Lower Leg Lateral Chronic Exertional Compartment Syndrome

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Lower Leg Lateral Chronic Exertional Compartment Syndrome: Prospective Surgical Treatment Outcomes for Isolated or Combined Lateral Fasciotomy

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Abstract

Background: Chronic exertional compartment syndrome involving the lower leg lateral compartment (lat-CECS) seldom occurs isolated but is usually combined with CECS of the anterior (ant-CECS) or deep posterior compartment (dp-CECS). Patient characteristics in lat-CECS and outcome after surgery are largely unknown. The aim of this prospective case series was to describe patient characteristics and symptoms and to report on outcome following a fasciotomy.

Methods: All patients diagnosed with lat-CECS based on exertional lateral lower leg symptoms and elevated intracompartmental pressure (ICP) measurements according to the Pedowitz criteria (ICP ≥ 15 mm Hg at rest, and/or ≥30 mm Hg after 1 minute, and/or ≥20 mm Hg 5 minutes after exercise) were eligible for this study. A standard intake questionnaire scoring symptom patterns was completed by all patients. Patients who were operated for lat-CECS were asked to complete a 3-month and 12-month postoperative questionnaire scoring symptoms and surgical outcome. Patients with a history of CECS surgery, recent lower leg trauma, or peripheral neurovascular disease were excluded.

Results: A total of 881 patients with possible lower leg CECS completed an intake questionnaire and 88 (10%) were diagnosed with lat-CECS according to the Pedowitz criteria (isolated lat-CECS n = 10; lat/ant CECS n = 54, lat/ant/dp CECS n = 19, lat/dp CECS n = 5). Severe pain during exercise and moderate tightness during rest were frequently reported. A group of 28 patients (49 legs; isolated lat-CECS n = 2; lat/ant CECS n = 22, lat/ant/dp CECS n = 3, lat/dp CECS n = 1) was analyzed after fasciotomy. Complications were minor (wound infection requiring antibiotics, n = 3; temporary complex regional pain syndrome with spontaneous recovery, n = 1). Superficial peroneal nerve damage was not observed. One year after surgery, 64% rated outcome as excellent or good, whereas 71% had resumed sports activities.

Conclusion: One in 10 patients with anterolateral exertional lower leg pain evaluated in a tertiary referral center met diagnostic criteria for lat-CECS. Pain and tightness were present during exertion and were often reported occurring during rest and at night. In this series, we found fasciotomy—either an isolated (lateral) or a multiple (combined with anterior and/or deep posterior) compartment fasciotomy—is safe and beneficial in most patients.

Level of Evidence: Level IV, case series.

Keywords: CECS, chronic exertional compartment syndrome, lateral compartment, lower leg

Introduction

The differential diagnosis of exercise-induced lower leg pain (ELP) includes a wide range of entities. One in 7 ELP patients is thought to have chronic exertional compartment syndrome (CECS).[13] There are 3 distinct types of lower leg CECS. The majority (>90%) has either the anterior (ant-CECS) and/or a deep flexor variant (dp-CECS). However, CECS of the lateral (peroneal) compartment may also cause

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ELP. It was estimated that 12% of all CECS cases also involves the lateral compartment.[20]

Most CECS studies report on young athletes and military personnel. Moreover, CECS is traditionally considered a bilateral entity causing pain and tightness during, or immediately after, repetitive exercise.[8,25] Interestingly, recent studies have shed a different light on this traditional clinical picture. One study in civilians found that 1 in 7 individuals with CECS is over 50 years of age and were more often having a unilateral form of CECS.[5] Another prospective study using a symptom questionnaire found that 85% of all CECS patients also reported mild to moderate symptoms at rest, or even at night.[22] These new findings illustrate that diagnosing CECS is even more challenging than previously thought.

If conservative treatments are unsuccessful, a fasciotomy is advised. The efficacy of surgery in ant-CECS and dp-CECS is well documented.[15,16,23,24,27] In contrast, surgical outcome for lat-CECS is scarcely reported, often in small retrospective case series, and frequently combined with ant-CECS.[6,7,9-11,18,24,25] The aim of this prospective case series was to describe patient characteristics and symptom patterns in lat-CECS and to report on the efficacy of surgery in a portion of these lat-CECS patients.

Materials and Methods

General Information

Approximately 600 patients with ELP are evaluated at our department of sports medicine yearly. Our department serves as a national referral center for exertional lower leg pathologies. Most patients (>95%) are engaged in recreational sportive activities. They are referred from within our hospital as well as by general practitioners and a range of specialists from other hospitals across the Netherlands.

Eligible for our prospective case series were individuals with ELP who were analyzed for possible lower leg CECS between January 2013 and April 2019. They all had a history including lateral lower leg pain and tightness provoked by repetitive exercise, and tenderness of the lateral muscle compartment on palpation. All patients completed a standard questionnaire just before intracompartmental pressures (ICP) testing. All had at least 1 positive lateral compartment ICP reading according to the Pedowitz criteria (ICP $\geq$ 15 mm Hg at rest, and/or $\geq$30 mm Hg after 1 minute, and/or $\geq$ 20 mm Hg 5 minutes after exercise) following a provocative treadmill test.[12] A portion of these patients underwent a fasciotomy and completed a 3 month and/or 12-month postoperative questionnaire. Excluded were patients with a history of earlier CECS surgery, a recent lower leg trauma, or peripheral neurovascular disease.

All study procedures complied with the Declaration of Helsinki (1964) and its amendments. As confirmed by the local medical ethical review board, the rules laid down in the Medical Research Involving Human Subjects Act did not apply to this research.

Questionnaire

During a 15-minute waiting period prior to the dynamic ICP measurement, it is standard procedure in our department to complete a questionnaire. This set of questions evaluates severity and frequency of symptoms that are traditionally associated with CECS including pain, tightness, cramps, muscle weakness, and paraesthesia. These cardinal symptoms are scored using a 5-point verbal rating scale (VRS) as reported previously.[19]

Briefly, symptom *severity* is quantified as no (1 point), mild (2 points), moderate (3 points), severe (4 points), or very severe (5 points). Symptom *frequency* is quantified as never (1 point), sometimes (2 points), half of the time (3 points), most of the time (4 points), or all of the time (5 points). For each of these 5 cardinal symptoms, a symptom score is calculated by multiplying severity score with its frequency score. For instance, if a patient reports moderate pain (3 points) most of the time (4 points), he obtains $3 \times 4 = 12$ points for the item pain. A total symptom score is calculated as the sum of each of the 5 symptom scores. Consequently, a total symptom score ranges from a minimum of 5 points ("never any of the 5 cardinal symptoms") to a maximal of 125 points ("each symptom always very severe"). Scores are calculated during *rest* as well as during *exercise*.

All patients who were operated were also asked to complete a 3-month and 12-month questionnaire scoring residual symptom patterns after the fasciotomy. They also rated outcome as excellent or good (successful), or average, fair or poor (unsuccessful).

Dynamic ICP Measurement

Patients are in a supine position with a 20-degree plantar flexion of the ankle joint and 10- to 30-degree flexion of the knee. The patient's history and physical examination dictate which compartments (lateral, anterior, and/or deep flexor) undergo an ICP measurement. In case a patient is reporting bilateral symptoms, only the most symptomatic leg is measured. After infiltrating skin and subcutaneous tissue using 2 mL of 1% lidocaine, a slit catheter is inserted in the belly of each potentially symptomatic compartment of the most affected leg (Indwelling Slit Catheter Set; Stryker Instruments, Kalamazoo, MI). After catheter placement, it is connected to an arterial line manometer and a display (pressure monitor device 783547; Hewlett Packard) and patients are instructed to move the foot against resistance to confirm correct placement in the muscle. After the values of ICP are obtained during a 5-minute rest, the catheter is disconnected and taped onto the skin before initiation of a

provocative treadmill test.[3,19,26] Patients are instructed to run with a speed of 8 km/h and an 8% inclination until symptoms are maximal. If necessary, running speed and inclination are adjusted to provoke symptoms. If this exercise does not provoke any symptoms, a patient is instructed to perform speed skater jumps for provocation of symptoms of the lateral compartment. ICP measurements are again recorded immediately, 1 and 5 minutes after cessation of the test in a supine position.

Fasciotomy of the Lateral Compartment

If history, physical examination, and ICP values were all consistent with the presence of lat-CECS, patients received information on conservative and operative treatment options. A conservative treatment generally consists of activity modification, gait pattern adaptation, physical therapy, icing, podiatry, deep tissue massage, dry needling, or a combination thereof. If a patient opted for a fasciotomy in our department of surgery, they were informed on the procedure and possible complications such as wound infection, hematoma, and peroneal nerve damage. It was up to the patient to decide whether he/she wanted to undergo therapy in our center, or in the referring hospital.

In our hospital, a fasciotomy is performed as an outpatient procedure under general or spinal anesthesia. Before anesthesia, not only the outlines of the lateral compartment and bony landmarks (fibular head, lateral malleolus) were marked on the skin with a skin marker, but with help of the patient, the area of pain was also identified. After sterile exposure, the lateral compartment is opened via two 4-6-cm incisions. The fascia is freed bluntly and opened in a longitudinal manner using a knife and scissors beyond the area of pain. The superficial peroneal nerve that often runs underneath ventral portions of this fascia was usually identified. Accidental damage is prevented as the fasciotomy is performed at the posterior portion of the compartment. The skin incisions were closed intracutaneously.[21] If ant-CECS is simultaneously present, the anterior compartment is also opened via a separate 2-cm incision as previously reported.[3] In case of a bilateral lat/ant-CECS, all 4 compartments are opened during 1 surgical session. If a lat/ant patient also has a bilateral dp-CECS, one leg additionally undergoes a deep flexor fasciotomy via an 8- to 10-cm incision along the medial tibial rim.[27] If successful, the contralateral deep flexor compartment is operated approximately 3 months later. Unlike some other surgeons,[14,19] we do not standardly open both the anterior and lateral compartment in patients with exertional anterolateral lower leg pain. We previously reported that patients reporting on exertional anterolateral lower leg pain may suffer from either isolated ant-CECS, isolated lat-CECS, or both.[22] Therefore, standardly opening both fascias in all patients may not be required.

Postoperatively, patients receive a bandage for 1 day and compressive stockings for 2 weeks thereafter, 24 hours a day. They are allowed to resume normal weightbearing activities at day 1 but jumping and sports activities are prohibited. Two weeks postoperatively, a physical examination and wound inspection are performed at the surgical outpatient clinic, and patients are allowed to start light jogging and bicycling. Exercise regimen is intensified to maximal levels between 6 and 8 weeks after the operation.

Data Analysis

Statistical analysis was performed using SPSS Statistics, Windows version 25 (IBM Corp). The Shapiro Wilk test was used to assess normality of distribution of continuous data. When distributed normally, data are expressed as mean ± SD. If not, they are expressed as median and range. A Kruskal-Wallis *H* test determined possible group differences regarding age and symptom scores. Fisher exact test was used to determine possible group differences in sex, bilaterality, presence of symptoms, and sports level. All data missing in the questionnaires were not included in the analysis.

Results

A total of 881 ELP patients were analyzed at our department of sports medicine outpatient clinic for possible CECS during the almost 6.5 years of interest, and 88 patients with lat-CECS fulfilled study criteria (Figure 1). Ten of these 88 patients were diagnosed with an isolated lat-CECS, whereas the remaining 78 patients had combinations with other CECS types (lat/ant CECS n = 54, lat/ant/dp CECS n = 19, lat/dp CECS n = 5; Table 1). Interestingly, the majority (83%) reported some degree of discomfort at night. With the numbers available, no significant difference could be detected. Isolated lat-CECS patients (n = 10) mostly participated in soccer (n = 5) or (ice) skating (n = 3). Half of the population could not continue with any sort of sports activities as symptoms were too disabling.

Data sets of characteristics and 12-month outcome following surgery were complete in 28 patients (49 legs; Table 2). A group of 21 patients underwent a different surgical treatment than suggested: fasciectomy instead of fasciotomy (n = 5), fasciotomy in 1 or 2 compartments whereas CECS was diagnosed in 3 compartments (n = 5), fasciotomy in only 1 compartment whereas CECS was diagnosed in 2 compartments (n = 5), unilateral fasciotomy whereas bilateral CECS was diagnosed (n = 2), bilateral CECS whereas unilateral CECS was diagnosed (n = 1), fasciotomy in 2 compartments whereas CECS was only diagnosed in 1 compartment (n = 1), fasciotomy in 3 compartments whereas CECS was only diagnosed in 2 compartments (n = 1), and

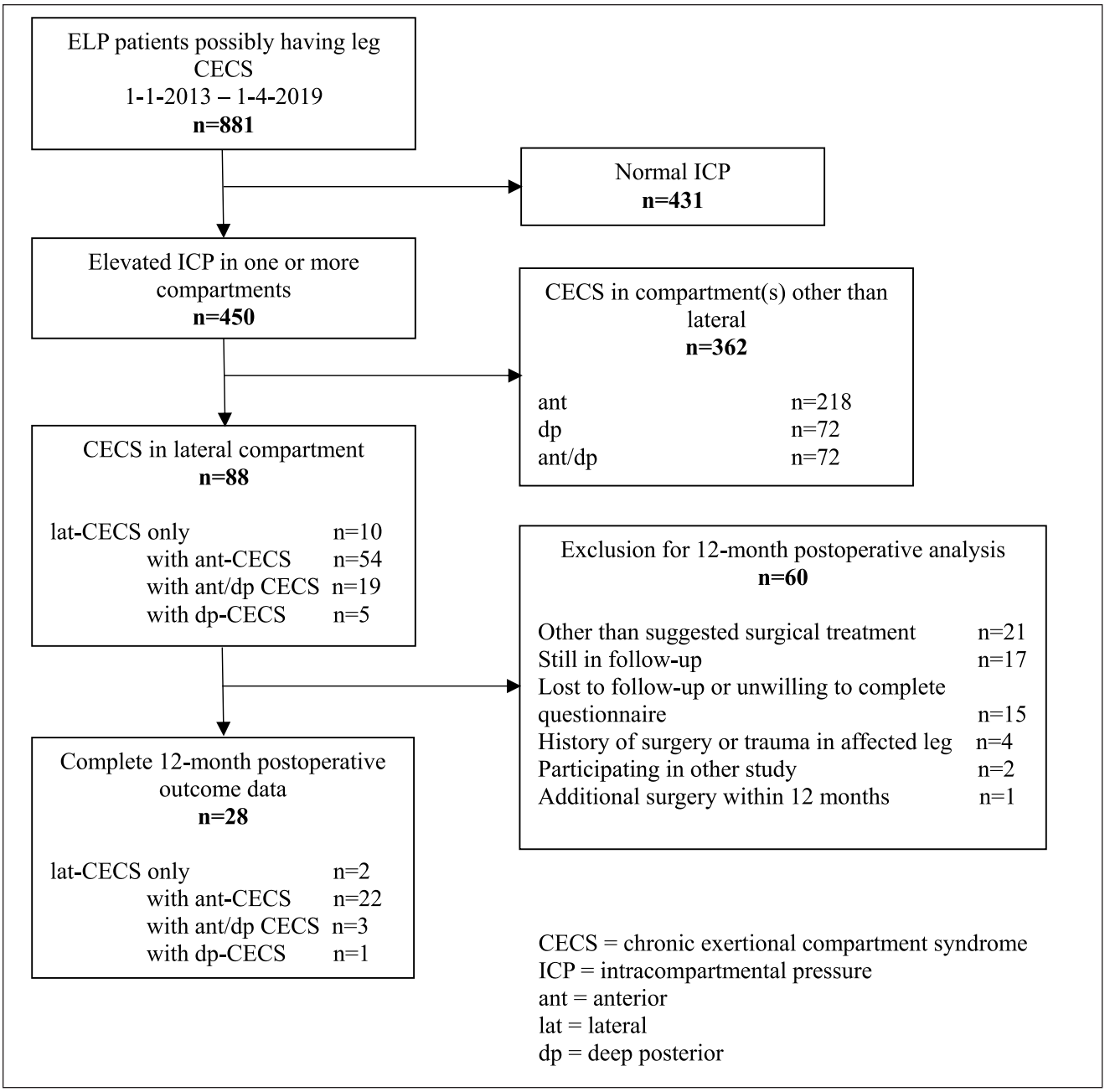

Figure 1. Flow-chart of patients having lat-CECS.

fasciotomy of the anterior and lateral compartments whereas CECS was diagnosed in the lateral and deep posterior compartments (n = 1). The other patients who were excluded were still in follow-up at time of analysis (n = 17), were lost to follow-up or unwilling to complete questionnaires (n = 15), had a history of surgery or trauma in affected leg (n = 4), were participating in another study (n = 2), or underwent additional surgery within 12 months after fasciotomy (n = 1)—an anterior cruciate ligament reconstruction (Figure 1).

Median patient-reported postoperative recovery time was 3 weeks (range 1-6 weeks). Complications were wound infection requiring antibiotics (n = 3) and complex regional pain syndrome (CRPS) (n = 1), which recovered spontaneously after 4 weeks. No patient sustained a superficial peroneal nerve damage or required a reoperation for complications. After 3 months, surgery was considered successful by more than half of the patients (55%). After 12 months, this percentage had increased to 64%. By then, symptom scores during exercise were lower compared to

Table 1. Characteristics of Patients With Isolated Lat-CECS, or Lat-CECS Combined With Other CECS.

	Lat-CECS, Isolated (n=10)	Lat-CECS, Combined With Other CECS Types (n=78)	*P* Value
Sex, m/f	5/5	45/33	.740
Age, median (range)	25 (16-63)	27 (15-72)	.636
Symptoms during exertion, n			
Pain	10	78	—
Feeling of tightness	10	78	—
Cramps	8	55	.718
Muscle weakness	6	47	>.999
Paraesthesia	6	52	.730
Bilateral symptoms, n	8	60	>.999
Symptoms at night, n	9	64	>.999
Sports level, n			
No sports	0	7	>.999
Social	3	23	>.999
Local competitive	5	32	.736
National	2	15	>.999
International	0	1	>.999

Abbreviations: CECS, chronic exertional compartment syndrome; lat-CECS, lateral CECS.

Table 2. Patient-Reported Outcome After a Fasciotomy Including Lat-CECS (28 Patients, 49 Legs).

				Symptom Score, Exercise		Patient-Reported Outcome	
Patient No.	CECS	Sex	Age	Baseline	12 mo	3 mo	12 mo
1	Lat	Female	17	57	18	Good	Average
2	Lat	Female	63	125	8	Excellent	Excellent
3	Lat/ant	Female	52	58	5	Poor	Excellent
4	Lat/ant	Male	58	44	24	Excellent	Good
5	Lat/ant	Male	19	87	5	–	Good
6	Lat/ant	Male	22	46	5	Excellent	Good
7	Lat/ant	Male	47	57	8	Excellent	Good
8	Lat/ant	Male	18	41	14	–	Excellent
9	Lat/ant	Male	46	69	92	Average	Fair
10	Lat/ant	Female	22	44	55	–	Good
11	Lat/ant	Female	50	38	32	Good	Fair
12	Lat/ant	Male	46	35	18	Good	Good
13	Lat/ant	Male	25	48	26	Fair	Average
14	Lat/ant	Male	39	94	59	Average	Good
15	Lat/ant	Male	50	68	5	–	Good
16	Lat/ant	Male	29	62	58	–	Poor
17	Lat/ant	Male	19	50	19	–	Good
18	Lat/ant	Female	21	75	62	–	Poor
19	Lat/ant	Male	41	64	5	Excellent	Excellent
20	Lat/ant	Male	43	74	8	Excellent	Excellent
21	Lat/ant	Female	22	84	20	Excellent	Good
22	Lat/ant	Male	55	53	33	Average	Average
23	Lat/ant	Female	24	38	36	Fair	Fair
24	Lat/ant	Female	25	75	11	Fair	Good
25	Lat/ant/dp	Male	20	104	17	Average	Good
26	Lat/ant/dp	Male	36	51	19	Average	Fair
27	Lat/ant/dp	Male	16	64	60	–	Poor
28	Lat/dp	Female	39	62	5	Excellent	Excellent

Abbreviations: ant, anterior; CECS, chronic exertional compartment syndrome; dp, deep posterior; lat, lateral.

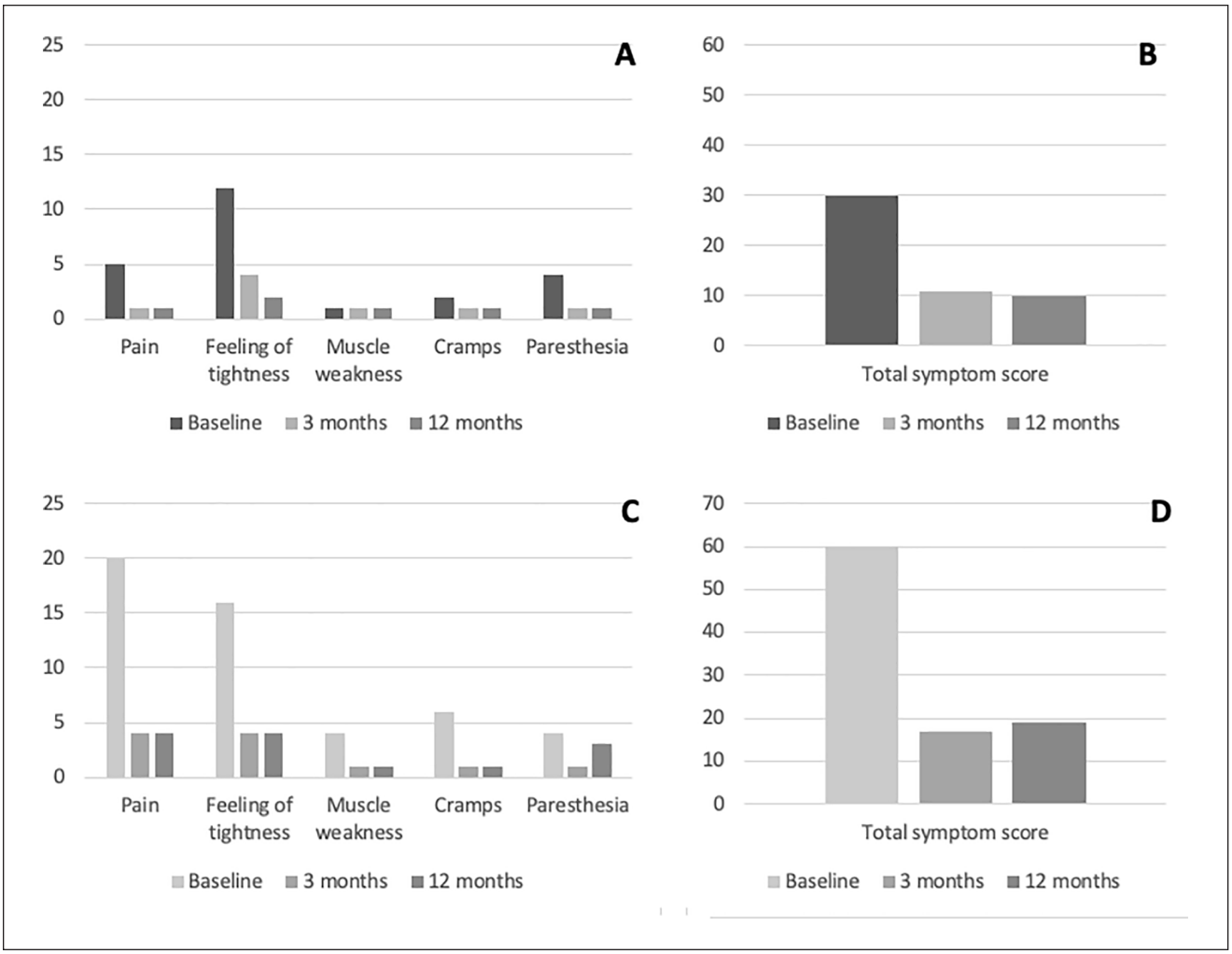

Figure 2. Symptom scores before and 3 and 12 months after fasciotomy (A, B) during rest and (C, D) during exercise for CECS including lat-CECS (n = 28 patients, 49 legs). See text for score calculation.

preoperative in 26 of 28 patients, and 71% had resumed their sports activities.

Symptom scores during rest and exercise at various time points are depicted in Figure 2. Three months after the fasciotomy, all symptom scores dropped noticeably, and these beneficial effects were sustained at 12 months.

Discussion

Most patients with CECS have the anterior (ant-CECS) or a deep flexor variant (dp-CECS). Knowledge of lat-CECS is sparse and only based on small, retrospective case series. The aim of this first prospective case series to date was to describe patient characteristics and symptom patterns in lat-CECS, and to report on efficacy of a fasciotomy in a portion of this population. The results in 88 lat-CECS patients indicate that just 10 individuals had an isolated form of lat-CECS. Conversely, the majority of lat-CECS patients had combinations with other CECS types, most often ant-CECS (69%). Apart from severe pain and tightness during exercise, 83% of these CECS patients also reported ongoing mild to moderate discomfort during rest and at night. A fasciotomy of the lateral compartment in 49 legs (28 patients) was safe as nerve damage or reoperations were absent. One year after surgery, a 64% success rate was attained, whereas 71% of all patients had resumed sports activities.

The traditional view of a patient with CECS is an individual who reports symptoms associated with exercise that subside during rest. The discomfort is often described as a feeling of pain and tightness, but muscle weakness, cramps, paraesthesia, or a combination thereof may also be experienced. In lat-CECS, these symptoms are reportedly located on the lateral side of the lower leg.[1,2,25] However, it must also be appreciated that symptoms in patients with isolated lat-CECS, isolated ant-CECS or both (ant/lat-CECS) are rather alike.[22] In our study population, 8 of 10 patients with

an isolated lat-CECS experienced bilateral symptoms. Pain and a feeling of tightness were dominant. Interestingly, 9 of these 10 patients also experienced these symptoms during rest and at night. These new findings were not reported before and may alert a sport physician to lat-CECS once an ELP patient has pain and stiffness on the lateral side of the lower leg, both during exercise as well as nocturnally.

The scarcely reported results of a fasciotomy for lat-CECS in current literature show varying outcomes. Packer et al[11] reported on the largest population to date, all diagnosed with lat/ant-CECS (n=26). In their study, surgical outcome was successful in 69%.[11] Small studies by Micheli et al[9] (n=3), Mouhsine et al[10] (n=4), and Maffulli et al[6] (n=8) report good results in 33% to 100%, but all authors used a different method of rating their results. Our study is the largest prospective report, demonstrating a 64% success rate, defined as a self-reported excellent or good result at 12 months postoperatively. By then, 71% had resumed their sports activities at a desired level.

Most physicians who are reluctant to refer a CECS patient for an anterolateral fasciotomy use an unacceptable risk of a superficial peroneal nerve (SPN) damage as their most important argument. Although its course may be variable, the SPN usually perforates the fascia in the lower one-third of the leg, some 10-12 cm proximal to the lateral malleolar bone. Because of this location, this nerve is potentially at risk while performing a fasciotomy of the lateral as well as the anterior compartment.[14,17] However, nerve damage was absent in a recent study in 120 legs with ant-CECS if the 2-cm incision is placed at the proper location.[4] In addition, nerve damage was also absent in the present study encompassing 49 legs undergoing a lateral fasciotomy. It must be realized that the SPN always penetrates the crural fascia at a ventral rather than a dorsal level, usually in the groove between the anterior and the peroneal muscle. Therefore, the SPN will likely not be harmed once the fascia of the lateral compartment is opened at a relatively dorsal location.

The present study has limitations including a relatively small number of operated patients who reached the 12 months postoperative evaluation. However, it must be appreciated that just a very small percentage of ELP patients having CECS suffer from lat-CECS. In addition, data of patients who chose to undergo surgery in one of the numerous referring hospitals were not available. Self-reported success as well as return to sports were considered important outcome parameters, but these items may not be universally accepted by others as such.

In conclusion, 1 in 10 (88/881) civilian patients with exercise-induced leg pain undergoing an analysis for possible CECS in a tertiary referral center suffers from chronic exertional compartment syndrome of the lateral leg (lat-CECS). Pain and tightness are present during exertion but often also during rest and at night. An analysis in 28 of these patients showed that fasciotomy for lat-CECS is safe and beneficial in the majority of patients.

Ethical Approval

Ethical approval for this study was obtained from METC Máxima Medical Center (2014-34).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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References

1. Bong MR, Polatsch DB, Jazrawi LM, Rokito AS. Chronic exertional compartment syndrome: diagnosis and management. *Bull Hosp Jt Dis*. 2005;62(3-4):77-84.
2. Davis DE, Raikin S, Garras DN, Vitanzo P, Labrador H, Espandar R. Characteristics of patients with chronic exertional compartment syndrome. *Foot Ankle Int*. 2013;34(10):1349-1354.
3. de Bruijn JA, van Zantvoort AP, Winkes MB, et al. Feasibility and safety of an operative tool for anterior chronic exertional compartment syndrome treatment. *Foot Ankle Int*. 2015;36(12):1475-1482.
4. de Bruijn JA, van Zantvoort APM, Hundscheid HPH, Hoogeveen AR, Teijink JAW, Scheltinga MR. Superficial peroneal nerve injury risk during a semiblind fasciotomy for anterior chronic exertional compartment syndrome of the leg: an anatomical and clinical study. *Foot Ankle Int*. 2019;40(3):343-351.
5. de Bruijn JA, van Zantvoort APM, Winkes MB, et al. Lower leg chronic exertional compartment syndrome in patients 50 years of age and older. *Orthop J Sports Med*. 2018;6(3):2325967118757179.
6. Maffulli N, Loppini M, Spiezia F, D'Addona A, Maffulli GD. Single minimal incision fasciotomy for chronic exertional compartment syndrome of the lower leg. *J Orthop Surg Res*. 2016;11(1):61.
7. Martens MA, Backaert M, Vermaut G, Mulier JC. Chronic leg pain in athletes due to a recurrent compartment syndrome. *Am J Sports Med*. 1984;12(2):148-151.
8. Meulekamp MZ, van der Wurff P, van der Meer A, Lucas C. Identifying prognostic factors for conservative treatment outcomes in servicemen with chronic exertional compartment syndrome treated at a rehabilitation center. *Mil Med Res*. 2017;4(1):36.
9. Micheli LJ, Solomon R, Solomon J, Plasschaert VF, Mitchell R. Surgical treatment for chronic lower-leg compartment syndrome in young female athletes. *Am J Sports Med*. 1999;27(2):197-201.

10. Mouhsine E, Garofalo R, Moretti B, Gremion G, Akiki A. Two minimal incision fasciotomy for chronic exertional compartment syndrome of the lower leg. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(2):193-197.
11. Packer JD, Day MS, Nguyen JT, Hobart SJ, Hannafin JA, Metzl JD. Functional outcomes and patient satisfaction after fasciotomy for chronic exertional compartment syndrome. *Am J Sports Med*. 2013;41(2):430-436.
12. 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(1):35-40.
13. Qvarfordt P, Christenson JT, Eklöf B, Ohlin P, Saltin B. Intramuscular pressure, muscle blood flow, and skeletal muscle metabolism in chronic anterior tibial compartment syndrome. *Clin Orthop Relat Res*. 1983;179:284-290.
14. Rorabeck CH, Bourne RB, Fowler PJ. The surgical treatment of exertional compartment syndrome in athletes. *J Bone Joint Surg Am*. 1983;65(9):1245-1251.
15. Roscoe D, Roberts AJ, Hulse D, Shaheen AF, Hughes MP, Bennet AN. Effects of anterior compartment fasciotomy on intramuscular compartment pressure in patients with chronic exertional compartment syndrome. *J R Army Med Corps*. 2018;164(5):338-342.
16. Schepsis AA, Gill SS, Foster TA. Fasciotomy for exertional anterior compartment syndrome: is lateral compartment release necessary? *Am J Sports Med*. 1999;27(4):430-435.
17. 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(6):811-817; discussion 817.
18. Turnipseed W, Detmer DE, Girdley F. Chronic compartment syndrome. An unusual cause for claudication. *Ann Surg*. 1989;210(4):557-562; discussion 562-553.
19. Turnipseed W. Diagnosis and management of chronic compartment syndrome. *Surgery*. 2002;132(4):613-617;discussion 617-619.
20. van Zantvoort AP, de Bruijn JA, Winkes MB, et al. Isolated chronic exertional compartment syndrome of the lateral lower leg: a case series. *Orthop J Sports Med*. 2015;3(11):2325967115617728.
21. van Zantvoort APM, de Bruijn JA, Hundscheid HPH, van der Cruijsen-Raaijmakers M, Teijink JAW, Scheltinga MR. Fasciotomy for lateral lower-leg chronic exertional compartment syndrome. *Int J Sports Med*. 2018;39(14):1081-1087.
22. van Zantvoort APM, Hundscheid HPH, de Bruijn JA, Hoogeveen AR, Teijink JAW, Scheltinga MRM. Isolated lateral chronic exertional compartment syndrome of the leg: a new entity? *Orthop J Sports Med*. 2019;7(12):2325967119890105.
23. van Zoest WJ, Hoogeveen AR, Scheltinga MR, Sala HA, van Mourik JB, Brink PR. Chronic deep posterior compartment syndrome of the leg in athletes: postoperative results of fasciotomy. *Int J Sports Med*. 2008;29(5):419-423.
24. Verleisdonk EJ, Schmitz RF, van der Werken C. Long-term results of fasciotomy of the anterior compartment in patients with exercise-induced pain in the lower leg. *Int J Sports Med*. 2004;25(3):224-229.
25. Waterman BR, Liu J, Newcomb R, Schoenfeld AJ, Orr JD, Belmont PJ Jr. Risk factors for chronic exertional compartment syndrome in a physically active military population. *Am J Sports Med*. 2013;41(11):2545-2549.
26. 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(8):1899-1905.
27. 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(5):1309-1316.