

# Exertional Compartment Syndrome of the Forearm in an Elite Flatwater Sprint Kayaker

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Chronic exertional compartment syndrome (CECS) is a potentially debilitating entity among athletes across a variety of sports. Defined as an intermittent and reversible pathologic elevation of compartment pressures following exertion,<sup>17</sup> it has been best recognized in the lower extremities.<sup>5,15,19,22</sup> Only rarely has CECS been reported in the upper limbs, with just 25 reported cases of exertional compartment syndrome in the forearm.<sup>†</sup> Where noted, the majority of these reported cases involve activities that place substantial demands on the forearm musculature, including manual labor,<sup>4,11,12,21,25</sup> motorcycle racing,<sup>1,9,16</sup> tennis,<sup>2</sup> rock climbing,<sup>24</sup> and weight lifting.<sup>13</sup>

We report a novel case of CECS in an elite flatwater kayaker, discuss this patient's management, and present a review of the literature.

## CASE REPORT

A 27-year-old left-hand-dominant Olympic flatwater kayaker was seen at our office with complaints of left forearm weakness and pain over the preceding year. Painful forearm swelling, fatigue, and intermittent ulnar-sided hand paresthesia were noted to gradually develop in association with training activities—as well as off-season tennis—and without preceding injury. Symptoms occurred essentially only after exertion, particularly during training activities, and were relieved by rest. Over time, a mild degree of discomfort was noted even between exertional episodes. These symptoms were significantly limiting with respect to the patient's ability to train and compete. No right-sided symptoms were reported.

On physical examination, full active and passive motion of the left wrist and elbow were appreciated and there was no bony tenderness. The left upper extremity was grossly neurovascularly intact, without findings to suggest any nerve entrapment syndromes, including ulnar nerve compression at the elbow or wrist. Mild symptoms of pain and weakness were reproduced by resisted volar wrist flexion and ulnar deviation, as well as forearm pronation, but not supination. Diffuse tenderness and fullness were noted over the flexor muscle compartments, and slight weakness was appreciated with respect to volar wrist flexion when compared with the opposite side. No extensor forearm findings were appreciated. Forearm circumference, measured 7.5 cm distal to the medial epicondyle, was 30.0 cm on the right and 30.8 cm on the left. After 5 to 10 minutes of resisted left forearm exercises with weights, symptoms were accurately reproduced, with worsened forearm tenderness and fullness on examination and increased measured left forearm circumference (31.2 cm). Plain films of the elbow and forearm were normal, without any evidence of stress fracture or other abnormality.

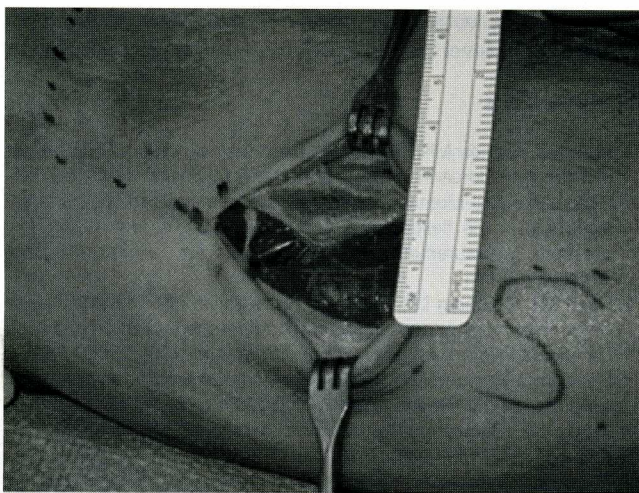
A diagnosis of CECS of the left forearm volar compartments was made based on these findings, and the patient opted for compartment release. In the holding area before surgery, the patient was asked to perform resisted forearm exercises for 5 to 10 minutes. After this, the left forearm was prepared and draped appropriately in the operating room and an arm tourniquet was inflated. A 7- to 8-cm midvolar forearm incision was made sharply (Figure 1). Subcutaneous tissues were mobilized, and the medial antebrachial cutaneous nerve was identified and protected. The superficial fascia was identified and was divided using a carpal tunnel fascial tome from the lacertus fibrosus proximally to within 2 cm of the wrist crease distally. Discrete, tight fibrous bands were noted in the pronator teres–flexor carpi radialis interval and were released under direct visualization. The forearm musculature was noted to bulge appreciably after fasciotomy and release of these bands. Complete visualization (and palpation) of the fasciotomy both proximally and distally demonstrated no residual fascial constriction, and there was no persistent tense muscular swelling—superficially or deep.

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†References 1, 2, 4, 8-14, 16-18, 21, 24-29.



**Figure 1.** A midvolar approach was used to expose the superficial flexor-pronator compartment. Compartment release was performed beyond the incision both proximally and distally, after which the muscles in this compartment were seen to expand dramatically. Direct palpation of the deep volar compartment through this incision demonstrated normal muscle turgor and hence was not thought to require release.

Because of the exceptionally low muscle turgor in the deep compartment, a decision was made to not perform further releases. Routine skin closure was performed after dropping the tourniquet and achieving hemostasis.

At the first postoperative visit, the patient reported immediate relief of preoperative rest symptoms. After suture removal, early motion of the left wrist and forearm were encouraged, and a supervised therapy regimen consisting of wrist and forearm stretching and strengthening and a gradual return to training activities was undertaken over the next 4 to 6 weeks. At 2-year follow-up, the patient reported complete and persistent relief of his preoperative complaints, symmetric right and left grip-strength measurements, and an unencumbered return to full-time flatwater kayaking training and competition at the Olympic Training Center.

## DISCUSSION

Because of its typically benign presentation, CECS is often a difficult diagnosis to make but one that can significantly affect both athletic performance and quality of life. To date, the published literature has focused primarily on the recognition and management of the more common lower extremity CECS.<sup>5,15,19,22</sup> However, a growing collection of primarily case report data have brought attention to CECS in the forearm. To our knowledge, only 25 cases of forearm CECS have been reported.<sup>1,2,4,8-14,16-18,21,24-29</sup>

Anatomically, forearm compartment anatomy is more complex than in the lower extremity. Because fascial divisions are less distinct in the forearm—a number of muscular planes connecting 1 “compartment” to another—there

exist multiple potential fascial enclosures. Frober and Linss<sup>7</sup> defined 3 dorsal compartments (ulnar extensor, dorsal extensor, and radial) and Chan et al<sup>3</sup> have defined 3 volar compartments (pronator quadratus, superficial, and deep flexor). Although each potential compartment must be considered in evaluating patients with suspected forearm CECS, the majority of published cases involve the superficial and deep flexor compartments,<sup>†</sup> with a smaller group reporting isolated extensor compartment syndromes<sup>11,12,17,26,27</sup> or both.<sup>4,25</sup> Roughly one-third of the reported cases involve both forearms.<sup>8,11,13,17,24,25</sup> Our patient's unilateral CECS involving predominantly the superficial flexors would be in keeping with the most common reported anatomic distribution (ie, flexor vs extensor). It is interesting that during our surgical release, we noted particularly dense fibrous bands superficially at the flexor-pronator interval. Although we did not directly measure deep volar compartment pressures in this patient (palpably soft at the time of surgery), we believe the superficial flexor-pronators were exclusively involved, a finding reported only once previously.<sup>2</sup>

Reported activities among patients with forearm CECS carry the common theme of placing significant demands on the forearm musculature, including manual labor,<sup>4,11,12,21,25</sup> motorcycle racing,<sup>1,9,16</sup> tennis,<sup>2</sup> rock climbing,<sup>24</sup> and weight lifting.<sup>13</sup> Our report of forearm CECS in an elite, Olympic-level flatwater kayaker is the first we are aware of but is consistent with these prior reports given the considerable demands flatwater kayakers place on their forearms—particularly the volar compartments, through which the majority of load is transmitted during the sprint stroke.

Among the reported cases of forearm CECS, the classic presentation is one of forearm pain, often with associated weakness, during and shortly after forearm exertion. In all but 2 reports of acute exertional syndromes,<sup>4,10</sup> forearm symptoms are noted to resolve shortly after the offending activity is terminated, as was generally the case with our patient. It is interesting to us that this syndrome developed in our patient late in his kayaking career. Despite years of intense training with likely similar kayaking mechanics, his symptoms developed only in the year preceding his presentation. Although this would appear to be the typical (yet unexplained) presentation for CECS,<sup>§</sup> we postulate that the late development of CECS in our patient may have been the result of a prior forearm injury in which the fibrous bands noted at surgery developed secondarily.

Physical examination findings in forearm CECS classically include swollen, tender compartments shortly after exertion (symptoms reproduced with provocative forearm exercise), but with otherwise normal findings.<sup>9,13,25</sup> Our patient's findings were consistent with this reported presentation, with isolated volar compartment swelling and pain. We found it useful to document both reproduction of symptoms as well as increases in forearm circumference following exertion.

Because of the rarity of forearm CECS, other potential causes of forearm pain and weakness should be considered.

<sup>†</sup>References 1, 2, 9, 10, 13, 14, 16, 18, 21.

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