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ORIGINAL ARTICLE

Severity of spinal degeneration does not affect the pain reduction under continuous epidural analgesia

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Abstract

Purpose To outline clinical effectiveness of continuous epidural analgesia (CEA) in patients with failed back surgery syndrome (FBSS) or lumbar spinal stenosis (LSS) depending on severity of spinal degeneration.

Methods In this retrospective cohort study, all patients with FBSS or LSS who underwent CEA within an inpatient rehabilitation program were evaluated. The pain reduction was measured by VAS on an hourly basis. Substantial pain reduction was defined as a minimal clinically important difference (MCID) > 50%. Severity of spinal degeneration, side effects and patient-specific characteristics were documented.

Result We included a total of 148 patients with 105 patients suffering from FBSS and 48 with LSS. The average pain reduction was − 37.6 ± 19.2 in FBSS and − 38.1 ± 17.8 in LSS group ($p < .001$ and $p < .001$, respectively). In the FBSS group, sensory deficits ($p = .047$) and numbness ($p = .002$), and in the LSS group, a severe disability measured by ODI (38.2 ± 15.4 vs. 57.3 ± 11.3, $p < .001$) significantly contributed to a worse outcome. The severity of the spinal degeneration and psychological disorders did not affect the pain reduction in terms of MCID.

Conclusions This study provides new evidence about CEA in the treatment of FBSS and LSS. CEA provides a significant pain reduction even under intensified physiotherapeutic exercising in patients with severe spinal degeneration and a broad variety of secondary diagnoses. Neurologic deficits in case of FBSS and severe disability in case of LSS may be risk factors for less favorable outcome.

Keywords Failed back surgery syndrome · Spinal stenosis · Chronic spinal pain · Continuous epidural analgesia · Epidural catheter

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Introduction

Low back pain (LBP) with or without radiculopathy has developed to be the number one condition causing disability in an aging population [1]. As a result, the rate of spinal surgery for degenerative lumbar spinal diseases incessantly increased within the last three decades [2]. However, non-surgical treatment remains inevitable. For example, several risk factors are associated with a negative postoperative outcome, including psychological disorders, multimorbid patients or failed back surgery syndrome (FBSS) [3–6]. In these cases, installation of anesthesia is established and yields promising results in managing LBP even in severe degenerative spinal diseases [7, 8].

One of the most performed procedures in the treatment of LBP with or without radiculopathy are epidural injections [9]. Due to the nature of single-shot infiltrations, the analgesic effect of the infiltrated anesthesia decreases after several hours. To sustain long-lasting analgesia, some authors propose repeated epidural injections, which however increases the rate of complications and is not tolerated by some patients [10, 11]. Alternatively, continuous epidural analgesia (CEA) via epidural catheter is feasible in inpatient treatment. This treatment enables enhanced physiotherapeutic mobilization even in patients with severe degenerative spinal conditions including failed back surgery syndrome (FBSS) and lumbar spinal stenosis (LSS) In a previous study, we were able to show that the CEA was able to improve the mobility of patients suffering from failed back surgery syndrome (FBSS) or lumbar spinal stenosis (LSS) in hospital stay, with on average, a low periinterventional risk [12]. Nevertheless, some patients have benefited from CEA more than others and the cause for this phenomenon is still unclear. Furthermore, the pain reduction after CEA depending on underlying diagnosis and patient-specific characteristics is of great interest in order to be able to make asseverations in recommendations for a targeted therapy. However, even though CEA is widely used in perioperative or peripartal pain management, there is still a lack of evidence for the use of CEA in the treatment of degenerative spinal conditions. To our knowledge, no study has been published yet that describes the effectiveness of CEA with respect to different degenerative spinal conditions or possible factors influencing the clinical outcome of CEA in patients with LBP.

Thus, the aim of this study was to investigate the short-term clinical outcome of CEA in terms of pain reduction measured by the Visual Analogue Scale (VAS) as well as to analyze the impact of the extent of the spinal degeneration on the improvement, measured by the minimal clinically important difference (MCID) in patients with chronic LBP due to FBSS and LSS [13]. Moreover, we aimed to determine possible risk factors predicting deteriorated clinical outcome following this non-surgical treatment. We hypothesized that patients with advanced or multisegmental spinal degenerative as well as postoperative conditions with distorted anatomy will benefit to a lesser extent from CEA.

Methods

Study design

We conducted a retrospective, monocentric cohort study reviewing our prospectively collected institutional database. The study was approved by the institutional review board (no. 284/16). We enrolled all consecutive patients with chronic LBP due to FBSS or LSS that received CEA as part of an inpatient multidisciplinary biopsychosocial rehabilitation program at our institution within a timeframe of four years. The patient's cohort comprised those who priorly participated and failed an outpatient monomodal treatment and had a wish for an extended conservative therapy. All patients included showed multilevel degeneration of the lumbar spine. Additionally, FBSS was defined as a collective of patients that suffered from (1) symptomatic recurrent lumbar disc herniation, or (2) insufficient pain relief or pain recurrence after mono- or bi-segmental decompression or mono- or bi-segmental fusion at least 6 months postoperatively. The diagnosis was made by a spinal surgeon. LSS was defined as an abnormal narrowing of the lumbar spinal canal with a limitation of the pain-free walking distance due to pain or motorical dysfunction in both legs. Exclusion criteria were pregnancy, present malignoma, infections, fractures, and patients receiving anticoagulation therapy.

Intervention

All patients received patient-controlled CEA via standardized epidural catheter with a background infusion of 1.5 ml per hour of 0.2% ropivacaine and a 3 ml bolus with a lockout time of 120 min. In FBSS patients, the catheter was placed above or below the surgical scar, in case of LSS closest to the clinical level of pathology or one segment higher or lower. Accompanying enhanced physiotherapeutic treatment was performed regularly following standard protocols. The maximum time of CEA was 120 h, subsequently the epidural catheter was removed after application of 40 mg triamcinolone. After removal of the epidural catheter, the patients stayed at least for one more day in the hospital before being discharged home. In case of facet joint osteoarthritis or nerve root entrapment detected by MRI, probatory injections were performed to differentiate a specific LBP cause from asymptomatic findings.

Data collection

Demographic data, such as sex, age, BMI, comorbidities, American Society of Anesthesiologists (ASA) score, and peri-interventional adverse events were obtained from the patients' electronic medical records. In addition, we retrospectively analyzed the patients' X-rays, CT scans, and MRIs to evaluate the lumbar spinal degeneration.

Clinical outcome measures and data analysis

VAS score was measured before CEA as median pain level the last month before treatment and hourly during treatment (5 days, 7 am to 11 pm) after catheter insertion [14]. The medium pain level was calculated daily. A substantial change in pain reduction was defined by MCID of 50% on VAS scale [13]. All patients included had a severe degeneration of the lumbar spine suffering at least from FBSS or symptomatic LSS. However, we were interested in whether the severity of spinal degeneration, defined as the extent of degenerative changes in the lumbar spine that contribute to chronic pain, may influence pain reduction under CEA. As there is no severity score to grade lumbar spinal degeneration, FBSS was graded according to the surgery performed prior to diagnosis of FBSS (lumbar discectomy, lumbar decompression, lumbar fusion, or multiple lumbar surgeries), and severity of LSS was graded according to Schizas' classification [15]. Furthermore, the groups were divided in patients that suffered from symptomatic or asymptomatic facet joint osteoarthritis or nerve root entrapments using diagnostic blocks, which were performed prior to CEA; in addition, patients were grouped in those with erosive intervertebral osteochondrosis type Modic I [16], spondylolisthesis with segmental instability in lateral X-ray, and patients with single or multilevel disc degeneration. Statistical analysis was done using "BiAS for Windows" (version 11.09.). For numerical data medians and quartiles or mean values and standard deviations are presented. Categorical data were calculated as relative and absolute frequencies. In between groups, the student's t-test was used to compare normally distributed data and the Mann–Whitney-*U*-test for non-normally distributed data. In case of small sample sizes, the two-sided Fisher's exact test was used. Differences in between categorical data were detected by Chi-Square test. A p-value ≤ 0.05 was considered statistically significant.

Results

Clinical outcome

A total of 153 patients (88 females, 65 males) matched the criteria of CEA within an inpatient treatment and were included in this study. CEA was performed in 105 patients with FBSS and 48 patients with LSS. The average age of these patients was 57.4 ± 11.9 years with 60 females (57.1%) suffering from FBSS and 28 females (58.3%) with symptomatic LSS. Before intervention, mean VAS score was 67.1 ± 17.3 in the FBSS group and 64.6 ± 19.6 in the LSS group ($p = 0.539$). Average pain reduction did not significantly differ within both groups and was -37.6 ± 19.2 for FBSS and -38.1 ± 17.8 for LSS as shown in Fig. 1 ($p = 0.859$).

63 patients with FBSS (60.0%) showed a MCID between day 1 to 5 with a pain reduction ranging from -42.8 ± 15.4 to -50.9 ± 17.0 (Table 1). Similarly, 33 patients with LSS (68.8%) with a pain reduction between -42.2 ± 18.7 and -47.2 ± 15.8 improved substantially in terms of MCID, whereas the initial pain level did not significantly affect the rate of MCID (FBSS: $p = 0.853$; LSS: $p = 0.467$).

Outcome in FBSS

The impact of patient-specific characteristics and adverse events on the pain reduction in terms of MCID are shown in Tables 2 and 3. In the FBSS group, patients with sensory deficit prior to CEA were significantly less likely to show a MCID than patients without sensory deficits (17 (40.5%) vs. 13 (20.6%), $p = 0.047$). Additionally, numbness during the treatment was associated with a pain reduction below the MCID in patients with FBSS (27 (64.3% vs. 20 (31.7%, $p = 0.002$). Table 4 gives detailed information according to the impact of the spinal degeneration on the pain reduction in terms of the MCID. In FBSS group, the outcome was not affected by the surgery performed prior to CEA. Therefore, neither prior nucleotomy (n = 47), nor decompression (n = 9), intervertebral fusion (n = 14) or multiple operations (n = 34) influenced the pain reduction during CEA.

Outcome in LSS

In the LSS group, the ODI score prior to treatment strongly affected the outcome of CEA. Patients that achieved a MCID had an ODI of 38.2 ± 15.4, whereas patients with a pain reduction below the MCID following CEA had an ODI of 57.3 ± 11.3 ($p = < 0.001$). 3 patients with intervertebral osteochondrosis at L1/2 level showed a pain reduction below a MCID ($p = 0.026$, Supplementary Table 1). Other factors, including degenerative changes of the lumbar spine, did not significantly contribute to the achievement of a MCID, neither in FBSS nor in LSS.

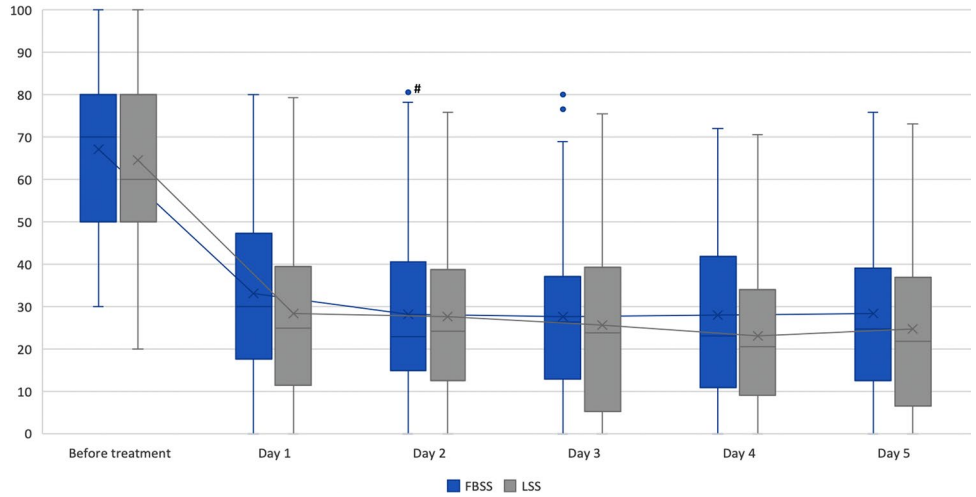

Fig. 1 Pain reduction within CEA (FBSS vs. LSS). Outliers: this is an observation point that is distant from other observations; for box-plots—as shown in this figure—outliers are defined as a value that is not in Q3 (third quartile) + 1.5 IQR (interquartile range), or Q1 (first quartile)—1.5 IQR. FBSS Failed back surgery Syndrome, LSS Lumbar spinal stenosis. Pain level measured by VAS (Visual Analogue Scale) depicted as box-plot diagram. Pain level before treatment does not significantly differ between groups (FBSS: 67.1 ± 17.3 vs. LSS: 64.6 ± 19.6, p= 0.539). Additionally, both groups do not differ in average pain reduction within CEA treatment (− 37.6 ± 19.2 vs. − 38.1 ± 17.8, p = 0.859)

Table 1 Pain reduction MCID vs. VAS

	FBSS (n = 105)			LSS(n = 48)		
	MCID > 50% (n = 63)	MCID < 50% (n = 42)	p value	MCID > 50% (n = 33)	MCID < 50% (n = 15)	p value
VAS before treatment (SD)	67.1 (± 17.3)	66.4 (± 17.0)	0.853	63.0 (± 21.1)	68.0 (± 14.2)	0.467
ΔVAS Day 1 (SD)	− 42.8 (± 15.4)	− 20.7 (± 16.6)	< 0.001*	− 42.2 (± 18.7)	− 22.9 (± 14.9)	< 0.001*
ΔVAS Day 2 (SD)	− 49.5 (± 16.3)	− 23.2 (± 15.9)	< 0.001*	− 45.2 (± 17.4)	− 18.6 (± 11.2)	< 0.001*
ΔVAS Day 3 (SD)	− 48.7 (± 15.3)	− 23.0 (± 17.7)	< 0.001*	− 46.5 (± 16.0)	− 22.4 (± 10.9)	< 0.001*
ΔVAS Day 4 (SD)	− 50.9 (± 17.0)	− 19.7 (± 15.0)	< 0.001*	− 47.2 (± 15.8)	− 26.3 (± 14.7)	< 0.001*
ΔVAS Day 5 (SD)	− 48.8 (± 16.9)	− 21.7 (± 14.1)	< 0.001*	− 45.6 (± 16.9)	− 22.9 (± 9.7)	< 0.001*

FBSS Failed Back Surgery Syndrome, *LSS* Lumbar Spinal Stenosis, *MCID* minimal clinically important difference, *n* number, *SD* standard deviation, *VAS* Visual Analoque Scale, ΔVAS pain reduction compared to the level of pain measured by VAS before treatment

*Significant (p value ≤ .0.05)

Discussion

Current literature lacks proof of effectiveness and safety of non-surgical interventions for the treatment of FBSS or LSS.[17, 18]. This study provides new evidence about CEA in the non-surgical treatment of FBSS and LSS. According to our data, CEA is feasible in patients with advanced spinal degeneration leading to a significant and constant pain reduction over several days. This enabled intensified physiotherapeutic treatment and mobilization on a daily basis, which is crucial in inpatient rehabilitation [19].

However, daily clinical routine showed that some patients benefit less from CEA in terms of MCID. We hypothesized, that a smaller cross-sectional spinal area as in case of multi-segmental spinal stenosis or advanced postoperative changes of the spine are associated with less pain reduction during CEA. Several reasons underlining this theory appear obvious: First, patients with severe spinal degeneration or postoperative conditions often suffer from multi-segmental severe spinal stenosis, distorted anatomy, or development of scar tissue, which complicates the catheter placement. Secondly, a reduced epidural space challenges the adjustment of the background infusion rate to gain pain release without incapacitating the patient. Additionally, several other factors such as a longer persisting pain leading to long-lasting chronic pain conditions or multiple degenerative diseases in multiple levels of the lumbar spine may contribute to less pain reduction during CEA.

Table 2 Impact of patient-specific characteristics on pain reduction

	FBSS (n = 105)			LSS (n = 48)		
	MCID > 50% (n = 63)	MCID < 50% (n = 42)	*p* value	MCID > 50% (n = 33)	MCID < 50% (n = 15)	*p* value
Age [year] (SD)	53 (± 11)	52.4 (± 11.2)	.971	60.4 (± 12.9)	62.3 (± 11.7)	.628
Sex, female	33 (52%)	27 (64%)	.314	22 (67%)	6 (40%)	.155
BMI [kg/m2] (SD)	28.7 (± 5.4)	28.3 (± 5.6)	.759	31.2 (± 5.8)	33.6 (± 7.5)	.247
ODI	50.6 (± 14.4)	54.8 (± 15.3)	.195	38.2 (± 15.4)	57.3 (± 11.3)	< .001*
ASA score			.114			
I	11 (18%)	4 (10%)		2 (6%)	0	.544
II	39 (62%)	34 (81%)		19 (58%)	8 (53%)	
III	13 (21%)	4 (10%)		12.(36%)	7 (47%)	
Cardiopulmonary disease	16 (25%)	11 (26%)	> .999	10 (30%)	6 (40%)	.741
Hypertension	22 (35%)	16 (38%)	.901	16 (49%)	11 (73%)	.195
Depression	23 (37%)	22 (52%)	.159	9 (27%)	6 (40%)	.585
Lower extremity neurological deficit	20 (32%)	21 (50%)	.094	8 (24%)	3 (20%)	> .999
Sensory deficit	13 (21%)	17 (41%)	.047*	6 (18%)	2 (13%)	> .999
Motor deficit	11 (18%)	12 (29%)	.270	4 (12%)	1 (7%)	.949

ASA American Society of Anesthesiologists, *BMI* Body Mass Index, *FBSS* Failed Back Surgery Syndrome, *LSS* Lumbar Spinal Stenosis, *MCID* minimal clinically important difference, *n* number, *ODI* Oswestry Disability Index, *SD* standard deviation

*Significant (*p* value ≤ .05)

Table 3 Impact of adverse events on pain reduction

	FBSS (n = 105)			LSS (n = 48)		
	MCID > 50% (n = 63)	MCID < 50% (n = 42)	*p* value	MCID > 50% (n = 33)	MCID < 50% (n = 15)	*p* value
Temporary bladder-colon disturbances	1 (1.6%)	0	> .999	0	0	NA
Accidental fall	0	1 (3%)	.400	0	1 (7%)	.313
Irritation/reddening at puncture site	0	3 (7%)	.06	1 (3%)	0	> .999
Temporary lower extremity neurological impairment	39 (56%)	29 (69%)	.236	19 (58%)	8 (53%)	> .999
Temporary numbness	20 (32%)	27 (64%)	.002*	17 (52%)	6 (40%)	.668
Reaction of the autonomic nervous system	3 (5%)	2 (5%)	> .999	0	1 (7%)	.313
Prolonged superficial bleeding	8 (13%)	7 (17%)	.776	2 (6%)	2 (13%)	.579

FBSS Failed Back Surgery Syndrome, *LSS* Lumbar Spinal Stenosis, *MCID* minimal clinically important difference, *n* number, *NA* not applicable, *SD* standard deviation

*Significant (*p* value ≤ .05)

Intriguingly, we found that the extent of the degenerative changes of the lumbar spine do not affect the pain reduction, neither in patients with FBSS or LSS. In fact, in the FBSS group, only sensory deficits prior to and numbness within CEA was associated to a deteriorated outcome in terms of MCID. As persistent sensory deficits or numbness are caused by a chronic nerve damage mainly resulting from either initial nerve compression prior to surgery or iatrogenic genesis, these patients likely do not only suffer from nociceptive, but also from neuropathic pain [20]. Thus, CEA might be less effective for those patients. In these cases, neuropathic pain modulating drugs should complement the treatment. However, in case of FBSS with mixed postoperative pain conditions including severe spinal degeneration, CEA represents not only a therapeutic but—simultaneously—also a diagnostic tool and can be used in a probatory manner to simulate the possible pain reduction following a possible (re-) operation.

In the LSS group higher ODI prior to treatment significantly correlated with a diminished pain reduction. As reported in the literature, the average ODI in patients with symptomatic LSS is about 36.7 ± 18 [21]. In the spine patient outcome research trial, Weinstein et al. found a significant difference in patients with a baseline ODI of 45.6 ± 17.9 in

Table 4 Impact of spinal degeneration on pain reduction

	FBSS (n = 105)			LSS (n = 48)		
	MCID > 50% (n = 63)	MCID < 50% (n = 42)	*p* value	MCID > 50% (n = 33)	MCID < 50% (n = 15)	*p* value
FBSS with surgery performed prior to CEA						
Nucleotomy/Sequesterectomy	30 (48%)	17 (41%)	.603	0	0	NA
Decompression	6 (10%)	3 (7%)	.738			
Intervertebral fusion	6 (10%)	8 (19%)	.266			
Others**	21 (33%)	14 (33%)	> .999			
LSS						
None	44 (70%)	28 (67%)	.898	0	0	NA
Schizas A/B						
1 level	10 (16%)	6 (14%)	> .999	12 (36%)	6 (40%)	> .999
> 1 level	4 (6%)	6 (14%)	.193	9 (27%)	6 (40%)	.504
Schizas C/D						
1 level	8 (13%)	4 (10%)	.759	12 (36%)	8 (53%)	.430
> 1 level	0	1 (2%)	.400	7 (21%)	2 (13%)	.670
Intervertebral osteochondrosis						
None	31 (49%)	13 (31%)	.098	12 (36%)	9 (60%)	.224
1 level	19 (30%)	15 (36%)	.702	6 (18%)	2 (13%)	> .999
> 1 level	13 (21%)	14 (33%)	.218	15 (46%)	4 (27%)	.360
Spondylolisthesis						
None	58 (92%)	35 (83%)	.215	25 (76%)	12 (80%)	> .999
1 level	5 (8%)	5 (12%)	.516	6 (18%)	3 (20%)	> .999
> 1 level	0	2 (48%)	.158	2 (6%)	0	> .999
Facet joint osteoarthritis			.162			.854
None	13 (21%)	13 (31%)		8 (24%)	4 (27%)	
Asymptomatic	24 (38%)	19 (45%)		16 (49%)	6 (40%)	
Symptomatic	26 (41%)	10 (24%)		9 (27%)	5 (33%)	
Nerve root entrapment			.221			.692
None	40 (64%)	20 (48%)		18 (54%)	10 (67%)	
Asymptomatic	17 (27%)	18 (43%)		13 (39%)	4 (27%)	
Symptomatic	6 (10%)	4 (10%)		2 (6%)	1 (7%)	
Disc protrusion						
None	37 (59%)	29 (69%)	.387	24 (73%)	9 (60%)	.504
1 level	18 (29%)	11 (26%)	.964	5 (15%)	5 (33%)	.249
> 1 level	8 (13%)	2 (5%)	.309	4 (12%)	1 (7%)	> .999

FBSS Failed Back Surgery Syndrome, *LSS* Lumbar Spinal Stenosis graded according to Schizas' classification [15], *MCID* minimal clinically important difference, *n* number, *NA* not applicable, *SD* standard deviation

*Significant (p value ≤ 0.05)

**Others (Multiple surgeries performed, adjacent segment disease, and mixed indications included)

the surgical, and 36.3 ± 18.1 in the non-surgical group at 4-years follow-up [22]. This highlights the importance of disability in the treatment of LSS. Obviously, non-surgical treatment is limited by severe disability in case of LSS. This is in line with our findings: patients with a severe disability showed significantly less pain reduction compared to patients with a moderate disability. In accordance with the literature, in the LSS group neither neurogenic claudication nor the level of disability were associated to the severity of spinal degeneration and spinal stenosis. Thus, independent of MRI findings, CEA is suitable for patients with moderate disability measured by ODI. On the contrary, in case of LSS with severe disability patients should be consented about possible insufficient pain reduction and early surgical management including decompression and—in case of predominant back pain and spondylolisthesis—additional lumbar interbody fusion should be considered, without prior CEA [23]. In addition, in the LSS group erosive intervertebral

osteochondrosis at the L1/2 level correlated with a diminished pain reduction. In these patients, CEA was performed to address a LSS at levels L4/5 and L5/S1. As the epidural catheter was placed at the interspace closest to the level of pathology in the lumbar spine, the adjusted amount of ropivacaine did not offer pain reduction at the thoracolumbar junction due to limited diffusion within the epidural space. Subsequently, axial back pain persisted, resulting in an overall pain reduction smaller than the MCID. Those patients experienced a sufficient pain relief after lumbar interbody fusion. Thus, according to our data CEA seems also less effective in patients suffering from degeneration including both, the thoracolumbar and lumbosacral junction.

Furthermore, this study reveals several other interesting findings. The pain reduction is almost unchanged for the time of CEA and sustained under physiotherapeutic treatment. Therefore, CEA might be more appropriate for patients in inpatient treatment than single epidural injections, as those cannot be performed on a daily base. However, it seems to be an interesting aspect for future studies to evaluate whether a continuous increase of the background infusion rate can lead to further pain reduction over the course of the treatment.

Moreover, the standard deviation of the pain reduction showed to be high and only a few patients experienced a complete remission from the chronic pain. In our experience, this is due to the multifactorial and interindividual differences towards genesis of the pain, pain-coping types and response to the treatment. In order to expand the understanding of this, further studies should be performed in a prospective setting, and pay particular attention to the precise processing of psychosocial causes of chronic pain, as well as define clear inclusion criteria with regard to the underlying spinal disease.

In accordance with the literature, we defined the MCID as more than 50% pain reduction to detect a substantial change [24–26]. Still, this is an ambitious definition for MCID. Other studies defined 20 or 30% pain reduction to be the MCID [27]. In our study, even patients that did not show a MCID in pain reduction were enabled to perform concomitant intensified physiotherapy. Nevertheless, we think a substantial, constant pain reduction of at least 50% compared to the initial pain level is imminent, as this additionally offers the possibility of reducing oral pain medication.

This study is limited due to its retrospective design. Thus, a randomization or comparison with a placebo group was not possible. However, we provide a high-quality dataset with a considerable number of patients suffering from FBSS. Regarding LSS, a higher amount of performed interventions would be desirable, but even in the few cases included we found a significant pain reduction that sustained under intensified physiotherapeutic treatment.

As this study focuses on the pain reduction under CEA, follow-up studies demonstrating the mid- and long-term outcome will be necessary to be able to assess the value of this treatment. In addition, as no randomized controlled trial has yet compared CEA to epidural injections in chronic spinal pain according to pain reduction, quality of life measures and cost effectiveness, further research is required.

Conclusion

CEA is widely used in perioperative or peripartal pain therapy, but there is a gap of evidence for the use of CEA in the treatment of spinal disorders. This is the first study to systematically analyze effectiveness of CEA in patients with FBSS and LSS. We found that CEA offers significant pain reduction regardless of the severity of spinal degeneration, psychological illness, or concomitant diseases. The absence of neurological impairment improves the effectiveness of CEA in FBSS. CEA shows excellent results in patients with LSS and a moderate disorder; however, in case of a severe disorder the effect seems limited and early surgical intervention should be considered.

This should be investigated in future studies comparing CEA to epidural injections as well as spinal surgery. Furthermore, longstanding effects, after removal of the catheter, must be investigated. The demonstrated cohort will be followed-up and the effects in between one and five years after CEA will be published.

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Code availability Not applicable.

Declarations

Conflict of interest Vincent J. Heck, Bastian Himpe, Juan M. Vinas-Rios, Tobias Prasse, Michael J. Pflüger, Sven Schmidt and Michael Rauschmann declare that they have no conflict of interest. Paul Kes-

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