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Research Article

Clinical Outcomes of Epidural Catheter Therapy as A Spinal Intervention: A Retrospective Statistical Study

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Abstract

Background: Chronic spinal pain resulting from disc herniation and degenerative spinal disorders is a major cause of disability and increased healthcare utilization worldwide. Although conservative management remains the first-line treatment, a considerable proportion of patients develop persistent symptoms that are refractory to standard therapeutic approaches.

Objective: To assess the clinical effectiveness, safety, and long-term outcomes of percutaneous Epidural Catheter Treatment (ECT) in patients with disc herniation, nerve root compression, spinal canal stenosis, postoperative pain syndrome (failed back surgery syndrome), and epidural adhesion formation, and to identify factors associated with favorable clinical outcomes. The purpose of this clinical study is to provide a logical and systematic framework for the application of epidural interventions in the management of spinal pain. These recommendations are based on the best available evidence regarding the effectiveness and safety of epidural and related interventional procedures for spinal pain, including pain arising from disc herniation, spinal stenosis, and post-surgical pain syndromes. The aim of this study was to evaluate the clinical effectiveness, safety, and long-term outcomes of percutaneous ECT in patients with disc herniation and related spinal disorders. We hypothesized that this intervention would result in significant and sustained pain reduction with a very low complication rate and reduced need for surgical intervention.

Methods: This retrospective statistical study included 1,850 patients with radiologically confirmed Cervical, Thoracic and lumbar disc herniation, nerve root compression syndromes, neuroforaminal stenosis, recess stenosis, and spinal canal stenosis, Adhäsion, Failed Back Surgery Syndrome who were treated with a percutaneous Epidural Catheter (ECT) at Spine and Neurosurgery Center with advanced pain management, Hamburg, Germany, between 2014 and 2024. Demographic characteristics, clinical presentation, imaging findings, and treatment-related variables were systematically collected. Pain intensity was evaluated using the Visual Analog Scale (VAS), while functional status was assessed using the Oswestry Disability Index (ODI). Assessments were performed at baseline and during follow-up at 1 week, 2 weeks, 6 weeks, 3 months, 6 months, 1 year, 3 years, and 5 years after the intervention. Statistical analyses were conducted using SPSS software, with statistical significance defined as $p < 0.05$. All procedures were performed on an outpatient basis without the need for hospital admission or overnight observation. As a preventive measure against infection, patients received standardized antibiotic prophylaxis administered twice daily for five days, starting on the evening before the procedure according to the institutional protocol. Clinical follow-up was supplemented by serial laboratory evaluations, including pre- and post-procedural measurement of C-reactive protein (CRP), to assess for potential infectious complications.

Results: A total of 200 patients were included in the study (mean age 54 years, 73% female). Significant improvement was observed following treatment. VAS pain scores decreased from 8.29 ± 1.24 to 2.62 ± 1.63, with a mean reduction of 5.67 ± 1.58 points ($t(199) = 50.88$, $p < 0.001$; Cohen's $d = 3.60$). ODI scores also improved markedly, decreasing from 73.89 ± 12.19 to 20.10 ± 12.44, with a mean reduction of 53.79 ± 13.25 points ($t(199) = 57.41$, $p < 0.001$; Cohen's $d = 4.06$). Only 25% of patients required surgery during follow-up. Younger age and absence of motor deficit were identified as independent predictors of successful conservative treatment. ECT resulted in a statistically significant reduction in pain intensity and a marked improvement in functional outcomes. Overall clinical improvement was observed in approximately 75–85% of patients ($p < 0.001$). Younger age and the absence of significant neurological deficits were independently associated with superior clinical outcomes. No clinically relevant infections or major procedure-related complications were identified during long-term follow-up

Conclusion: Percutaneous ECT represents a safe and effective minimally invasive therapeutic option for patients with lumbar disc herniation and chronic spinal pain syndromes. The intervention provides substantial and sustained pain relief, with reported pain reduction of up to 75–80%, and may significantly decrease the need for surgical intervention in appropriately selected patients.

Keywords: Cervical, Thoracic and Lumbar Disc Prolapse; Epidural Catheter Treatment; Intervertebral Disc Protrusion; Nerve Root Compression Pain Management; Spinal Canal Stenoses.

Introduction

Chronic spinal pain is one of the most prevalent chronic conditions worldwide and constitutes a major source of disability, reduced quality of life, and economic burden. Disc herniation and degenerative spinal disorders commonly lead to pain in the spine and neuroforaminal stenosis and recessal stenosis due to mechanical compression and inflammatory irritation of neural structures. Multiple anatomical components have been identified as potential pain generators, including intervertebral discs, nerve roots, facet joints, sacroiliac joints, ligaments, epidural tissues, and paraspinal musculature. However, a subset of patients fails to achieve sustained symptom relief despite optimized conservative and surgical therapy. Epidural catheter was developed in the late 1980s by Dr. Gabor B. Racz at the Texas Tech University Health Sciences Center. This technique has since been recognized as a pioneering advancement in the field of interventional pain management. Initially, the procedure involved the injection of normal saline alone through the ECT to achieve mechanical lysis of adhesions. A minimally invasive interventional technique aims to mechanically break up epidural adhesions that may trap nerve roots or impede drug delivery. Professor. Dr. Arous at this center developed this technique to include the administration of saline solution, enzyme agents such as hyaluronidase, and low doses of corticosteroids via catheter to enhance therapeutic efficacy and minimize side effects. These clinical evidences aim to support logical and systematic framework for the application of epidural interventions in the treatment of spinal pain. These recommendations are based on the best available evidence regarding the efficacy and safety of epidural interventions and related interventional procedures for the treatment of spinal pain, including pain caused by herniated discs, spinal stenosis, and post-operative pain syndromes. We hypothesized that percutaneous ECT would result in significant and sustained pain reduction and functional improvement in patients with disc herniation, intervertebral disc protrusion, nerve root compression, spinal canal stenosis, and postoperative pain syndrome with a low rate of complications and reduced need for surgical intervention.

Review of Evidence

Observational and controlled studies have demonstrated clinically meaningful pain relief in a substantial proportion of patients undergoing percutaneous epidural adhesiolysis, with reported improvement rates approaching 80%. We hypothesized that percutaneous ECT would result in significant and sustained pain reduction and functional improvement in patients with disc herniation, intervertebral disc protrusion, nerve root compression, spinal canal stenosis, with a low rate of complications and reduced need for surgical intervention.

Methods

Study Design

This retrospective observational study was conducted at our center. Data analyses contain retrospective review and statistics.

Study Population

Patients mean age was 54 years with MRI-confirmed lumbar, thoracic, or cervical disc herniation, neuroforaminal stenosis and recessal stenosis, nerve root compression or spinal canal stenosis were included. Patients with progressive neurological deficits or cauda equina syndrome were excluded. The present statistical analysis was conducted using random sampling of patients treated over the last four years, in accordance with accepted standards for observational clinical research.

Inclusion Criteria

Adult patients were eligible for inclusion if they met the following criteria: radiologically confirmed disc herniation, disc protrusion, nerve root compression, spinal canal stenosis, epidural adhesion formation, or failed back surgery syndrome; presence of persistent radicular and/or axial spinal pain refractory to conservative therapy; and clinical stability without progressive neurological deterioration.

Exclusion Criteria

Patients were excluded if they had known coagulation disorders (including hemophilia or other bleeding diatheses), active local or systemic infection, inflammatory or autoimmune disease affecting the spine, significant vascular pathology, and pregnancy, known hypersensitivity to any component of the treatment protocol, progressive neurological deficits, or cauda equina syndrome. Epidural catheterization was deliberately avoided in patients with increased risk of bleeding or infection to ensure procedural safety.

Diagnoses

This procedure was applied to patients diagnosed with a range of spinal pathologies, including intervertebral disc protrusion, nerve root compression, spinal canal stenosis, postoperative pain syndrome (failed back surgery syndrome), lumbar disc herniation, and epidural adhesion formation.

Treatment Protocol

At our center, the protocol includes the administration of normal saline combined with hyaluronidase and very low-dose corticosteroids (17), in addition to Osmofundin 15% N (Mannitol) and Ropivacaine 2mg/ml for analgesia. This multimodal approach aims to reduction of pressure, edema, and inflammation on nerve roots, in addition to the fact that enzymes aid in making the herniated nucleus pulposus smaller and softer over time. The procedure is performed under CT guidance during the first session to ensure highly accurate access to the targeted anatomical region. Subsequently, over the following four days, the same medications are administered twice daily with a three-hour interval between injections. Although the foundational protocol was designed to mechanically break down adhesions using catheter-directed fluid and medication, in our practice the procedure has been further refined by the addition of agents such as hyaluronidase, very low-dose corticosteroids, normal saline, and adjunctive analgesics prior to consideration of surgical intervention in patients with pain related to disc herniation, spinal stenosis, or nerve root compression. Observational and controlled studies have demonstrated clinically meaningful pain relief in a substantial proportion of patients undergoing percutaneous epidural adhesiolysis, with reported improvement rates approaching 80% in selected cohorts. In addition, patients with secondary conditions resulting from spinal stenosis, including chronic radicular pain and functional impairment, were also included in the treatment protocol.

Post-Treatment Rehabilitation

Following completion of ECT, all patients were advised to participate in physical therapy, swimming, and regular exercise as part of a comprehensive rehabilitation program. Following ECT, patients who demonstrated insufficient clinical improvement and declined surgical intervention received additional supportive pain management in conjunction with structured physical therapy and supervised exercise programs. In patients who demonstrated clinical improvement following ECT, the supportive pharmacological treatment plan was implemented for a duration ranging from one week to one month, depending on individual pain severity and clinical response. Analgesic therapy in this subgroup was administered in a stepwise manner based on the principles of the World Health Organization (WHO) analgesic ladder. Patients with mild residual pain were treated with non-opioid analgesics (step 1). In cases of moderate pain, medium potency opioids such as Tilidine Hydrochloride were prescribed (step 2). Patients with severe pain received high potency opioids, including oxycodone (step 3). In refractory or persistent cases, advanced pain management strategies were employed, including transdermal opioid patches and, in selected patients, implantation of a subcutaneous pain pump for continuous analgesic delivery. In addition, muscle relaxants were prescribed in selected patients presenting with paraspinal muscle spasm in order to reduce muscle-related pain, improve mobility, and support functional rehabilitation. This selective multimodal post-interventional approach aimed to optimize pain control, facilitate functional recovery, and support rehabilitation in patients who did not achieve sufficient symptom relief following ECT alone.

Intervention Description

Epidural Catheter involves the placement of a catheter into the epidural space with the active aim of relieving nerve root compression and improving nerve root mobility, particularly in cases involving extruded components of the intervertebral disc. Catheter insertion was performed using either the sacral canal or the interlaminar to reach the targeted anatomical region. The procedure lasted approximately 10–20 minutes and was performed under light sedation with CT guidance [1]. The catheter remained in the epidural space for a duration of five days. This is followed by a standardized injection protocol designed to mechanically decompress the affected structures, expand the involved epidural tissue layers, and facilitate optimized targeted drug delivery. Following medication injection, the catheter was secured and covered with a sterile dressing to maintain aseptic conditions. This

technique has been extensively described in the literature and is commonly employed in patients with chronic spinal pain who are refractory to conventional conservative treatment modalities (Figures 1,2).

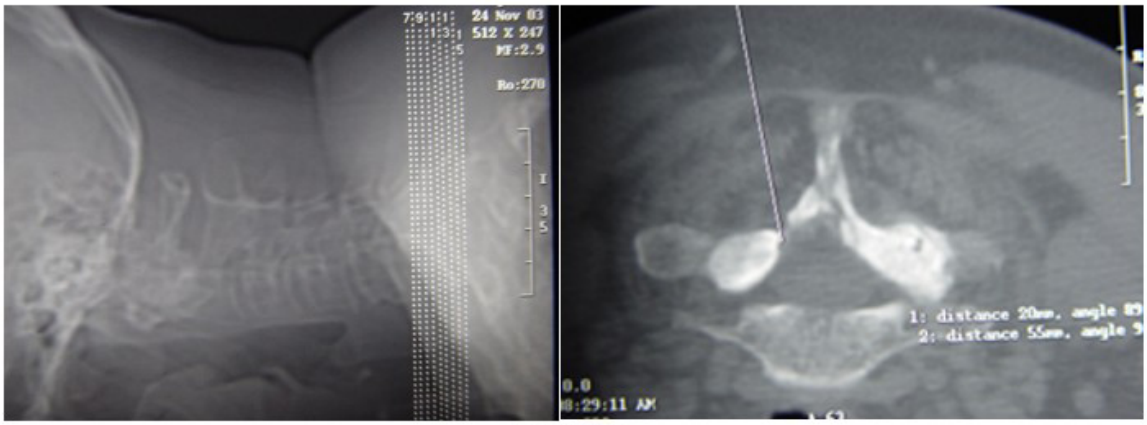

Figure 1

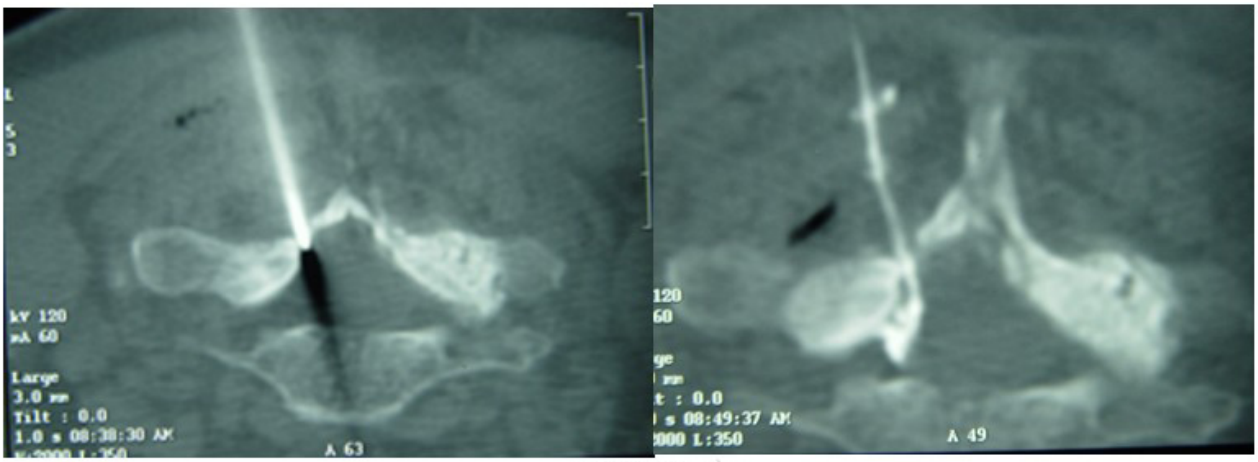

Figure 2

Outcome Measures

Primary outcomes included pain reduction assessed by VAS and ODI. Secondary outcomes included the need for subsequent surgical intervention. Follow-up was conducted using standardized outcome assessment principles in line with WHO recommendations for the evaluation of acute and chronic pain and clinical outcome reporting. Patients were assessed at predefined time points, including baseline (pre-treatment), 1 week, 2 weeks, 6 weeks, 3 months, 6 months, 1 year, and during long-term follow-up when available Pain intensity was evaluated using the VAS, which is an internationally validated instrument recommended for pain-related outcome measurement. Clinical improvement, adverse events, and the need for additional interventions were systematically documented at each follow-up visit. This structured follow-up protocol allowed consistent monitoring of treatment effectiveness, functional recovery, and safety over time. Follow-up evaluation was additionally performed using Magnetic Resonance Imaging (MRI).

Statistical Analysis

Paired-samples t-tests were used to compare pre- and post-treatment outcomes for pain intensity VAS and functional disability ODI. Effect sizes were calculated using Cohen's dz, which is recommended for within-subject (paired) designs. Ninety-five percent confidence intervals (95% CI) were computed to assess the precision of effect size estimates. Statistical significance was set at p-value < 0.05 was considered statistically significant. All analyses were performed using SPSS (31.1.0(49)).

Treated Level					
		Frequency	Percent	Valid Percentages	Cumulative Percentages
Valid	C5-6	13	6.5	6.5	6.5
	C6-7	58	29	29	35.5
	L3-L4	2	1	1	36.5
	L4-L5	31	15.5	15.5	52
	L5-S1	87	43.5	43.5	95.5
	Th 7 - 8	9	4.5	4.5	100
	In total	200	100	100	

Diagnosis					
		Frequency	Percent	Valid Percentages	Cumulative Percentages
Valid	Disc protrusion	110	55	55	55
	Nerve root compression	56	28	28	83
	spin canal compression	34	17	17	100
	In total	200	100	100	

Ethical Approval

This descriptive research is anonymous and retrospective in nature. General ethical approval is granted by German Medical Association to these studies as per professional law of physician.

Results

A total of 200 patients were included in the analysis. The mean age was 54 years, and 73% were female. The treated spinal levels included cervical (C5-C6, C6-C7), thoracic (T7-T8), and lumbar (L3-L4, L4-L5, L5-S1) segments, with L5-S1 being the most frequently treated level.

The mean baseline VAS score was 8.29 ± 1.24, which decreased to 2.62 ± 1.63 following treatment. Paired-samples analysis demonstrated a significant reduction in pain intensity, with a mean difference of 5.67 ± 1.58 (95% CI: 5.45–5.89; $t(199) = 50.88$, $p < 0.001$). A moderate correlation between pre- and post-treatment VAS scores was observed ($r = 0.426$, $p < 0.001$), indicating consistent within-subject improvement. The magnitude of treatment effect was large, with Cohen's $d = 3.60$ (95% CI: 3.22–3.98) and Hedges' $g = 3.58$ (95% CI: 3.21–3.96). Similarly, ODI scores improved substantially from 73.89 ± 12.19 at baseline to 20.10 ± 12.44 post-treatment. The mean difference was 53.79 ± 13.25 (95% CI: 51.94–55.64; $t(199) = 57.41$, $p < 0.001$). A comparable moderate correlation was observed between pre- and post-treatment ODI scores ($r = 0.421$, $p < 0.001$). The effect size for ODI improvement was also extremely large, with Cohen's $d = 4.06$ (95% CI: 3.64–4.48) and Hedges' $g = 4.04$ (95% CI: 3.62–4.46), supporting the robustness of the observed functional The relative magnitude of improvement was considerable, with a mean percentage improvement of 68.9% for VAS and 73.2% for ODI. Clinically meaningful response was achieved in the vast majority of patients: 191 patients (95.5%) met the responder criterion of ≥50%

improvement in both pain and disability outcomes. Furthermore, 194 patients (97.0%) demonstrated at least some reduction in pain intensity, while 6 patients (3.0%) showed no change and none experienced worsening. Escalation to surgery was uncommon, with only 5 patients (2.5%) requiring surgical conversion during follow-up. Similarly, only 4 patients (2.0%) required central painkillers. No major patient-reported adverse complaints or serious treatment-related complications were observed.

VAS_Responder					
		Frequency	Percent	Valid Percentages	Cumulative Percentages
Valid	0	9	4.5	4.5	4.5
	1	191	95.5	95.5	100
	In total	200	100	100	0

ODI_Responder					
		Frequency	Percent	Valid Percentages	Cumulative Percentages
Valid	0	9	4.5	4.5	4.5
	1	191	95.5	95.5	100
	In total	200	100	100	

A complementary non-parametric paired-rank analysis confirmed the robustness of the findings, demonstrating that 97.0% of patients experienced a reduction in VAS scores, while 3.0% showed no change and no patients deteriorated. The need for treatment escalation remained low, with only 5 patients (2.5%) requiring surgical conversion and 4 patients (2.0%) requiring central analgesics during follow-up. No major patient-reported adverse events or serious treatment-related complications were observed. Exploratory multivariate analysis suggested that younger age and absence of motor deficit were associated with a higher likelihood of treatment success; however, these findings should be interpreted with caution given the retrospective study design.

Clinical Outcomes

During patient follow-up, clinical improvement was observed in approximately 75-85% of cases, with a progressive increase in treatment effectiveness over time.

Discussion

The present retrospective study indicates that percutaneous epidural catheter-based therapy ECT is associated with clinically meaningful and sustained reductions in pain intensity, accompanied by functional improvements, in patients with cervical, thoracic, and lumbar disc herniations as well as related degenerative spinal disorders.. These findings support the potential role of minimally invasive epidural interventions as a therapeutic option in carefully selected patients Overall [2,3]. Our results align with previously published observational studies, randomized controlled trials, and systematic reviews evaluating percutaneous epidural adhesiolysis and catheter-based interventions, which have reported clinically relevant improvements in pain and disability, particularly among patients with chronic radicular symptoms refractory to conventional conservative management. Reported response rates in prior literature range from approximately 60% to 80%, depending on patient selection, underlying pathology, and duration of follow-up. While direct comparisons across studies are limited by methodological heterogeneity, the magnitude of improvement observed in this cohort appears comparable to, and in some instances favorable relative to, earlier reports. Several factors may have influenced the observed clinical outcomes. Early intervention, particularly in patients with acute or subacute symptoms, was associated with improved treatment response. Exploratory subgroup analyses suggested that patients treated within six months of symptom onset demonstrated higher rates of pain and functional improvement compared with those with longstanding chronic symptoms.

This observation is consistent with existing evidence indicating that prolonged nerve root compression and sustained inflammatory processes may reduce responsiveness to interventional pain therapies. However, these subgroup findings should be interpreted cautiously due to their exploratory nature and the retrospective design. Procedural and anesthetic factors likely contributed to the observed efficacy as well. All interventions were performed under short-duration propofol-based sedation, which facilitated patient comfort, minimized procedural stress, and allowed precise catheter placement [4,5]. Radiological and anatomical

characteristics further influenced outcomes, with patients exhibiting extruded or contained disc fragments demonstrating particularly favorable responses. These findings suggest that ECT may be especially effective in soft disc herniation compared with advanced degenerative spinal stenosis, likely due to its capacity for targeted mechanical decompression and localized drug delivery [6,7]. The standardized multimodal treatment protocol applied at our center may have also contributed to favorable outcomes. This protocol included catheter-directed saline infusion, low-dose corticosteroid therapy, and hyaluronidase. Enzymatic agents such as hyaluronidase have been proposed to enhance epidural spread of injectates and facilitate both mechanical and pharmacological effects of adhesiolysis. In this study, adjunctive use of hyaluronidase was associated with improvements in pain relief, perceived quality of quality, and patient satisfaction, although these findings should be interpreted with caution. Previous evidence indicates that hyaluronidase may enhance the absorption and dispersion of injectable medications, potentially increasing the bioavailability of co-administered agents by degrading hyaluronic acid within the interstitial matrix, consistent with its FDA-approved indications. From a safety perspective, ECT represents a minimally invasive treatment option with a favorable safety profile, and available evidence suggests a low incidence of clinically relevant adverse events, with limited risk of epidural fibrosis or clinically significant scar formation. Clinical deterioration directly attributable to catheter-based procedures appears uncommon, and repeated treatments may be considered in selected patients with insufficient initial response, provided careful monitoring and appropriate patient selection are maintained [8-10]. While surgical management remains an established option for cervical, thoracic and lumbar spinal disorders, it is associated with recognized risks, including nerve or spinal cord injury, dural tears with cerebrospinal fluid leakage, postoperative epidural fibrosis, persistent neural compression, or suboptimal fusion outcomes, sometimes necessitating revision surgery. In contrast, epidural catheter-based therapy offers a minimally invasive alternative with a comparatively favorable safety profile. Notably, the low rate of subsequent surgical intervention observed in this cohort suggests that ECT may delay or potentially obviate the need for surgery in a substantial proportion of patients [11-12], particularly in the absence of progressive neurological deficits. In this context, based on the Schizas grading classification, ECT can be considered a potential non-surgical treatment option for lumbar spinal canal stenosis up to Grade C in appropriately selected patients. The responder analysis is particularly noteworthy, as 95.5% of patients achieved a clinically meaningful improvement in both pain and disability outcomes. This suggests that the observed treatment effect was not limited to statistical group differences, but was also highly relevant at the individual patient level.

Strengths and Limitations

Strengths

The strengths of this study include the relatively large patient cohort, a standardized treatment protocol, long-term follow-up, an outpatient-based procedural setting, and strict safety-oriented patient selection criteria. Additionally, protocol modifications implemented in response to observed adverse effects allowed individualized patient management, potentially enhancing both treatment safety and tolerability.

Limitations

Several limitations warrant consideration. First, the single-center design may limit the generalizability of the findings to other clinical settings with differing patient populations or procedural expertise. Second, the retrospective nature of the study and absence of a control group preclude definitive causal inference. Third, although pain and functional outcomes were assessed using validated instruments, patient-reported measures remain susceptible to subjective influences and placebo effects, which are inherent challenges in interventional pain research.

Conclusion

Percutaneous epidural catheter-based therapy appears to be a safe and potentially effective minimally invasive treatment option for selected patients with cervical, Thoracic and lumbar disc herniation and chronic spinal pain. Early intervention and careful patient selection may optimize clinical outcomes and reduce the need for subsequent surgical intervention. Prospective, controlled studies are warranted to further clarify the role of ECT within evidence-based treatment algorithms.

Conflict of Interest

The authors declare no conflict of interest.

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