patients were either “cured or significantly improved” with fasciotomy<sup>2</sup>. Styf and Körner reported similarly improved results in 89% of their patients, with resolution of anterior or lateral compartment symptoms after fascial decompression<sup>3</sup>. In a study of twenty-five athletes treated with elective fasciotomies, Rorabeck et al. reported that twenty-two of them were able to return to full activity and that three patients with involvement of the posterior compartment had a failure<sup>4</sup>. Schepsis and colleagues evaluated the results of fasciotomy in groups with and without posterior compartment involvement and determined that they were good or excellent in 60% and 96%, respectively<sup>9</sup>. However, in contradistinction to the general civilian population, military service members have intense physical requirements that are most comparable with those of high-demand, competitive athletes, including routine aerobic fitness training, weight

training, and marching with heavy fighting loads (e.g., 60 to >80 lb [27 to >36 kg]).

Furthermore, nearly half of all patients in the current study experienced incomplete relief with varying degrees of symptom recurrence after initial postoperative recovery, and 5.9% of the individuals underwent revision. After revision surgery, only 13.9% of the patients experienced complete recovery. The rate of recurrence of chronic exertional compartment syndrome has been inconsistently documented and variably reported in the literature, with documented rates between 3% and 17%<sup>3,4,9-11</sup> and with differing degrees of severity. Postoperative recurrence can be associated with insufficient fascial release, inadequate mobilization, postsurgical fibrosis, persistent superficial peroneal nerve entrapment, errors in diagnosis, or untreated affected compartments (e.g., the deep posterior compartment)<sup>12-14</sup>. Repeat fasciotomy<sup>2,15</sup>, partial fasciectomy<sup>14</sup>, and superficial peroneal nerve decompression<sup>14</sup> may all be considered for the revision surgery and can result in reasonable results. In the largest series of which we are aware, Schepsis et al. reported satisfactory outcomes in thirteen of eighteen patients who had undergone revision surgery after unsuccessful surgical treatment<sup>14</sup>. However, when the successful treatment of all eight individuals with superficial peroneal nerve entrapment is excluded, satisfactory results were seen in only 50%.

The complication profile associated with elective fasciotomy is not negligible, with reported rates of up to 11%<sup>2</sup>. Although hematoma or seroma formation, superficial peroneal neuritis, and surgical site infection are the most common, wound-healing complications, neurovascular injury, complex regional pain syndrome, and thromboembolic disease may also be encountered<sup>2</sup>. Additionally, the rate of secondary surgical intervention or subsequent rehospitalization has not been well defined, and the long-term consequences of these complications are also unknown. In the current series, 15.7% of the patients experienced at least one surgical complication, and sixteen secondary surgical procedures were required. Furthermore, nearly one in five patients with a complication underwent medical discharge from military service, indicating the high rates of disability following complications in this physically active population. Additional studies should be performed to evaluate the utility of evolving conservative treatment strategies, including alterations in gait mechanics during running or at-risk activity<sup>16</sup>.

Certain limitations within this study must be acknowledged. This is a retrospective evaluation of prospectively collected

data from the M2 database, which relies heavily on surgeon-reported outcomes and clinical information available in the electronic medical record. Multiple orthopaedic providers across thirty-two separate medical treatment facilities were involved, and there were no formal standardized operative indications, surgical techniques, or rehabilitation protocols. Compartment pressure measurements and certain demographic, surgical, and clinical parameters were not always available or reported, so independent confirmation of a diagnosis of chronic exertional compartment syndrome could not be performed. Lastly, the possibility that some patients were motivated by secondary gain to pursue a disability-associated military discharge could not be eliminated and may introduce confounding.

In conclusion, chronic exertional compartment syndrome is common in the military population and treatment with elective fasciotomy of the leg leads to high rates of symptom recurrence, surgical complications, and disability-associated military discharge. This study represents the largest known cohort with chronic exertional compartment syndrome of the leg to our knowledge and provides valuable information on the surgical outcomes after elective fasciotomy in a physically active patient population. While the majority of patients returned to active duty, almost half of the soldiers experienced symptom recurrence and a quarter were unable to return to full activity after elective fasciotomy. At least one in five individuals had unsuccessful surgical management for chronic exertional compartment syndrome in our study. ■

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