Systematic Review

Surgical Management for Chronic Exertional Compartment Syndrome of the Leg: A Systematic Review of the Literature

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Purpose: To review published literature to characterize the at-risk demographic, operative indications, surgical techniques, functional outcomes, and reoperation and complication rates after operative management of chronic exertional compartment syndrome (CECS) of the lower leg. **Methods:** We searched PubMed, Embase, Cochrane Database, and CINAHL (Cumulative Index to Nursing and Allied Health Literature) through February 1, 2015, using the terms "chronic exertional" and/or "exercise induced compartment syndrome." The inclusion criteria were studies of Level I to IV evidence in English, published in 1970 or later, involving human subjects, reporting clinical outcomes of operative management of CECS of the lower leg, including at least 5 patients, and having follow-up of at least 80% and 6 months. **Results:** Among the 204 original articles, 24 primary studies with 1,596 patients met the inclusion criteria. The mean age was 26.6 years (SD, 8.9 years), and the majority of patients were male patients (70%). The total study population mostly comprised military service members (54%) and athletes (29%). Of the athletes, 83% were recreational; 9% were college level; and 8% were either national, international, or professional. The most commonly involved compartment was the anterior compartment (51%; 95% confidence interval [CI], 48.6% to 52.3%), followed by lateral (33%; 95% CI, 31.4% to 34.9%), deep posterior (13%), and superficial posterior (3%). The cumulative posterior involvement rate was 16% (95% CI, 15.1% to 17.8%). Mean follow-up was 48.8 months (SD, 22.1 months; 95% CI, 47.1 to 50.5 months). Six percent underwent revision surgery. The overall complication rate was 13% (due to postoperative neurologic dysfunction, infection, and so on). **Conclusions:** Primary operative management of lower-extremity CECS was successful in approximately two-thirds of all young athletic patients, and 84% were satisfied with their surgical outcomes at short- to mid-term follow-up. Open fasciotomy remains the predominant surgical technique, although its comparative efficacy relative to newer endoscopic or other minimally invasive techniques is not currently known. These data may be used to guide the orthopaedic community on accurate preoperative counseling and benchmark patient outcomes for future quality-improvement initiatives. **Level of Evidence:** Level IV, systematic review (studies ranging from Level I to Level IV).

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Chronic exertional compartment syndrome (CECS) of the lower extremity was first described in 1956 in a 24-year-old professional football player who presented with bilateral leg pain related to increased training intensity.[1] Although the contemporary incidence of CECS in the general population is unknown,[2] it has been described in athletic subpopulations at a rate of 0.49 cases per 1,000 persons-years.[3] The lower extremity is most commonly involved,[4] with as many as 13.9% to 34.4% of patients with leg pain attributable to CECS.[5,6]

Although the exact mechanism has not been fully elucidated, the pathology is thought to arise from transient muscular ischemia and progressive neurovascular dysfunction due to the increased intramuscular pressures experienced during endurance

exercise.[7,8] Clinical manifestations include pain on exertion that subsides with rest, typically from chronic repetitive use, and a history of failed nonsurgical treatment.[9] As a result, CECS has been seen and described chiefly among the athletic[2,7-20] and military[21-27] populations, although it may also occur in nontraditional, sedentary individuals.[28]

Conservative management of CECS involves rest, physical therapy, and activity modification involving avoidance of inciting activity, gait retraining, and forefoot running.[29,30] With evidence of increased intracompartmental pressures during exertion,[31] refractory pathology is most often addressed by compartment-specific fasciotomy.[32]

Literature is mixed on the clinical outcomes of operative management in active individuals. Furthermore, the complication profile varies across the existing literature, with incidences ranging from 4% to 19%,[2,17] and the recurrence rate has also been reported as high as 45%.[27]

To this end, we performed a systematic review of the published literature to characterize the at-risk demographic, operative indications, surgical techniques, functional outcomes, and reoperation and complication rates after operative management of CECS of the lower leg. We hypothesized that operative management of CECS of the lower leg would offer moderate symptomatic relief but with a significant rate of complications and reoperation among the young athletic demographic.

Methods

Literature Search

We conducted a systematic review of the literature to identify all publications regarding CECS of the lower leg. A comprehensive literature search was performed using an Internet-based search beginning with queries of the PubMed, Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Cochrane, and Embase databases for all articles between January 1, 1970, and March 1, 2015. A total of 5 search terms were used and were entered into the title and keyword search fields: (1) "chronic exertional compartment syndrome," (2) "compartment syndrome," (3) "chronic compartment syndrome," (4) "exertional compartment syndrome," and (5) "exercise-induced compartment syndrome." This yielded a total of 204 original articles that were isolated for screening.

Study Selection and Inclusion and Exclusion Criteria

The abstracts of all identified articles were subsequently analyzed to determine relevance to CECS (Fig 1). Articles were initially excluded if they involved 1 or more of the following criteria: animal model or basic science research, acute compartment syndrome, compartments other than those of the leg, non−English language, nonsurgical treatment, or publication before 1970. The full-text articles on the remaining investigations were then reviewed for the following inclusion criteria: peer-reviewed clinical studies of Level I to IV evidence, case series including at least 5 patients, and clinical follow-up of at least 80% and 6 months. The references of all articles were reviewed as well for any additional articles that were not found on the initial search.

Patient demographic characteristics (age, sex, occupation), activity profile (athlete, military, other), and level of competition (recreational, collegiate, professional) were extracted from each article. We further assessed the duration of symptoms, operative indications, surgical technique, compartment involvement, reported preoperative and postoperative clinical outcomes, presence of revision surgery or unplanned reoperation, and perioperative complication profile. "Clinical success" was defined as 1 or more of the following: a good or excellent patient-reported outcome, postoperative patient satisfaction, an indication that the patient would elect to undergo the surgical procedure again, complete resolution of pain or exertional symptoms, or a return to full preoperative levels of activity.

Statistical Analysis

For continuous data, the weighted averages were calculated and reported including 95% confidence intervals (CIs) for the population age, success rate, composition (military, athletes, and so on), compartment involvement, and overall follow-up. The cumulative standard deviation (retrieved from included studies) for age and follow-up is reported in this article.

Results

Literature Selection

Of the 204 articles discovered on our initial search, 164 articles were eliminated based on abstract review based on clear irrelevance and exclusion criteria. For the 40 articles remaining, full abstracts were reviewed in depth by the 2 lead investigators (D.C., J.A.R.) and confirmed for inclusion by the independent senior authors (J.C.D., N.K., B.R.W.), as were the references for additional studies. After retrieval and review of these 40 full-text articles, 27 were eliminated based on redundancy of data between studies (5 studies), inadequate sample size (fewer than 5 patients) (13 studies), focus on pathologies aside from CECS (3 studies), and/or emphasis on surgical technique with no clinical outcomes reported (6 studies). A review of included article references yielded an additional 11 publications that were not found on the initial search (Fig 1). The final review included 24 publications: 1