Original Article

Return to Sport Rates and Subjective Outcomes Are Similar After Open or Endoscopically Assisted Compartment Release for Chronic Lower-Extremity Exertional Compartment Syndrome

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Purpose: To retrospectively compare return to sport rates and subjective outcomes of patients who underwent open or endoscopic compartment release for the surgical management of chronic exertional compartment syndrome. **Methods:** This was a retrospective review of patients who underwent lower-extremity fasciotomy for chronic exertional compartment syndrome from June 2012 to June 2020. Eligibility included patients 15 to 45 years of age who identified as an athlete and had at least 6 months of follow-up. Fasciotomies for trauma or infection were excluded. One surgeon exclusively performed each type of surgery. Postoperative outcome measures included the Lower Extremity Functional Scale, the Marx Activity Scale, and a return to play survey. **Results:** In total, 24 patients (13 endoscopically assisted fasciotomies, 11 open fasciotomies) had a mean follow-up of 3.8 ± 2.1 years; 19 patients returned to their sporting activity. No significant difference existed between return to play rates ($P = .630$) or return to play times ($P = .351$). There were no significant differences between the groups in the Lower Extremity Functional Scale score, Marx Activity Scale score, Single Assessment Numeric Evaluation score, pain score at rest, and during sporting activity. Overall satisfaction rates were found to be significantly greater in the endoscopically assisted fasciotomy group ($P = .041$). **Conclusions:** In this small sample of heterogenous groups of patients, we found no significant differences in return to sport rates or subjective results after surgery. Patients experienced a high subjective recurrence rate. The endoscopically assisted fasciotomy group reported greater subjective patient satisfaction compared with the open fasciotomy group. **Level of Evidence:** Level III, comparative study, retrospective.

Chronic exertional compartment syndrome (CECS) is seen most frequently in young athletes or otherwise-active populations.[1] The classic symptoms of CECS are aching or sharp pain with recurring tightness during exercise that often resolves with rest.[1] CECS has historically posed a challenge for clinicians, as the diagnosis is often one of exclusion, and initial nonoperative management often is attempted but frequently unsuccessful.[1-18] Surgery, originally in the form of open fasciotomy (OF), was described as the treatment of choice and traditionally has had success rates ranging from 65 to 100%.[6,19-21] This technique has subsequently been modified, and operative management may include surgery in the form of mini-open fasciotomy, minimally invasive subcutaneous fasciotomies, single-incision fasciotomy, and/or fasciotomies with partial fasciectomies. As these procedures involve some degree of blind dissection, reported complications include nerve and vessel injury, hematoma formation, wound infections, and deep venous thrombosis. Furthermore, there remains a lack of consensus in the literature regarding the optimal surgical technique for the management of CECS as postoperative fibrosis,

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neurovascular injury, inadequate fascial release, cosmetic dissatisfaction, and recurrence have led to poor patient outcomes in both open and mini-open procedures.[1,4-9] Seemingly to address these complications, endoscopic treatment of recalcitrant CECS was described in 1999.[15] This technique has been shown to decrease postoperative hematoma, reduce risk of infection, and improve return to activity time secondary to reduced damage to soft tissues and limited fibrosis.[5,13-16]

Outcomes of endoscopic release of lower-extremity compartments for CECS have only been reported in 3 previous studies[5,14,16] and have been limited by small sample size. In addition, none of these studies directly compared endoscopic with open or mini-open groups. Therefore, the purpose of this study was to retrospectively compare the outcomes of patients undergoing either open or endoscopic compartment release for the surgical management of CECS. The null hypothesis was that there would be no significant difference in postoperative outcomes between patient groups following open or endoscopic compartment release.

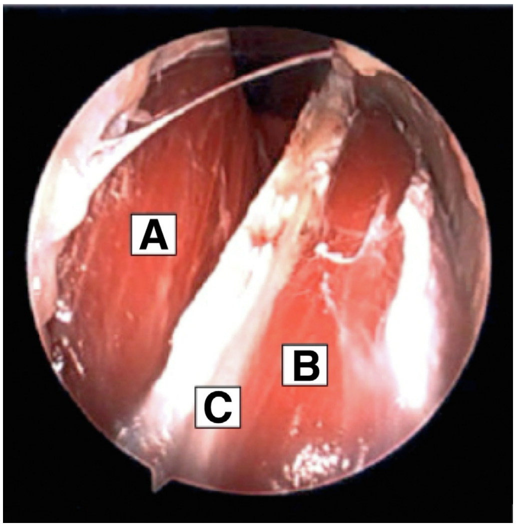

Fig 1. Endoscopic image showing the interval between the anterior (B) and lateral (A) compartments following left endoscopically assisted anterior and lateral compartment release. In this image, the endoscope is oriented distally through the distal anterolateral incision with the patient in the supine position. The released superficial peroneal nerve is also in view (C).

Methods

Following institutional review board approval, a retrospective review of patients who underwent lower-extremity fasciotomy for chronic exertional compartment syndrome by the 2 senior surgeons (K.B.F. and S.H.) was performed from June 2012 to June 2020. One surgeon (K.B.F.) exclusively performed OF whereas the other (S.H.) exclusively performed endoscopically assisted fasciotomies (EAF). Patients were eligible for inclusion into the study if they were between 15 and 45 years of age at the time of the procedure and identified as an athlete preoperatively. Patients who underwent a fasciotomy for trauma, infection, or an acute pathologic process were excluded from analysis. All patients were diagnosed based on medical history and were confirmed with pre- and postexercise compartment pressure testing. A specific compartment was released if there was elevated pressure or if the patient was symptomatic in a compartment with elevated pressure in another compartment. The compartment pressures were evaluated as described by Pedowitz et al.[17] Compartment pressures consistent with the diagnosis of compartment syndrome include a pre-exercise pressure $\geq$15 mm Hg, a 1-minute postexercise pressure of $\geq$30 mm Hg, or a 5-minute postexercise pressure $\geq$20 mm Hg.[17] In total, 30 patients were eligible for this study, and of these patients, 24 (80%) were successfully reached via telephone and agreed to participate in the study. Of those who agreed to participate, 13 were in the EAF group whereas 11 were in the OF group. Three patients in the OF group had previous compartment releases and completed the surveys with respect to their more recent procedure.

Patient-Reported Outcomes

At final follow-up, all patients included in the study completed a custom survey designed to collect basic demographics, clinical data, and subjective satisfaction among other variables. In addition, all patients completed the Lower Extremity Functional Scale (LEFS) and the Marx Activity Scale (MAS), both of which are standardized, validated patient-reported outcome instruments. The full surveys may be found in the Appendix, available at www.arthroscopyjournal.org.

Surgical Treatment

Open Fasciotomy Technique

An Esmarch bandage is used to exsanguinate the limb before tourniquet inflation and 2 lateral incisions are made through the skin and subcutaneous tissue. A transverse fascial incision is made crossing the intermuscular septum in the proximal incision. The fascia is then completely released in both proximal and distal directions. The distal incision is centered over the intermuscular septum with the midpoint centered 11 cm proximal to the tip of the lateral malleolus. The superficial peroneal nerve is identified and protected. Next, the lateral compartment fascia is identified, and scissors are used to release this compartment proximally and distally while protecting the nerve. Using both the proximal and distal skin incision, complete

Table 1. Demographic Data of the Patients Stratified by EAF and OF

	EAF (n = 13)	OF (n = 11)	*P* Value
Sex			.142
Male	1	4	
Female	12	7	
Age at procedure date, y	19.1 ± 2.1 (15-22)	22.4 ± 8.4 (15-40)	.231
Body mass index	24.9 ± 2.9 (19-31.17)	23.7 ± 4.1 (19.13-30.51)	.408
Number of legs			.576
One leg	1	2	
Both legs	12	9	
Number of compartments released			.105
Four	6	9	
Two	7	2	
Preoperative Sx duration, mo	20.9 ± 16.9 (2-60)	22.7 ± 15.7 (6-48)	.790
Mean follow-up time, y	3.2 ± 2.1 (1.0-5.4)	4.5 ± 2.1 (1.2-7.4)	.138

EAF, endoscopically assisted fasciotomy; OF, open fasciotomy; Sx, symptom.

fasciotomy of the anterior and lateral compartments is insured. Attention is then turned to the medial aspect. Two 3- to 4-cm incisions are made 1 cm posterior to the medial tibial border at the distal third and proximal third of the leg. The saphenous nerve and vein are identified and protected. The superficial posterior compartment is visualized and incised over the gastric—soleus complex. The fascia is release proximally and distally. The deep posterior compartment is then completely released with care to avoid the posterior tibial neurovascular bundle. The wounds are thoroughly irrigated, and a layered running closure is performed with absorbable sutures.

Endoscopically Assisted Fasciotomy Technique

Anterior and Lateral Compartment Fasciotomy. Following lower-extremity exsanguination and tourniquet inflation, a 1-inch distal lateral incision is made at the junction of the distal third and middle third of the lateral side of the leg (Fig 1). The subcutaneous tissue is incised with care to identify the superficial peroneal nerve where it pierces the fascia. Blunt dissection is then performed to further separate the subcutaneous tissue from the fascia of the anterior compartment. With the use of retractors, the endoscope is then inserted into the interval between fascia and the subcutaneous tissue. Under endoscopic guidance, the superficial peroneal nerve is identified and mobilized. A small longitudinal incision of the fascia is then made in the anterior and lateral compartment using a #15 blade. With care to avoid the nerve and any small crossing vessels, the longitudinal incision of the fascia is extended proximally until the point where the fascia can no longer be safely visualized from the distal skin incision endoscopically. The endoscope is then turned distally, and the fasciotomy of the anterior compartment is completed using Metzenbaum scissors. At this stage, attention is then turned to identify the fascia of the lateral compartment, and an endoscopic fasciotomy is performed in the same manner, again using care to avoid the superficial peroneal nerve and small vessels.

In the proximal third of the leg, another 1-inch incision is made and the subcutaneous tissue is bluntly released from the proximal fascia of the anterior compartment. The endoscope is inserted into the created interval and the proximal extent of the distal fasciotomy is visualized. A #15 blade is used to further extend the fasciotomy proximally. The endoscope is directed proximally, and the fasciotomy of the anterior compartment is continued and completed using Metzenbaum scissors. Attention is turned to the lateral compartment and the endoscope is positioned in the proximal subcutaneous incision and directed distally. Metzenbaum scissors are then inserted into the distal subcutaneous incision and used to continue the distal fasciotomy proximally towards the endoscope. When the Metzenbaum scissors cannot reach any further proximally, a #15 blade in the proximal incision is used to make a small incision in the lateral compartment. Metzenbaum scissors are then used to connect this proximal fascial incision with the previous distal fasciotomy. The endoscope is again directed proximally, and the lateral fasciotomy is completed by extending the fascial incision proximally. The endoscope is used to confirm that the proximal and distal fascial incisions are connected for both the lateral and anterior compartments to ensure complete compartment releases.

Superficial and Deep Posterior Compartment Fasciotomy. An 8-cm incision at the central one third of the tibia just off the posterior tibial crest is created. The branches of the saphenous vein and nerve are identified and retracted anteriorly. A #15 blade is used to incise the superficial posterior compartment. Blunt dissection is then used to clear tissue from above and below the fascia. A #15 blade is then used to release the superficial compartment proximally and distally. Next, the muscle of the superficial compartment is

Table 2. Sport Involvement in Patients With Lower-Extremity CECS

Sport	EAF (n = 13)	OF (n = 11)
Running	0 (0%)	6 (55%)
Field hockey	6 (46%)	1 (9%)
Soccer	3 (23%)	0 (0%)
Lacrosse	1 (8%)	2 (18%)
Football	1 (8%)	1 (9%)
Volleyball	1 (8%)	0 (0%)
Basketball	0 (0%)	1 (9%)
Horseback riding	1 (8%)	0 (0%)

NOTE. N (%) refers to the percentage of the sub-group, either EAF or OF.

CECS, chronic exertional compartment syndrome; EAF, endoscopically assisted fasciotomy; OF, open fasciotomy.

dissected off of the posterior aspect of the tibia and retracted to allow for direct visualization of the deep posterior compartment. The deep posterior compartment fascia is then released off the posterior tibia border proximally and distally with Metzenbaum scissors under endoscopic guidance. The tourniquet is deflated, the wounds are irrigated and closed using running absorbable sutures.

Postoperative Rehabilitation

Patients are partial weight-bearing with crutch use for the first 2 weeks after surgery. Aspirin is prescribed for venous thromboembolism prophylaxis. At weeks 2 to 4, crutches are discontinued, and patients progress to weight-bearing as tolerated. Ice, elevation, and compression of the extremity through use of an Ace bandage or knee-high compression stocking are used throughout the postoperative period.

Statistical Analysis

Continuous variable data are reported as means with standard deviations and categorical data are reported as frequencies with percentages. The Shapiro—Wilk test was employed to determine whether data were normally distributed. Continuous variables compared between 2 groups were assessed with the Student *t* test for parametric and the Mann—Whitney *U* test for nonparametric data whereas categorical variables between 2 or more groups were assessed with chi-squared analysis. Statistical significance was set at $P < .05$. All statistical analyses were performed with Statistical Package for the Social Sciences (SPSS) Statistics software 26 (IBM Corp., Armonk, NY).

Results

Demographic Characteristics

The study population of 24 patients (19 male and 5 female, mean age 20.6 ± 6.0 years) included 13 (54.1%) patients in the EAF and 11 (45.8%) patients in the OF group. Minimum follow-up was 6 months with an average 4.6 years for OF group and 3.2 years for EAF group. There was no statistically significant difference observed between the 2 groups with respect to demographic data, as summarized in Table 1. Participation in sporting activity was diverse and is summarized in Table 2.

Table 3. Clinical Outcome Comparison Between EAF and OF

	EAF (n = 13)	OF (n = 11)	*P* Value
Subjective symptom assessment			.576
Resolved or improved	12	9	
No change or worsened	1	2	
Returned to play?			.630
Yes	11 (84.6%)	8 (72.7%)	
Higher-level performance	5	2	
Same-level performance	3	4	
Lower-level performance	5	2	
No	2 (15.4%)	3 (27.2%)	
Return to sport activity, mo	4.3 ± 3.0	5.3 ± 2.4	.351
Reasons for no RTP			
Symptom related	1	2	
Other	1	1	
Recurrence of symptoms?			.851
Yes	9	8	
No	4	3	

EAF, endoscopically assisted fasciotomy; OF, open fasciotomy; RTP, return to play.

Clinical Outcomes and Patient-Reported Outcomes

With respect to the entire cohort, at a mean follow-up time of 3.8 ± 2.1 years, 19 (79.2%) patients returned to their sporting activity, whereas 5 (20.8%) patients did not. Those who returned did so at an average 4.7 ± 2.7 months postoperatively. There was no significant difference between return to play rates (84.6% EAF, 72.7% OF; $P = .630$) or return to play times (4.3 ± 3.0 vs 5.3 ± 2.4, $P = .351$) between the EAF and OF groups. Both groups had a high subjective recurrence rate, but there was no significant difference between the groups (69.2% EAF, 72.7% OF; $P = .85$) No other differences were detected with respect to any of the collected general clinical outcomes summarized in Table 3.

In addition, there were no significant differences between the EAF and OF groups with respect to either the LEFS score (93.3 ± 6.0 vs 91.6 ± 9.2, $P = .977$) or the MAS score (12.9 ± 3.7 vs 12.3 ± 3.5, $P = .733$). Similarly, no significant differences were detected between the 2 groups with respect to Single Assessment Numeric Evaluation score, pain score at rest, and during sporting activity. However, overall satisfaction rates, rated on a scale of 0 to 100, were found to be significantly greater in the EAF group as compared with the

Table 4. Subjective Outcomes Between EAF and OF

	EAF (n = 13)	OF (n = 11)	*P* Value
LEFS	93.3 ± 6.0 (82.5-100)	91.6 ± 9.2 (76.3-100)	.977
MAS	12.9 ± 3.7 (5-16)	12.3 ± 3.5 (6-16)	.733
SANE	82.5 ± 9.8 (68-100)	75.3 ± 21.6 (25-100)	.302
Pain at rest	3.7 ± 6.8 (0-20)	9.9 ± 16.9 (0-50)	.534
Pain when sport activity	39.9 ± 29.8 (0-85)	35.6 ± 31.6 (0-94)	.733
Overall satisfaction score	89.6 ± 10.1 (70-100)	63.8 ± 30.7 (20-100)	.041*

NOTE. Values are mean ± SD (range).

EAF, endoscopically assisted fasciotomy; LEFS, Lower Extremity Functional Scale; MAS, Marx Activity Scale; OF, open fasciotomy; SANE, Single Assessment Numeric Evaluation.

*Denotes a $P < .05$.

OF group (89.6 ± 10.1 vs 63.8 ± 30.7, $P = .041$). Subjective patient-reported outcomes between the 2 groups are summarized in Table 4.

There were 6 patients who reported a sensory/motor deficit following surgery, including 4 patients who underwent EAF and 2 patients who underwent OF. Among these, 1 patient who underwent EAF had persistent numbness in the saphenous nerve distribution. One patient who underwent EAF initially complained of transient inability to dorsiflex her right big toe, but this resolved. The remaining 2 patients who underwent EAF reported decreased sensation on the anterior shin distal to the incision sites, both of which resolved by 8 weeks postoperatively. One patient who underwent OF reported mild numbness on the anterior shin, which completely resolved by 5 weeks postoperatively. The other patient who underwent OF complained of persistent bilateral shin, ankle, and foot numbness following periods of intense exercise, which resolved after rest. One patient in the OF group developed a hematoma after sustaining a fall 1 week postoperatively, which resolved without intervention. No hematomas were reported in the EAF group. Four superficial infections were reported, including 1 in the EAF group and 3 in the OF group. Each of these was successfully managed with outpatient antibiotics. One additional patient in the EAF group developed cellulitis, which required intravenous antibiotics in addition to surgical irrigation and debridement. It should be noted that this patient was noncompliant with the initial postoperative rest period and gradual return to activity.

Discussion

In our study, we found no significant differences in return to sport rates or subjective outcomes in patients who underwent either open or endoscopic lower extremity fasciotomy for the treatment of chronic exertional compartment syndrome CECS is a difficult diagnosis and therefore a challenging condition that typically affects a high-functioning, athletic population. This study represents the first attempt to directly compare the results of 2 published surgical management strategies for CECS in athletes. Overall, no significant differences between groups were found with respect to return to play rates or timing, symptom recurrence, complications, or Single Assessment Numeric Evaluation, LEFS, or MAS scores. The only significant difference was that the EAF group reported greater overall satisfaction than the OF group. Patients in both groups self-identified as athletes, were similar in age and body mass index at presentation, and had a similar duration of preoperative symptoms. These results suggest EAF is a viable alternative to OF in the treatment of CECS.

The exact reason(s) for increased overall satisfaction with EAF compared with OF are not known, as the survey asked patients to rate their overall satisfaction on a 0 to 100 scale. A better cosmetic result after EAF may play a part in this increased satisfaction. An alternative explanation for the difference in patient satisfaction is that the score is less tied to differences in patient outcome but rather their interaction with their surgeon. As each surgeon performed only one kind of surgery, the bedside manner and demeanor of the physician in the office may have impacted patient satisfaction. In addition, while not statistically significant, on average those in the EAF group returned to sport 1 month earlier than patients in the OF group and had generally greater subjective outcome scores compared with the OF group. The lack of statistical significance may be related to the small sample size, with the combined improvements in pain and function leading to a statistically significant increase in overall satisfaction. The inclusion of revision cases, 3 of whom where in the OF group, also may explain the difference in overall patient satisfaction.

While the initial diagnosis is often difficult, evident by the >20 months of symptoms before surgical intervention seen in this cohort of patients, questions remain concerning appropriate treatment. Previously, there have been only three published case series reporting patient outcomes for EAF.[5,14,16] A recent systematic review summarized the results of these studies in a comparison to minimally invasive fasciotomy, and, despite finding no difference in outcomes and success rates, concluded that there simply was not enough published data on EAF to draw a final conclusion.[3] In general, there is low evidence for any management strategy of CECS. The findings of this study strengthen the current literature by providing a direct comparison between EAF and OF techniques and may help guide physicians in surgical decision making for CECS.

The return to sport rate (84.6% EAF and 72.7% OF) following operative intervention was consistent with other data in the literature. Wittstein et al.[5] reported on 14 legs in 9 patients with CECS and found that 8 of 9 patients returned to preoperative levels of activity. In the largest published study to date, Lohrer and Nauck[14] reported their results of 19 endoscopic compartment releases in 17 patients with CECS. Ten of their 17 patients returned to previous sport activities. Return to sport rates following open fasciotomies varies from 65% to 100% in the literature and is largely dependent on the involved compartments.[16,22,23]

Despite the high return to play rates, 9 of 13 (69.2%) patients in the EAF group and 8 of 11 (72.7%) in the OF group reported recurrence of symptoms following their procedure in this study. Symptom recurrence in patients who undergo compartment release for CECS has been inconsistently documented and have variable rates in the literature ranging from 0% to 45%.[24] High recurrence rates and reoperations have been reported to be associated with military personnel,[25,26] increased duration of preoperative symptoms,[8,14,27] and multiple compartments, especially in patients with posterior compartment involvement.[8] Waterman et al.[25] reported nearly one half of their cohort of 611 military patients (45%) experienced recurrence of symptoms with varying degrees of severity following open compartment release, although only 5.9% of their patients underwent revision surgery. In contrast, several mini-open fasciotomy studies have reported recurrence rates as low as 3%.[1,8] A study by Wittstein et al.[5] also reported a 0% recurrence rate following endoscopically-assisted fasciotomy. It is possible that the high rates of recurrence in this study may be related to the high incidence of patients undergoing a multiple compartment release procedure and prolonged mean duration of presentation to surgery. In addition, the diagnosis of CECS is difficult to make and any patient who may not have had true CECS would likely report recurrence of symptoms as the underlying etiology of their problem would not be corrected with fasciotomies. Given this variability in recurrence rate, future studies are needed to further delineate the risk factors for patients experiencing recurrence.

Three patients in the OF group had undergone previous compartment releases. All 3 initially had only 2 compartment anterolateral release but experienced symptom recurrence. Subsequently, they all underwent 4 compartment open fasciotomies. Two of these 3 patients returned to sport following their revision procedure. This is in accordance with the 67% return to sport rate following revision compartment release reported by Waterman et al.[25] in their retrospective review of CECS in the military population.

Limitations

We acknowledge several limitations in the current study. The retrospective nature of the study and the reliance on patient surveys are subject to selection and recall bias. In addition, the scarcity of CECS means that the included sample size is small and includes 4 times more female patients than male patients, which risks Type II error. Furthermore, each procedure type was performed by a different surgeon, introducing variables that may affect the results. As the main purpose of this study was to compare return to play between the 2 groups, it is possible that the larger number of field hockey players in the endoscopic release group compared with the larger number of runners in the open release group did not allow for a true comparison of return to play rates.

Conclusions

In this small sample of heterogenous groups of patients, we found no significant differences in return to sport rates or subjective results after surgery. Patients experienced a high subjective recurrence rate. The EAF group reported greater subjective patient satisfaction compared with the OF group.

References

1. Detmer DE, Sharpe K, Sufit RL, Girdley FM. Chronic compartment syndrome: Diagnosis, management, and outcomes. *Am J Sports Med* 1985;13:162-170.
2. Barnes M. Diagnosis and management of chronic compartment syndromes: A review of the literature. *Br J Sports Med* 1997;31:21-27.
3. Lohrer H, Nauck T, Lohrer L. Endoscopic-assisted release of lower leg chronic exertional compartment syndromes: Results of a systematic literature review. *Sports Med Arthrosc Rev* 2016;24:19-23.
4. Hallock GG. An endoscopic technique for decompressive fasciotomy. *Ann Plast Surg* 1999;43:668-670.
5. Wittstein J, Moorman CT 3rd, Levin LS. Endoscopic compartment release for chronic exertional compartment syndrome: Surgical technique and results. *Am J Sports Med* 2010;38:1661-1666.
6. Rorabeck CH, Bourne RB, Fowler PJ. The surgical treatment of exertional compartment syndrome in athletes. *J Bone Joint Surg Am* 1983;65:1245-1251.
7. Schepsis AA, Fitzgerald M, Nicoletta R. Revision surgery for exertional anterior compartment syndrome of the lower leg: Technique, findings, and results. *Am J Sports Med* 2005;33:1040-1047.
8. Slimmon D, Bennell K, Brukner P, Crossley K, Bell SN. Long-term outcome of fasciotomy with partial

fasciectomy for chronic exertional compartment syndrome of the lower leg. *Am J Sports Med* 2002;30: 581-588.
9. Winkes MB, van Zantvoort AP, de Bruijn JA, et al. Fasciotomy for deep posterior compartment syndrome in the lower leg: A prospective study. *Am J Sports Med* 2016;44: 1309-1316.
10. Lavery KP, Bernazzani M, McHale K, Rossy W, Oh L, Theodore G. Mini-open posterior compartment release for chronic exertional compartment syndrome of the leg. *Arthrosc Tech* 2017;6:e649-e653.
11. Cooper GG. A method of single-incision, four compartment fasciotomy of the leg. *Eur J Vasc Surg* 1992;6: 659-661.
12. Mubarak SJ, Owen CA. Double-incision fasciotomy of the leg for decompression in compartment syndromes. *J Bone Joint Surg Am* 1977;59:184-187.
13. Kitajima I, Tachibana S, Hirota Y, Nakamichi K, Miura K. One-portal technique of endoscopic fasciotomy: Chronic compartment syndrome of the lower leg. *Arthroscopy* 2001;17:33.
14. Lohrer H, Nauck T. Endoscopically assisted release for exertional compartment syndromes of the lower leg. *Arch Orthop Trauma Surg* 2007;127:827-834.
15. Ota Y, Senda M, Hashizume H, Inoue H. Chronic compartment syndrome of the lower leg: A new diagnostic method using near-infrared spectroscopy and a new technique of endoscopic fasciotomy. *Arthroscopy* 1999;15:439-443.
16. Stein DA, Sennett BJ. One-portal endoscopically assisted fasciotomy for exertional compartment syndrome 2005;21:108-112.
17. Pedowitz RA, Hargens AR, Mubarak SJ, Gershuni DH. Modified criteria for the objective diagnosis of chronic compartment syndrome of the leg. *Am J Sports Med* 1990;18:35-40.
18. Fronek J, Mubarak SJ, Hargens AR, et al. Management of chronic exertional anterior compartment syndrome of the lower extremity. *Clin Orthop Relat Res* 1987;220:217-227.
19. Styf JR, Körner LM. Chronic anterior-compartment syndrome of the leg. Results of treatment by fasciotomy. *J Bone Joint Surg Am* 1986;68:1338-1347.
20. Schepsis AA, Martini D, Corbett M. Surgical management of exertional compartment syndrome of the lower leg. Long-term followup. *Am J Sports Med* 1993;21:811-817; discussion 817.
21. Rorabeck CH, Fowler PJ, Nott L. The results of fasciotomy in the management of chronic exertional compartment syndrome. *Am J Sports Med* 1988;16:224-227.
22. García-Mata S, Hidalgo-Ovejero A, Martinez-Grande M. Chronic exertional compartment syndrome of the legs in adolescents. *J Pediatr Orthop* 2001;21:328-334.
23. Wallensten R. Results of fasciotomy in patients with medial tibial syndrome or chronic anterior-compartment syndrome. *J Bone Joint Surg Am* 1983;65:1252-1255.
24. Campano D, Robaina JA, Kusnezov N, Dunn JC, Waterman BR. Surgical management for chronic exertional compartment syndrome of the leg: A systematic review of the literature. *Arthroscopy* 2016;32:1478-1486.
25. Waterman BR, Laughlin M, Kilcoyne K, Cameron KL, Owens BD. Surgical treatment of chronic exertional compartment syndrome of the leg: Failure rates and postoperative disability in an active patient population. *J Bone Joint Surg Am* 2013;95:592-596.
26. Roberts AJ, Krishnasamy P, Quayle JM, Houghton JM. Outcomes of surgery for chronic exertional compartment syndrome in a military population. *J R Army Med Corps* 2015;161:42-45.
27. Winkes MB, Hoogeveen AR, Houterman S, Giesberts A, Wijn PF, Scheltinga MR. Compartment pressure curves predict surgical outcome in chronic deep posterior compartment syndrome. *Am J Sports Med* 2012;40:1899-1905.