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**An Original Contribution**

# One Day Lumbar Epidural Adhesiolysis and Hypertonic Saline Neurolysis in Treatment of Chronic Low Back Pain: A Randomized, Double-Blind Trial

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*Background:* Chronic, refractory low back pain and/or lower extremity is a common problem. Percutaneous adhesiolysis with hypertonic saline neurolysis was described in the management of chronic refractory low back pain and/or lower extremity, non-responsive to conservative modalities of management.

*Objective:* To determine the ability of percutaneous adhesiolysis and hypertonic saline administration to reduce pain and improve functional and psychological status in patients with chronic low back pain and/or lower extremity.

*Design:* Randomized, double-blind, controlled trial.

Methods: A total of 75 patients were studied, with 25 patients in each group. Three types of interventions were included, with Group I serving as control with catheterization without adhesiolysis, followed by injection of local anesthetic, normal saline, and steroid. Group II consisted of catheterization and adhesiolysis, followed by injection of local anesthetic, normal saline, and steroid. Group III consisted of adhesiolysis followed by injection of local anesthetic, hypertonic saline, and steroid. Statistical analysis incorporated intent-to-treat analysis.

*Outcome Measures:* Visual Analogue Scale pain scores, Oswestry Disability Index, work status, opioid intake, range of motion measurement, and P-3 ®. Significant pain relief was defined as average relief of 50% or greater.

*Results:* Significant improvement was seen in patients in Group II and III, at 3 months, 6 months, and 12 months, compared to baseline measurements, as well as compared to Group I without adhesiolysis. Seventy-two percent of patients in Group III (adhesiolysis and hypertonic neurolysis), 60% of patients in Group II (adhesiolysis only), compared to 0% in Group I (control) showed significant improvement at 12-month follow up. The average number of treatments for one year were 2.76 in Group II and 2.16 in Group III. Duration of significant relief with the first procedure was 2.8 ± 1.49 months in Group II and 3.8 ± 3.37 months in Group III.

*Conclusion:* Percutaneous adhesiolysis, with or without hypertonic saline neurolysis, is an effective treatment for chronic low back pain and/or lower extremity.

*Keywords:* Chronic low back pain, adhesiolysis, hypertonic saline neurolysis, epidural fibrosis

**P**ain emanating from various structures of the spine constitutes the majority of chronic pain problems, despite the efforts expended on information, research, prevention, treatment, and rehabilitation (1). The lifetime prevalence of low back pain has been reported as 65% to 80%(2-7); with a total of 13% of the population with low back pain suffering with high pain intensity coupled with moderate or severe disability; with an additional 12% suffering with low back pain with high pain intensity but with low disability. Further, recent investigations have shown that chronicity in low back pain is a common problem (8), with prevalence of low back pain ranging from 35% to 75% at 12 months after the initial episode (9-18).

Kuslich et al (19) identified intervertebral discs, nerve root dura, facet joints, ligaments, fascia, and muscles as tissues capable of transmitting pain in the low back and lower extremity. The pathophysiology of spinal radicular pain continues to be a subject of ongoing research and controversy. Proposed etiologies include neural compression with dysfunction, vascular compromise, inflammation, and biochemical influences (20). Multiple causes described for chronic low back and lower extremity pain include not only disc herniation with neural compression and dysfunction, but also vascular compromise, inflammation, biochemical influences, post lumbar laminectomy syndrome, and spinal stenosis. Post lumbar laminectomy syndrome or pain following operative procedures of the lumbar spine is estimated in approximately 5% to 40% of patients after surgical intervention (21-26).

Among post lumbar laminectomy syndrome patients, epidural fibrosis is seen as a common phenomenon, which contributes to approximately 60% of the patients with recurring symptoms in conjunction with instability (26). However, epidural fibrosis may develop without surgical intervention, secondary to annular tear, hematoma, infection, or intrathecal contrast media. McCarron (27) reported an inflammatory reaction in the spinal cord sections taken from dogs sacrificed after the initial injection of homogenized nucleus pulposus. Cooper et al (28) reported periradicular fibrosis and vascular abnormalities occurring with herniated intervertebral disc. Hoyland et al (29), in a cadaveric study, found significant pathological changes within and around the nerve root complex, including peri- and intraneural fibrosis, edema of nerve roots, and focal demyelination. Epidural adhesions were also demonstrated in ca-

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davers with lumbar disc herniation, with 40% of the cadavers showing adhesions at L4/5 level, 36% at L5/S1 level, and in 16% at L3/4 level (30). Further, it was shown that perineural fibrosis, which interferes with cerebrospinal fluid-mediated nutrition, can render nerve roots hyperesthetic and hypersensitive to compression forces (31, 32). Songer et al (33) showed that postoperative scar tissue renders the nerve susceptible to injury.

Even though epidural fibrosis is commonly seen in patients with recurring symptoms in conjunction with instability in post lumbar surgery syndrome (21-23, 25, 26, 34-39), its role as a causative factor of chronic spinal pain or as a pain generator continues to be questioned (22, 23, 25, 34, 37, 38). In a study of the relationship between peridural scar evaluated by magnetic resonance imaging (MRI) in radicular pain after lumbar discectomy, Ross et al (39) showed that subjects with extensive peridural scarring were 3.2 times more likely to experience recurrent radicular pain.

Significant evidence is lacking for interlaminar and caudal epidural steroid injections in chronic refractory low back and lower extremity pain (40-44). Phillips and Cunningham (22) reported that no form of surgical treatment or adhesion lysis procedure of epidural fibrosis has proven to be safe and effective.

Percutaneous epidural adhesiolysis emerged to eliminate the deleterious effects of a scar, which can physically prevent direct application of drugs to nerves or other tissues, and to assure delivery of high concentrations of injected drugs to the target areas (25). However, the literature thus far has been scant and unconvincing to non-believers. Nevertheless, the clinical effectiveness of percutaneous adhesiolysis has been evaluated in two randomized controlled trials (45, 46) and multiple retrospective evaluations (47-50).

This randomized, double-blind, controlled study was undertaken to evaluate the effectiveness of percutaneous lumbar epidural adhesiolysis and hypertonic saline neurolysis in the management of chronic low back and lower extremity pain.

## Methods

Evaluation was performed in an interventional pain management practice, a specialty referral center, in a private practice setting. The study protocol was approved by the Institutional Review Board. Patients were assigned to one of the three groups. Group I consisted of a control group without adhesiolysis, with injection of local anesthetic, steroid, and normal saline; Group II consisted of patients undergoing adhesiolysis, with injection of local anesthetic, steroid, and normal saline; and Group III consisted of patients undergoing adhesiolysis, as well as injection of 10% sodium chloride solution (hypertonic saline), in addition to local anesthetic and steroid.

### Inclusion and Exclusion Criteria

Eligible patients were identified from the existing patient load and from new patients as they were enrolled into the program during the study period.

Inclusion criteria included patients between 18 and 65 years of age, with a history of chronic low back pain and/or lower extremity of at least 2 years, with a minimum visual analog score of 6, have shown an absence of facet joint pain by controlled comparative local anesthetic blocks, have failed to respond to conservative treatment including fluoroscopically directed epidural injections, and willingness to participate in the clinical trial.

Exclusion criteria included large contained or sequestered herniation, cauda equina syndrome, compressive radiculopathy, lumbar surgical intervention in previous 6 months, drug addiction, uncontrolled major depression or psychiatric disorders, uncontrolled or acute medical illnesses, chronic severe conditions that could interfere with the interpretations of the outcome assessments, pregnant or lactating women, patients with multiple complaints involving concomitant hip osteoarthritis, etc., with overlapping complaints, history of adverse reaction to local anesthetic or steroids, and patients unable to understand the informed consent and protocol or patients unable to be positioned in prone position to perform the procedure.

### Informed Consent

All patients were provided with the approved protocol and the informed consent approved by the Institutional Review Board for this study. The informed consent described the details of the trial.

### Evaluation

The screening evaluation included demographic data, medical/surgical history with co-existing diseases, radiographic investigations, physical examination, psychological evaluation with Pain Patient Profile (P-3®), Visual Analogue Scale (VAS) pain scores, work status, Oswestry Disability Index 2.0, and lumbar spine range of motion by physical evaluation.

### Interventions

All procedures were performed in a sterile operating room under appropriate sterile conditions utilizing fluoroscopy and a specially designed RK® needle, as well as spring-wire catheter (Racz® catheter).

**Procedure:** The procedure included appropriate preparation with intravenous access, antibiotic administration, and appropriate sedation.

An RK needle was introduced into the sacral epidural space under fluoroscopy. Once the needle placement was confirmed to be in the epidural space, a lumbar epidurogram was carried out, utilizing approximately 2 to 5 mL of contrast. Identification of the filling defects was carried out by examining the contrast flow into the nerve roots. Intravascular or subarachnoid placement of the needle or contrast was avoided; if such malpositioning occurred the needle was repositioned.

After appropriate determination of epidurography, a Racz catheter, which is a spring guided reinforced catheter, was slowly passed through RK needle to the area of the filling defect or the site of pathology determined by MRI, CT, or patient symptoms. Following positioning of the catheter into the appropriate area, adhesiolysis was carried out as described in the protocol (Groups II and III) by mechanical means and injection of NaCl solution.

After completion of the adhesiolysis, a repeat epidurogram was carried out by additional injection of contrast. Appropriate adhesiolysis was identified by nerve root filling as well as ventral and lateral epidural filling. Additionally, the absence of subdural, subarachnoid, and intravascular uptake of contrast was confirmed. At that time, 5 mL of 2% lidocaine was injected.

Following completion of the injection, the catheter was taped utilizing a bio-occlusive dressing, and the patient was turned to supine position and transferred to the recovery room.

**Recovery room:** The patient was monitored for any potential complications or side effects. If no complications were observed, and the patient reported good pain relief without any motor weakness, further injection was carried out at this time by injection of 6 mL of normal saline (Group I and Group II) or 10% sodium chloride solution (Group III-hypertonic neurolysis). At least 15 minutes elapsed from the time the local anesthetic was instilled to the time then saline solution was injected. This was carried out by repeat injections in doses of 2 to 3 mL, followed by injection of 80 mg of methylprednisolone or 12 mg of Celestone Soluspan in all three groups.

The catheter was flushed with normal saline and was removed and checked for intactness. The patient was ambulated if all parameters were satisfactory, intravenous access was removed and the patient was discharged home with appropriate instructions.

In the control group, a catheter was introduced as in the treatment groups, to reach up to $S_3$ or $S_2$. Table 1 illustrates the summary of steps and procedural considerations.

### Co-Interventions

The same co-interventions as needed with narcotic and non-narcotic analgesics, adjuvant analgesics, and previously directed exercise program prior to enrollment, were continued in all patients. No specific physical therapy, occupational therapy, bracing, or other specific interventions were utilized.

### Additional Interventions

All the patients underwent the assigned treatments. If a patient required additional injections, these injections were provided based on the response, either after unblinding or without unblinding after 3 months. Patients without unblinding were offered only the assigned treatment. Unblinded patients were offered either the assigned treatment or another treatment based on their response. If the patients in Group I, or Group II, received adhesiolysis and injection of hypertonic saline, they were considered withdrawn, and no subsequent data was collected.

Table 1. *Summary of steps and procedural considerations*

**GROUP I (CONTROL)**
Preparation
Introduction of catheter up to S3 or S2
No adhesiolysis
Injection of 5 mL of 2% lidocaine (preservative free)
Transfer to recovery room
Injection of 6 mL of normal saline
Injection of 80 mg of methylprednisolone or 12 mg of Celestone Soluspan
Injection of 1 mL of normal saline
Removal of catheter

**GROUP II (ADHESIOLYSIS WITHOUT HYPERTONIC NEUROLYSIS)**
Preparation
Introduction of catheter
Adhesiolysis
Epidurography with confirmation of ventral and lateral filling
Injection of 5 mL of 2% lidocaine (preservative free)
Transfer to recovery room
Injection of 6 mL of normal saline
Injection of 80 mg of methylprednisolone or 12 mg of Celestone Soluspan
Injection of 1 mL of normal saline
Removal of catheter

**GROUP III (ADHESIOLYSIS WITH HYPERTONIC SALINE NEUROLYSIS)**
Preparation
Introduction of catheter
Adhesiolysis
Epidurography with confirmation of ventral and lateral filling
Injection of 5 mL of 2% lidocaine (preservative free)
Transfer to recovery room
Injection of 6 mL of 10% sodium chloride solution
Injection of 80 mg of methylprednisolone or 12 mg of Celestone Soluspan
Injection of 1 mL of normal saline
Removal of catheter

### Outcome Measures

Outcomes were assessed at 3-months, 6-months, and 12-months post-treatment with the VAS pain scale, Oswestry Disability Index 2.0, work status, opioid intake, range of motion measurement, and psychological evaluation by P-3. They were compared to pre-treatment data for the patients in the three groups. Each group was also compared to the other two groups at multiple time periods. Significant pain relief was defined as average relief of 50% or greater.

VAS was measured on a 10 cm scale. P-3 psychological evaluation and Oswestry Disability Index were assessed by administration of standardized questionnaires. Range of motion was evaluated by a certified physical therapist blinded to type of treatment.

Opioid intake was determined as none, mild, moderate, or heavy based on the dosage, frequency and schedule of the drug. Intake of Schedule IV narcotics (e.g., propoxyphene napsylate, pentazocine hydrochloride, tramadol hydrochloride up to a maximum of 4 times, or hydrocodone twice or less per day), was considered as mild; intake of Schedule III narcotics, (e.g., hydrocodone, up to 4 times), was considered as moderate; and intake of Schedule II narcotics, (e.g., oxycodone, morphine, meperidine, transdermal fentanyl, and methadone, in any dosage) was considered to be heavy.

Employment and work status (employed, unemployed, housewife, disabled, and retired) were determined from the pre-treatment and post-treatment work status. Only employed and unemployed patients were considered to be eligible for employment, whereas disabled patients and retired patients were considered not employable.

### Randomization

Twenty-five patients were randomly assigned into each group. Randomization was performed by computer generat-

ed random allocation sequence by a statistician, in blocks of 15 patients.

The random allocation was concealed until the intervention. Randomization was not revealed to personnel in the recovery room or the reviewing physician.

Patients were unblinded if they requested to be unblinded after 3 months. All other patients were unblinded at 12 months. Patients were also given an option to discontinue or to withdraw from the study for various reasons. They were considered to be withdrawn if follow-up was lost.

### Statistical Methods

**Statistical Analysis:** Data were recorded on a database using Microsoft® Access®. The SPSS Version 9.0 Statistical Package was used to generate the descriptive tables. Differences in proportions were tested by using the chi-squared test. Fischer's exact test was used wherever the expected value was less than five. Student's t test was used to test mean differences between groups. A paired t test was used to compare the pre- and post-treatment. Results were considered statistically significant if the *P* value was less than 0.05.

**Intent-to-treat analysis:** An intent-to-treat analysis was utilized in all patients utilizing last follow-up. After consideration of all the imputation methods in a sensitivity analysis, carrying forward the last observation. which showed the least bias.

## Results

A schematic presentation illustrating the patient flow is shown in Fig. 1. The Study period lasted from January 2002

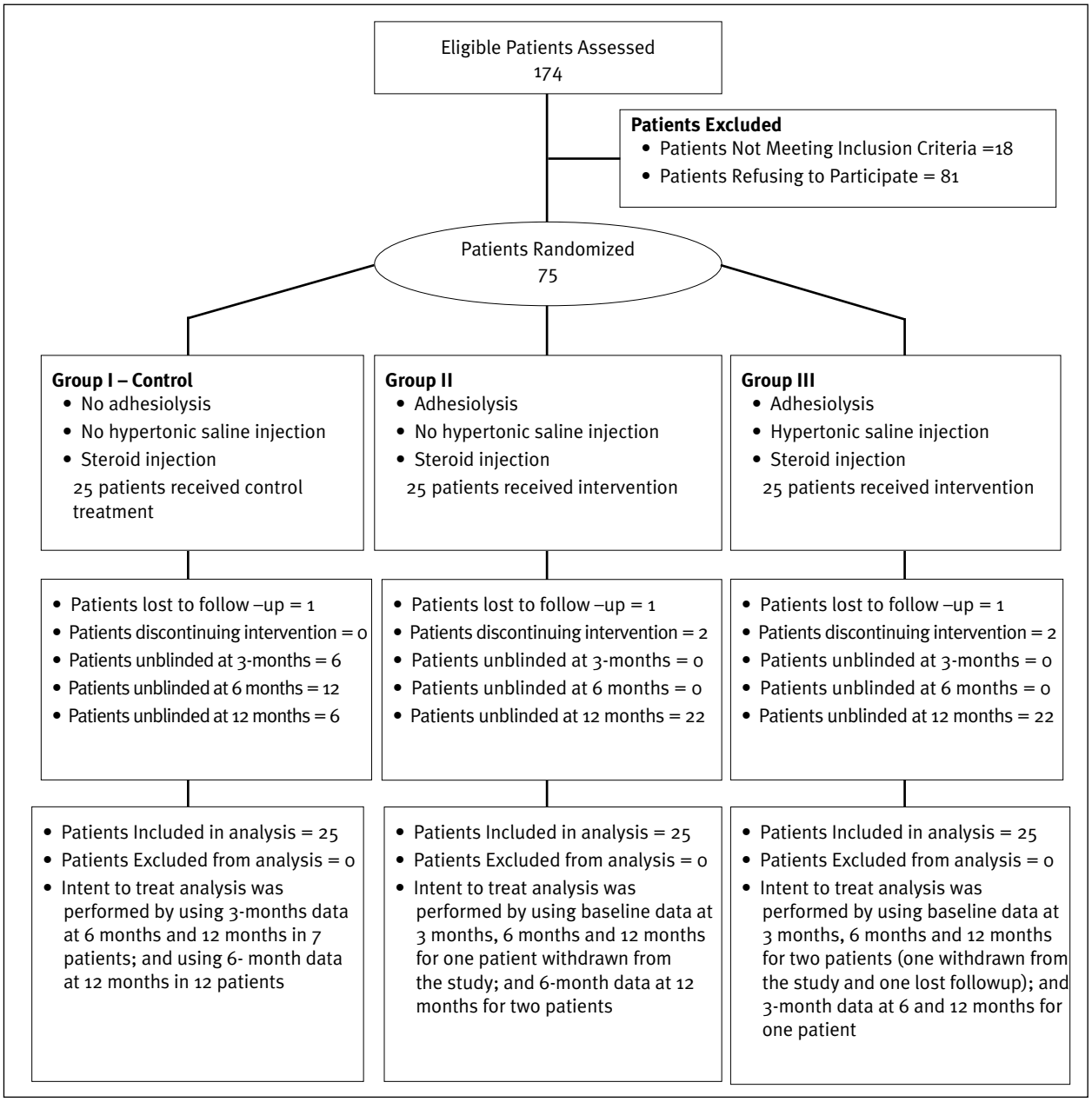


Fig 1. *Schematic representation of patient flow thru trial period*

to September 2003. One patient in each of Groups I, II, and III were lost to follow-up. The number of patients discontinuing intervention was zero in Group I, two in Group II, and three in Group III. In Group II, one patient experienced subarachnoid block following the intervention, and, consequently, withdrew from the study and refused further follow-up. A second patient underwent surgical intervention with fusion two months following the intervention and refused to return for follow-up. One patient in Group III discontinued intervention and was withdrawn from the study secondary to drug abuse. An additional two patients discontinued interventions due to lack of response; however, they stayed in the study through the entire period with unblinding carried out at 3 months.

### Demographic Characteristics

Table 2 illustrates demographic characteristics of patients. There were no significant differences noted between the groups.

Table 3 illustrates structural abnormalities as identified by the radiologist.

### Procedural Characteristics

The total number of interventions or treatments provided to the patients in the three groups were 53 in Group I, 69 in Group II, and 54 in Group III. The average number of treatments was 2.12 in Group I, 2.76 in Group II, and 2.16 in Group III. The number of patients receiving only one treatment with no response was highest in Group I with 40% of the patients, followed by Group II with 16%.

Table 2. *Demographics characteristics*

| | | Group I | Group II | Group III |
|---|---|---|---|---|
| Number of patients | | 25 | 25 | 25 |
| Age (Years) | Mean ± SD | 47 ± 10 | 47 ± 11 | 46 ± 10 |
| Gender | Male | 52% | 56% | 48% |
| | Female | 48% | 44% | 52% |
| Height (Inches) | Mean ± SD | 66 ± 3.7 | 68 ± 3.8 | 67 ± 3.9 |
| Weight (Lbs) | Mean ± SD | 186 ± 44 | 202 ± 44 | 185 ± 38 |
| Duration of pain (months) | Mean ± SD | 162 ± 75 | 150 ± 109 | 138 ± 117 |
| Onset of the pain | Traumatic | 56% | 52% | 64% |
| | Non-traumatic | 44% | 48% | 36% |
| Previous Surgery | | 72% | 64% | 72% |

Table 3. *Structural abnormalities based on MRI report by radiologist*

| | Group I | Group II | Group III |
|---|---|---|---|
| **Epidural Fibrosis*** | | | |
| Mild | 3 (12%) | 2 (8%) | 2 (8%) |
| Moderate | 5 (20%) | 5 (20%) | 5 (20%) |
| Extensive | 9 (36%) | 8 (32%) | 11 (44%) |
| **Total** | **17 (68%)** | **15 (60%)** | **18 (72%)** |
| **Spinal Stenosis*** | | | |
| Mild | 0 (0%) | 3 (12%) | 1 (4%) |
| Moderate | 0 (0%) | 0 (0%) | 0 (0%) |
| Extensive | 1 (4%) | 2 (8%) | 1 (4%) |
| **Total** | **1 (4%)** | **5 (20%)** | **2 (8%)** |
| **Disc degeneration*** | | | |
| Herniation | 4 (16%) | 2 (8%) | 6 (24%) |
| Bulging | 3 (12%) | 5 (20%) | 4 (16%) |
| Severe Degeneration | 4 (16%) | 1 (4%) | 2 (8%) |
| Protrusion | 1 (4%) | 2 (8%) | 3 (12%) |
| **Total** | **12 (48%)** | **10 (40%)** | **15 (60%)** |

* These categories were not mutually exclusive. Some patients had more than one pathology. Therefore, these totals do not = n.

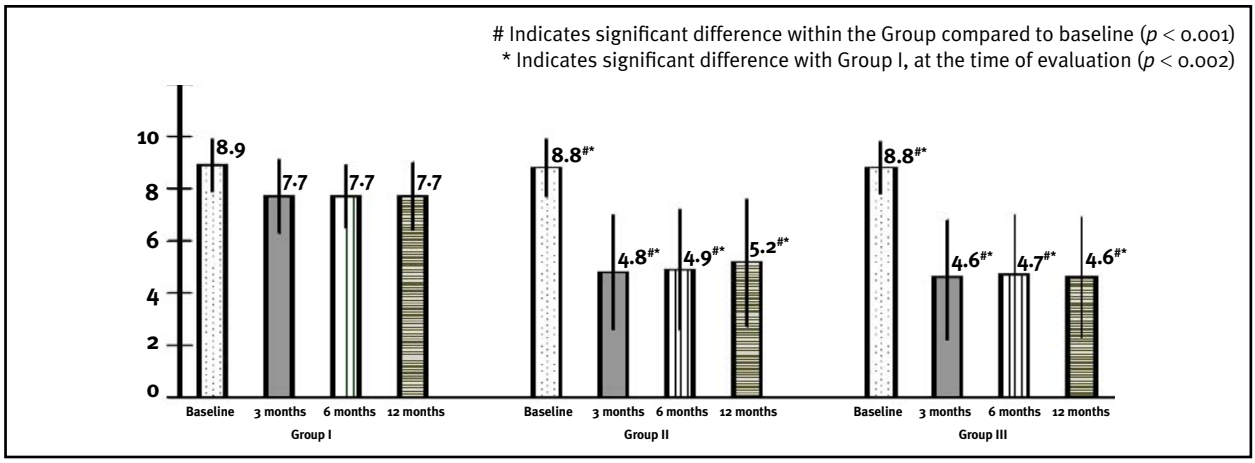


Fig 2. *Outcome measurements (Mean ± SD) based on Visual Analog Scale Report*

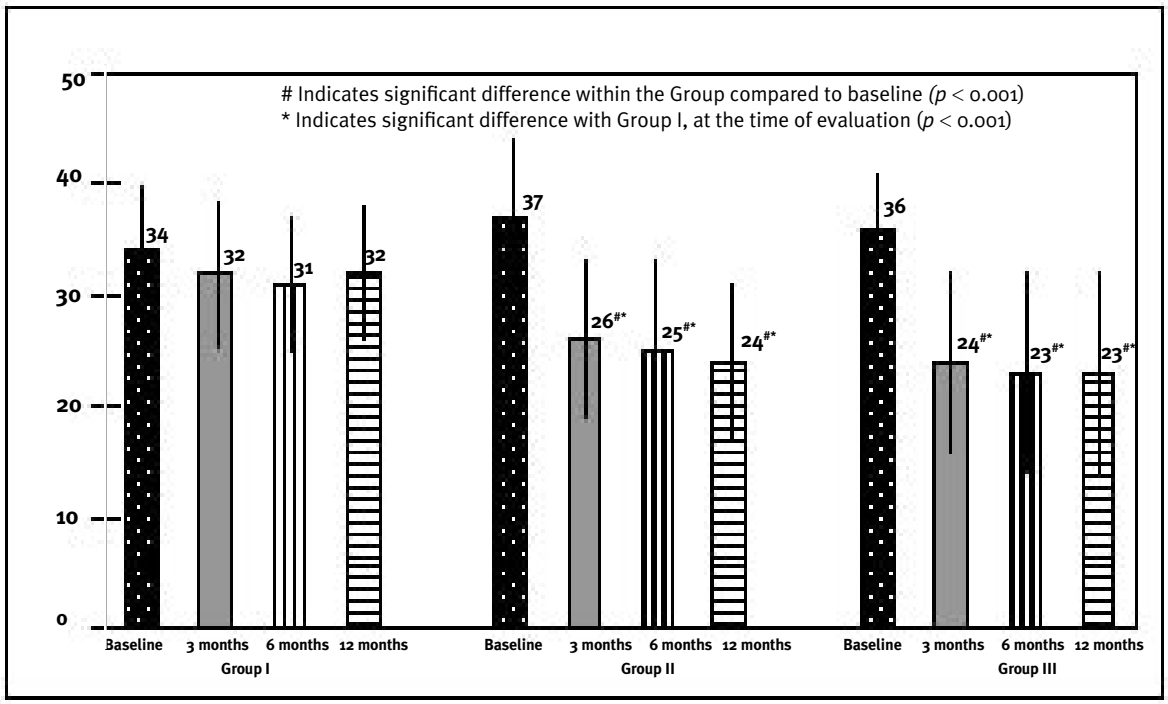


Fig. 3. *The outcome measurements based on Oswestry Disability Index (Mean ± SD)*

Table 4. *Analysis of range of motion evaluation*

| | | Baseline | | | 3 months | | | 6 months | | | 12 months | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | I | II | III | I | II | III | I | II | III |
| | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **Flexion (Normal 60°)** | **Mean ± SD** | 24.5 ± 10.3 | 25.6 ± 8.8 | 24.4 ± 8.9 | 25.4 ± 9.8 | 30.6# ± 11.3 | 34.1#* ± 12.9 | 24.8 ± 10.0 | 32.9#* ± 11.4 | 34.9#* ± 13.6 | 24.8 ± 10.0 | 33.8#* ± 11.7 | 37.3#* ± 13.5 |
| **Extension (Normal 25°)** | **Mean ± SD** | 9.4 ± 1.0 | 8.9 ± 3.6 | 8.9 ± 2.8 | 10.8 ± 5.7 | 11.4# ± 4.8 | 13.8#* ± 5.2 | 10.5 ± 5.6 | 13.6# ± 6.0 | 15.6#* ± 5.7 | 10.8 ± 5.8 | 15.4#* ± 5.0 | 17.0#* ± 5.7 |
| **Lateral Flexion (Normal 25°)** | **Mean ± SD** | 8.1 ± 3.0 | 7.7 ± 2.9 | 7.6 ± 3.2 | 7.4 ± 2.8 | 10.3#* ± 4.6 | 12.5#* ± 5.1 | 7.5 ± 3.2 | 12.6#* ± 5.7 | 12.8#* ± 5.4 | 7.3 ± 2.9 | 13.6#* ± 5.8 | 15.3#* ± 5.4 |

* Indicates significant difference with Group I ($p < 0.05$)
# Indicates significant difference within the Group compared to baseline ($p < 0.03$)

Table 5. *Duration of significant pain relief (> 50%) in months (Mean ± SD) with first procedure*

| | All patients | Successful Patients |
|---|---|---|
| **Group I** | 0.85 ± 0.83 (25) | 0 |
| **Group II** | 2.8* ± 1.49 (25) | 3.6 ± 0.81 (16) |
| **Group III** | 3.8* ± 3.37 (25) | 5.4# ± 2.88 (18) |

* Indicates significant difference with Group I ($p < 0.001$)
# Indicates significant difference with Group II ($p < 0.03$)
( ) Indicates number of patients

## Outcome Measures

Figures 2 and 3 illustrate pain and functional measures, which included VAS and Oswestry Disability Index 2.0. Table 4 illustrates computerized range of motion measurements by ARCON. There were no significant differences noted with baseline measurements among the three groups. However, significant differences were noted with pain relief, Oswestry Disability Index, and range of motion between Group I and Groups II and III. There were also improvements noted in II and III from baseline to 3 months, 6 months, and 12 months in all parameters.

Table 5 illustrates duration of significant pain relief (≥ 50%) in months with first procedure for successful patients and all patients. Patients in Group II and III experienced significantly longer relief. Successful patients in Group III, also showed longer relief than successful patients in Group II.

Figure 4 shows proportion of patients with significant relief (≥ 50%) at 3 months, 6 months, and 12 months. None of the patients in Group I, obtained significant pain relief, whereas 60% in Group II, and 72% in Group III obtained significant relief at 6 and 12 months.

Table 6 illustrates psychological outcomes of depression, anxiety, and somati-

zation derived from P-3® scores. Based on P-3® profile, the diagnosis of depression, anxiety and somatization were made with scores of 55, 56, and 56 or more respectively. Significant improvement was noted in psychological parameters in Group II and III compared to Group I. There were also differences noted at 12 months from baseline in Groups II and III.

Patients were evaluated for opioid intake. Opioid intake was significantly less at 12 months in Groups II and III

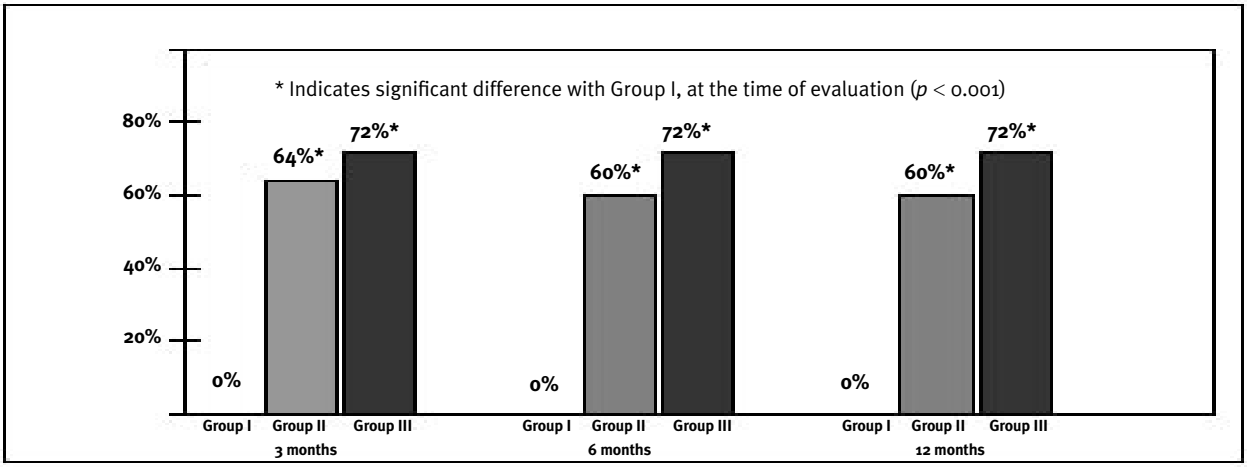


Fig. 4. *Proportion of patients with significant relief (≥ 50%) at 3 months, 6 months and 12 months*

Table 6. *Analysis of psychological outcome measurements*

| | | Baseline | | | 12 months | | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | I | II | III |
| | | 25 | 25 | 25 | 25 | 25 | 25 |
| **Depression** | **Diagnosis** | 15 (60%) | 18 (72%) | 16 (64%) | 13 (52%) | 6*# (24%) | 6*# (24%) |
| | **Score Mean ± SD** | 57 ± 8.7 | 59 ± 11.3 | 58 ± 13.0 | 55 ± 8.6 | 49*# ± 7.6 | 47*# ± 11.9 |
| **Anxiety** | **Diagnosis** | 14 (56%) | 16 (64%) | 13 (52%) | 12 (48%) | 4*# (16%) | 5*# (20%) |
| | **Score Mean ± SD** | 56 ± 10.6 | 58 ± 10.5 | 55 ± 11.4 | 54 ± 9.2 | 47*# ± 8.5 | 46* ± 10.3 |
| **Somatization** | **Diagnosis** | 14 (56%) | 19 (76%) | 16 (64%) | 12 (48%) | 4*# (16%) | 5*# (20%) |
| | **Score Mean ± SD** | 55 ± 8.0 | 59 ± 8.5 | 57 ± 8.3 | 54 ± 7.8 | 48*# ± 7.5 | 46*# ± 9.3 |

* Indicates significant difference with Group I, at the time of evaluation
\# Indicates significant difference with Baseline values within the Group

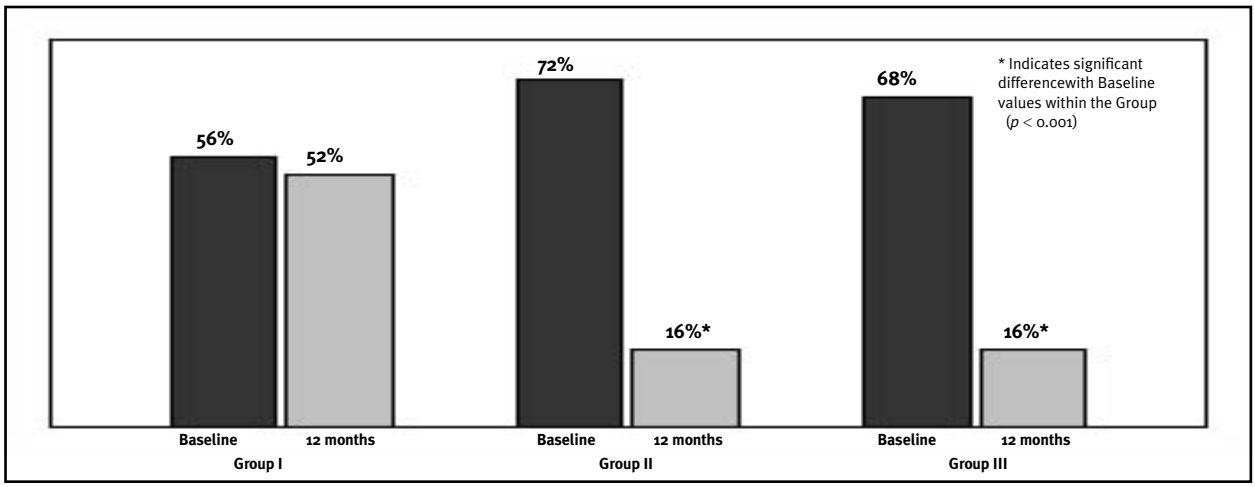


Fig. 5. *Change in proportion of patients with significant opioid intake*

Table 7. *Change in proportion of patients with employment status*

| Employment Status | Group I | | Group II | | Group III | |
|---|---|---|---|---|---|---|
| | Baseline | At 12 months | Baseline | At 12 months | Baseline | At 12 months |
| **Employed** | 8% (2) | 8% (2) | 4% (1) | 16% (4) | 8% (2) | 28% (7) |
| **Unemployed** | 8% (2) | 8% (2) | 12% (3) | 8% (2) | 16% (4) | 4% (1) |
| **Housewife** | 4% (1) | 4% (1) | 0% | 0% | 4% (1) | 0% |
| **Disabled** | 76% (19) | 76% (19) | 80% (20) | 72% (18) | 68% (17) | 64% (16) |
| **Over 65 (yrs)** | 4% (1) | 4% (1) | 4% (1) | 4% (1) | 4% (1) | 4% (1) |
| **Total** | 25 | 25 | 25 | 25 | 25 | 25 |

compared to the baseline intake (Fig. 5).

Employment status showed that the majority of the patients were in non-employable category (Table 7). At the end of 12 months, unemployment remained the same in Group I, decreased from 3 to 2 in Group II, while it decreased from 4 to 1 in Group III (75% decrease). There was no change in employment in Group I, while it increased to 4 (75% increase) in Group II, and from 2 to 7 (71% increase) in Group III.

### Adverse Events

There was one subarachnoid block noted in Group II, which was identified after completion of the procedure and injection of local anesthetic and steroid. There were no other adverse events noted.

## Discussion

In this randomized, double-blind trial, we demonstrated that none of the patients in Group I; 15 of 25 (60%) in Group II with adhesiolysis, but, without hypertonic saline neurolysis; and 18 of 25 patients (72%) in Group III, receiving adhesiolysis and hypertonic saline neurolysis, obtained significant relief for 12 months. Significant pain relief ($\geq$ 50%) was also associated with improvement in Oswestry Disability Index, range of motion, and psychological status compared to baseline measurements. The improvement was also significant in Groups II and III compared to Group I in multiple parameters. However, while there was only a trend of enhanced improvement in Group III compared to Group II, there was significant improvement in successful patients from Group II to III. Further, patients treated with adhesiolysis with hypertonic saline injection were less likely to require repeat treatments than were patients treated with steroids, without adhesiolysis (Group I) or patients with adhesiolysis without hypertonic saline injection (Group II). This study also showed significant improvement in psychological outcome measures in Groups II and III.

This study may be criticized for allowing the repeat procedure in most patients rather than following them with only one procedure. All studies thus far have shown that a single procedure is not an effective modality of treatment, in most patients. Further, in the previous study by Heavner et al (45), a 3-day protocol was utilized, involving daily injection of hypertonic saline for 3 days in each patient. In contrast, this study utilized a 1-day protocol. The present study also showed the effectiveness of hypertonic saline injection, as a smaller proportion of patients in Group III required repeat procedures.

The technique of percutaneous adhesiolysis overcomes the obstacle of being able to get various medications to a lesion specific site by placing the tip of a soft spring catheter within the scar and letting the injected fluid under pressure find the path of least resistance within the scar and open up the perineural space. Thus, the steroid and the hyperosmolar sodium chloride solution reach the appropriate site and provide anti-inflammatory effect, and neural blockade. Experiments on hypertonic saline and nerve conduction showed that osmolar depletion of water content within the peripheral axons resulted in decreased nerve conduction (51) and attenuation of transmitter release from neuromuscular junctions exposed to hypertonic solutions (52). In 1969, Hitchcock (53) showed the effectiveness of hypertonic saline was due to the hypertonicity of the solution, instead of any thermal effect. Multiple other effects described include selective C-fiber blockade in cat dorsal rootlets (54), reduction of spinal cord water content and depressed lateral column-evoked ventral root response (55), volume change due to outflow of water across the membrane, and ionic concentration changes producing the effect on axonal function (56). Racz et al (57), in the dural permeability study in dogs demonstrated transdural equilibration of hypertonic saline to occur very slowly, with doubling of cerebrospinal sodium concentration to occur 20 minutes after extradural placement of 10% sodium chloride solution.

Clinical effectiveness of percutaneous adhesiolysis was reported by multiple investigators with two randomized controlled trials (45, 46) and in four retrospective evaluations (47-50). Heavner et al (45) studied 59 patients with chronic intractable low back pain after failure of conservative management, including fluoroscopically directed epidural steroid injections. They allocated patients into four groups and performed adhesiolysis followed by injection of multiple drugs into the epidural space, including isotonic saline, for three days. The results showed, 49% of the patients with significant improvement at 3 months, 43% at 6 months, and 49% at 12 months. Since there were no significant differences noted among the groups receiving various types of solutions, the study was not considered as providing significant evidence for adhesiolysis or hypertonic saline neurolysis (58, 59). However, in this study, all the patients prior to being enrolled in the randomized, double-blind trial failed to respond to many types of conservative modalities of treatments, including fluoroscopically directed epidural steroid injections. Thus, this study provided evidence for the effectiveness of adhesiolysis, but not for injection of hypertonic saline or hyaluronidase.

Manchikanti et al (46) studied 45 patients with 30 patients in the treatment

group and 15 patients in the conservative management group with one-day adhesiolysis showing improvement with pain relief in 93% of the patients at 6 months and 47% of the patients at 1 year. However, procedures were repeated 1 to 3 times. Patients in the treatment group also showed significant improvement in functional and psychological status. The results of this study have not been considered significant, as it was neither blinded, nor did it include a control group undergoing placebo injections.

The results of the present study are similar to the results of the randomized trial by Heavner et al (45), reporting significant improvement in 49% of the patients at 3 months, 43% of the patients at 6 months, and 49% of the patients at 12 months. In the present study, 64% of the patients in Group II and 72% of the patients in Group III showed significant improvement at 3 months, compared to 60% and 72% at 6 and 12 months. However, there are also differences with the Heavner et al study (45) which used a 3-day protocol with multiple injections. The present study utilized a 1-day protocol, with repeat procedures in some patients.

The current study is the first randomized, double-blind trial to evaluate both 1-day epidural adhesiolysis and also the role of hypertonic saline injections. In addition, patients with facet joint pain were excluded by comparative local anesthetic blocks. In addition, inclusion criteria included patients to have had conservative treatments (failed or insignificant relief), including physical therapy, rehabilitation, drug therapy, and fluoroscopically directed epidural steroid injections. Further, this study utilized significant outcome parameters.

## Conclusion

Seventy-two percent of patients in Group III (adhesiolysis and hypertonic neurolysis), 60% of patients in Group II (adhesiolysis only), compared to 0% in Group I (control) showed significant improvement at 12 months. Fewer patients in Group III with adhesiolysis combined with injection of hypertonic saline required repeat procedures compared to Group II with adhesiolysis but without hypertonic saline injection.

It is concluded that percutaneous adhesiolysis, with or without hypertonic saline neurolysis, is a safe and effective treatment for chronic refractory low back and lower extremity pain.

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