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EVALUATION OF THE EFFICACY OF PERCUTANEOUS CAUDAL AND COMBINED CAUDAL/TRANSFORAMINAL NEUROPLASTY-ADESIOLYSIS FOR TREATING SYMPTOMATIC LUMBAR SPINAL STENOSIS

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ABSTRACT

Objective: Lumbar spinal stenosis (LSS) is a narrowing of the canal diameter due to degenerative changes, particularly in elderly individuals. This narrowing sometimes accompanies foraminal stenosis. The aim of this study was to investigate the efficacy of caudal and combined caudal/transforaminal adhesiolysis for treating symptomatic LSS patients.

Materials and Methods: Patients between the ages of 48-74, whose diagnosis was confirmed by magnetic resonance imaging were included in the study. The gender distribution was kept the same in both groups. The procedure was initially performed through the caudal way in all patients. Patients, with no evidence of foraminal passage in epidurography were categorized in group 2 as a combined caudal and transforaminal adhesiolysis groups. A total of 80 patients (40 patients in each group) were included in this study. Pain relief was evaluated using the walking distance, visual analog scale (VAS), and Oswestry Disability Index (ODI) before the procedure (baseline) and at the second week, the third and the sixth months after the procedure.

Results: Baseline VAS values were found to be at least 5 and higher in the patients without foraminal passage by epidurography. These values were present in 35% of the patients in the caudal group. The increase in walking distance was similar in both groups (72.5% in the caudal group and 75% in the combined group). The improvement in VAS was significant in the combined group, and was observed in 39 of 40 patients. The improvement in ODI was 97.5% in both groups. No complications were encountered during and after the procedures.

Conclusion: Caudal neuroplasty adhesiolysis is an effective method for treating chronic low back pain due to symptomatic LSS and its effectiveness is increased when adding a transforaminal procedures in cases with no foraminal passage in epidurography.

Keywords: Symptomatic lumbar spinal stenosis, neurogenic claudication, percutaneous neuroplasty, adhesiolysis, caudal, transforaminal, hyaluronidase, hypertonic sodium chloride solution

INTRODUCTION

Lumbar spinal stenosis (LSS) is defined as narrowing of the anterior posterior diameter of the spinal canal, nerve root canals (lateral recess), and intervertebral foramen[1,2]. This entity occurs due to hypertrophy of the ligamentum flavum and facet joints, osteophytic protrusions, and intervertebral disc herniations because of acquired degeneration of the spine[1-6]. Although the cause of this situation has not been fully understood, it can also be seen in asymptomatic individuals[7-9]. Symptoms generally vary according to the location of the neural compression. Neurogenic claudication is typically found in central canal stenosis, whereas lateral recess and foraminal stenosis are associated with radicular pain. Neurogenic claudication is a feeling of pain and weakness in the legs, which worsens in walking or prolonged standing and improves with rest or flexion of the lower back[1]. This results in patients to have decreased mobility and function, and eventually even simple tasks such as standing upright or picking up objects may become difficult to perform and necessitate some degree of help from others. Initially symptomatic LSS patients are treated with various conservative treatment modalities, whereas unresponsive cases are candidates for decompressive spinal surgery. Meanwhile, the importance of epidural procedures as a pre-surgical treatment method is increasing. However, the limited effectiveness of epidural steroid therapy, especially in the presence of neural compression, has brought new searches to the agenda[1,10]. Racz and Holubec[11] described

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percutaneous epidural neuroplasty-adhesiolysis in 1989. This method, also known as the Racz method, is gaining popularity and used reliably and effectively for treating different spinal pathologies[12]. In this study, it was aimed to investigate the efficacy of caudal and combined caudal/transforaminal adhesiolysis for treating symptomatic LSS patients.

MATERIALS AND METHODS

A total of 80 patients aged between 48 and 74 years with neurological claudication and diagnosis of symptomatic spinal stenosis confirmed by neurologic examination and radiographic evidence [plain films of the lumbar spine and magnetic resonance imaging (MRI)] were included. The study was conducted with the approval of the Demiroğlu Bilim University Ethics Committee (no: 44140529, date: 23.06.2020). An informed consent form of the procedure was obtained from all patients. The patient gender distribution was kept the same in both groups. The neuroplastic procedure was initiated caudally in all patients. Patients whose anteroposterior (AP) and lateral fluoroscopy could not show radiopaque material passing through the foramen were included in the combined caudal/transforaminal neuroplastic adhesiolysis group, which was designed as a second group. Forty patients were included in each group. In the follow-up of the patients, walking distance, visual analogue scale (VAS), and Oswestry Disability Index (ODI) scores were measured at four different times, including baseline, two weeks, three and six months. Patients with unclear or suspicious symptoms, spondylolisthesis findings on MRI imaging, or a history of previous spinal surgery were excluded from the study. In addition, patients with uncontrolled psychiatric disorders, bleeding disorders, sepsis, skin infection at the entry point, spinal infection, previous spinal surgeries with implants, and the patients who cannot lie in the prone position, those who are pregnant or breastfeeding, and the patients with a history of allergy to possible drugs to be used were also excluded from the study.

Procedures

All the procedures were performed in the operating room under anesthesia with necessary monitoring and fluoroscopy. The patients were placed in the prone position with local area cleaning and sterile isolation. A specially designed 16 gauge RX Coude® needle and a Racz® catheter (Epimed International Inc., Johnstown, NY) were used for caudal neuroplasty intervention and Couda Blunt Needle (Epimed International Inc., Johnstown, NY) for transforaminal neuroplasty. Neuroplasty was initiated caudally in all patients. The Racz® catheter was placed with minimal manipulation in the position closest to the desired level and side (ventral lateral epidural area) for neuroplasty. Neuroplastia-adhesiolysis was only caudally performed in the patients who has passage of radiopaque through the desired foramen. The transforaminal procedure was also added to the caudal approach in cases with no radiopaque material passage through the desired foramen. The study was designed as two groups. The first group was composed of the patients who underwent caudal intervention alone, and the second group included patients who underwent both caudal and transforaminal procedures. Serum sale (10%) was administered caudally alone. Patients who could not obtain sufficient volume or were treated as risky by clinical and radiological evaluation were excluded from the study. All patients were included in the post-procedure exercise program.

Caudal Approach

The sacral hiatus is defined and entered by lateral fluoroscopic guidance after the skin Infiltration with local anesthetic. When the skin is passed, the epidural needle (16-gauge RX Coudé®) is advanced so that it remains below the level of the S3 foramen. After being understood with negative aspiration, that we are in the epidural space, an epidurogram is performed by giving 10 cc of omnipaque. The presence of filling defects was evaluated. Then, under continuous AP fluoroscopic guidance, the tip of the catheter is advanced into the ventral lateral epidural space at the desired level (matching the filling defect) (Figure 1). Under real-time fluoroscopy, an additional 2-3 cc of contrast is injected through the catheter to see whether the radiopaque transition through the neural foramen responsible for spinal stenosis; (Figure 1 and 2). When the transition is satisfactory, the procedure is continued with a slow injection of 1500 U of hyaluronidase in 10 cc 0.5% lidocaine. Then, 3 cc of 10 cc local anesthetic/steroid solution containing 0.5% lidocaine and 80 mg methylprednisolone (Depo-Medrol) is given as a test dose. Five minutes later, if there isnot any evidence of intrathecal or

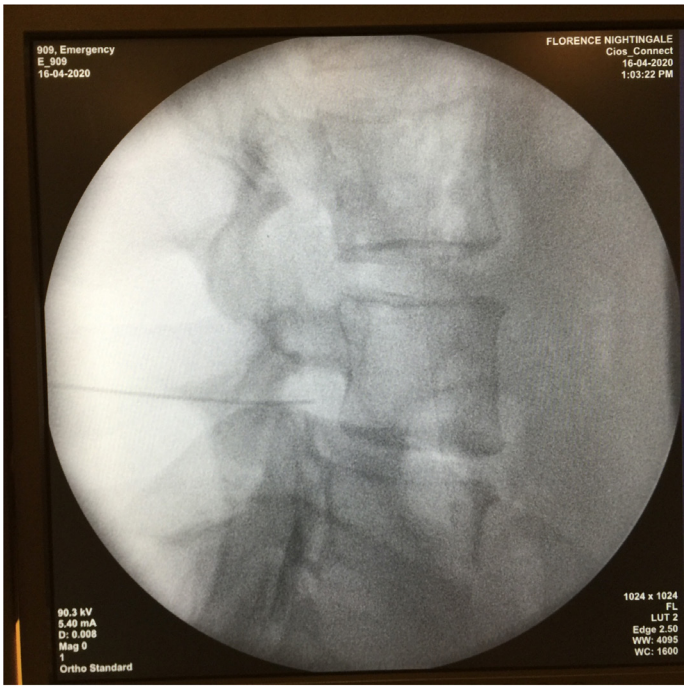

Figure 1. Lateral fluoroscopic view showed the needle positioned in the neural foramen following caudal injection and just before performing the transforaminal injection

intravascular passage, the remaining 7 cc is injected. Subdural or subarachnoidal passage carries the risk of motor block. So, the patients are followed up in the recovery room for 20-60 min to be sure if there is any sign of motor block. Then, 10 cc of 10% hypertonic saline solution is given by slow infusion. The catheter was removed 30 minutes later. The entrance area on the skin is covered with a sterile dressing, and the patient is transferred to his room after the recovery period.

Combined Caudal and Transforaminal Approach

In cases where the target level could not be reached with the caudal approach (no contrast passage through the foramen), a second catheter was placed in the ventral epidural space through the transforaminal way. For this purpose, the target level is defined in AP fluoroscopy. The vertebral endplate were superimposed on top of each other. The AP angle at this point is typically 15 to 20 degrees in the caudocephalad direction. Then, the fluoroscopy is rotated obliquely about 15 degrees to the targeted foramen side. In this position, the spinous process overlaps the contralateral superior articular process (SAP). The target point is at the very end of the SAP, also known as the Scottish dog's ear. The SAP forms the inferoposterior part of the target foramen and should be superimposed with the disc in an oblique view. This will create a secure bony target to pass behind the nerve root. The skin is passed with an 18 gauge needle, and then the 15-16 gauge RX Coude Blunt Needle, whose chuck is removed and replaced, is advanced until it contacts the medial SAP. The tip of the needle is turned 180 degrees laterally, and after 5 mm is advanced so that the bone tissue is bypassed, it is rotated 180 degrees medially again and proceeded slowly. It can be clearly felt that the tip of the needle crosses the intertransverse ligament. In lateral fluoroscopy, the tip of the needle should be anterior to the SAP in the posterior foramen (Figure 3 and 4). Preferably, in lateral fluoroscopy, radiopaque material is given to investigate if there is a venous spread or subarachnoidal passage. Then, 5 mL of 1% lidocaine containing 750 units of hyaluronidase and 40 mg of triamcinolone is

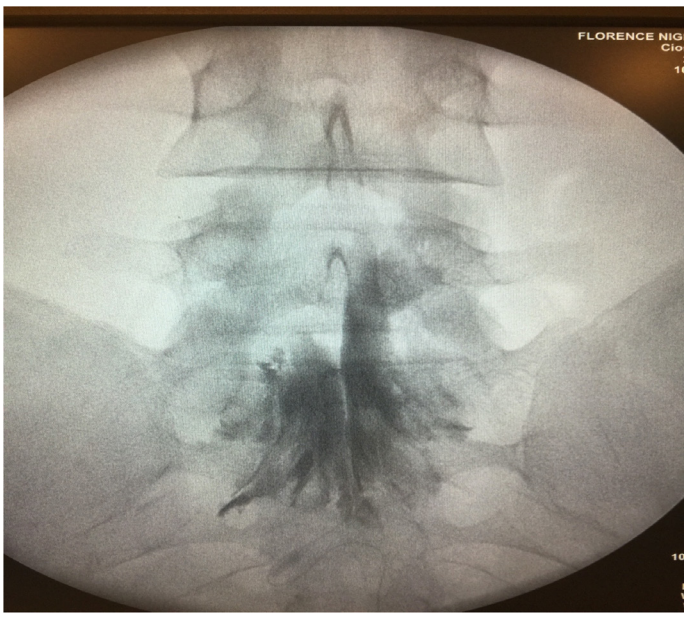

Figure 2. AP fluoroscopic view of a caudal injection
AP: Anteroposterior

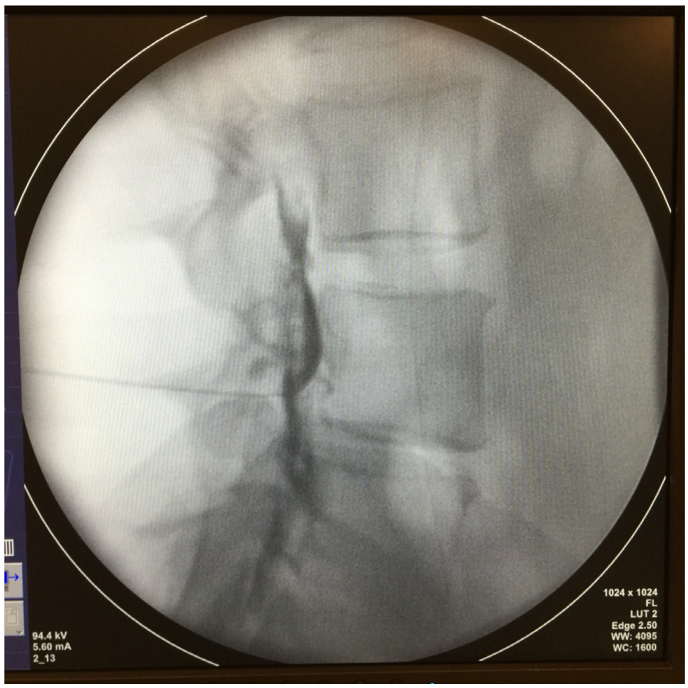

Figure 3. The lateral fluoroscopic view of a patient following caudal and transforaminal injections. Note that the contrast medium is radiated both in the neural foramen and downwards in the central canal

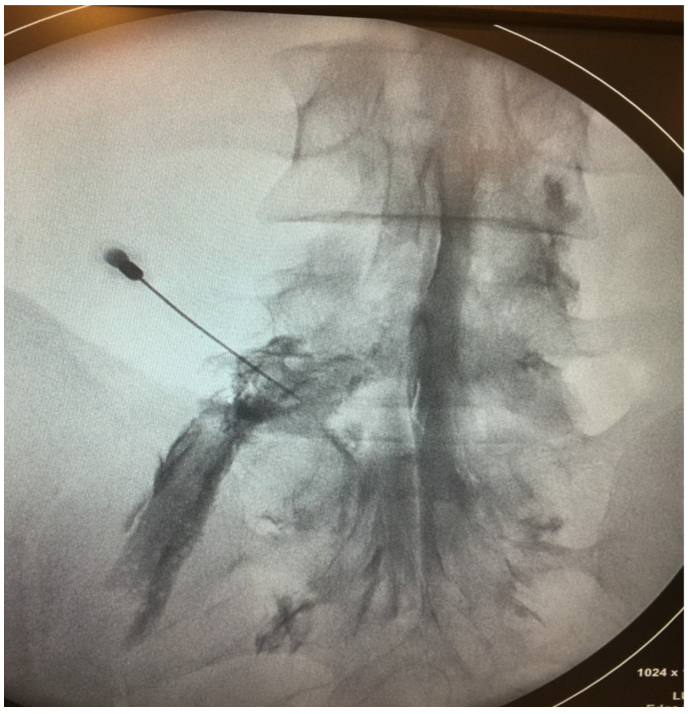

Figure 4. AP fluoroscopic view of a transforaminal injection in a patient in the combined injection group
AP: Anteroposterior

injected into the targeted areas. During the follow-up period, no caudal, interlaminar, or transforaminal epidural steroid injections were made. Pain levels were evaluated with VAS and ODI scores before the procedures as a baseline and after two weeks, three and six months, and a year. Walking distance was defined as the distance until the initiation of neurological claudication that inhibits the walking of the patient and it was specified in five categories, which is initiation between 0-50 meters, 50-150 meters, 150-350 meters, 350-750 meters, and above 750 meters.

Statistical Analysis

The normality of data distrubition was verified with Skewness and Kurtosis tests. Student's t-test was used for comparing the findings between the two groups and pairedsamples t-test for each group. Chi-square test was administered for categorical variables and the Wilcoxon signed-rank test for evaluating differences in walking distance. All statistical analyses were conducted using SPSS v20.0. A p-value of less than 0.05 was considered statistically significant.

RESULTS

According to the procedures administered, the patients were divided into two equal groups. Each group consisted of 23 female and 17 male patients (F/M: 1.35). Mean age was 58.98±6.51 years. The group in which the caudal approach was executed to the patients was named as group 1 and the group in which a combined approach was executed to the patients as group 2. Tables 1 and 2 summarize results for each group. The mean VAS score was 7.78±1.12 in group 1 and 7.78±1.14 in group 2. The mean ODI score was 38±3.6 in group 1 and 34.8±4.81 in group 2. After the procedures, the mean VAS scores at all three control examinations were 3.65±1.64, 3.38±1.41 and 3.4±1.65 in group 1 and all results showed statistical significance comparing the first evaluation ($p<0.001$ for all results). Also, the mean ODI scores were 24.55±6.25, 20.9±6.01 and 19.68±5.88 and the results had statistical significancy ($p<0.001$ for all results). When inspecting the results of group 2, similar significant findings were maintained as in group 1. The mean VAS scores were 3.35±1.37, 3±1.2 and 2.93±1.29 and the mean ODI scores were 23.3±5.09, 18.45±5.85, and 18.25±5.61 respectively (Figures 5 and 6). All results were statistically significant compared to the preoperative evaluation ($p<0.001$ for all results). The walking distances of the patients was evaluated according to the scale given above. An increase in walking distance was evaluated for each group and both group revealed a difference beginning from the first evaluation after the procedure. Distance scores of group 1 and group 2 had statistical significancy compared to the preoperative evaluation ($p<0.001$ for all results). After the last evaluation in the sixth month, 10 patients were need to have an additional injection treatment in group 1 and six patients in group 2 when individually observed that their pain improvements were unsatisfactory. Comparing the two groups, the treatment modalities did not showed a statistical significance if we consider the need for additional intervention as treatment failure ($p=0.264$).

DISCUSSION

LSS was first described by Arnoldi et al.[13] in 1976 as the narrowing of the spinal canal, nerve root canals, or intervertebral foramen. This narrowing is due to degenerative changes in the lumbar spine. These degenerative changes include hypertrophy of the ligamentum flavum and facet joints, osteophyte formation, decreased intervertebral disc height and bulging, and herniations of the lumbar disks[1,2,4,5,14-16]. LSS may remain asymptomatic or present with neurogenic claudication and/or radicular pain in affected patients. Neurogenic claudication is the most common symptom. Because of venous hypertension, ischemia in the nerve roots and neurogenic claudication occur as a result. Neurogenic claudication is defined as pain that worsens with walking and radiates to the legs. Pain is generally relieved by leaning forward and sitting[1,17-21]. Over time, the emergence of neurogenic claudication occurs at shorter distances, and vital activities are increasingly restricted[1]. The source of radicular pain in patients is usually stenosis in the lateral canal (foraminal and/or subarticular). It often presents with sciatic pain defined as low back, hip, and leg pain, and follows a dermatoma[4,14,22-26]. If a good result cannot be obtained with conservative methods in the treatment, epidural steroids and local anesthetics are administered via the caudal, interlaminar, or foraminal routes[27]. It is known that corticosteroids exert their effects by inhibiting the synthesis of a group of pro-inflammatory agents[27-29]. Local anesthetics may also help relieve symptoms in the short or long term, and they show this effect by suppressing nociceptive discharge, blocking the sympathetic reflex arc, inhibiting axonal transport of nerve fibers, and by their anti-inflammatory effects[27,30-35]. However, the recurrence of symptoms necessitated the development of new treatment modalities that can be applied before surgery. For this purpose, epidural adhesiolysis, also known as epidural neuroplasty, has been defined[36]. The treatment spectrum of epidural adhesiolysis, which was initially developed for treating epidural fibrosis secondary to surgery, expanded in time to include spinal stenosis and gained popularity[37]. Although there are various variations in this process, the technique on which it is based is the one defined by the Texas Tech Health Sciences Pain Center and was published in 1989[36]. In the original procedure, the epidural catheter had to remain in place for 3 days to administer different drugs each day. Today, however, the procedure has turned into an outpatient procedure since the catheter was withdrawn after the combination of steroids, local anesthetic, hyaluronidase, and hypertonic saline was applied[14,36,38,39]. Epidural adhesiolysis was first defined by Racz and Holubec[11] in 1989. That time the procedure have differences such as the local anesthetic dose or absence of hyaluronidase. In their study in 1994 (28 patients

Table 1. Shows characteristics and results of caudal injection group

Age	Gender	Baseline VAS	Baseline ODI	2nd week VAS	2nd week ODI	3rd month VAS	3rd month ODI	6th month VAS	6th month ODI	Additional injection
57	F	8	45	4	40	5	35	6	33	+
55	F	7	40	3	24	2	20	3	18	
60	F	6	35	3	26	3	20	2	16	
65	F	7	38	3	25	2	18	2	14	
67	M	8	37	2	14	2	12	1	12	
54	M	7	44	3	26	3	20	3	18	
64	M	6	37	2	34	5	34	4	30	+
55	F	9	42	3	24	3	18	3	18	
70	M	8	43	4	26	3	20	2	16	
68	M	9	44	3	28	3	18	3	14	
66	F	7	36	2	18	2	16	2	16	
60	M	8	40	3	17	3	15	3	15	
61	F	9	43	6	32	4	18	4	18	
64	F	6	37	7	35	5	35	7	33	+
62	F	10	42	7	28	3	28	5	28	+
56	F	9	45	6	22	6	22	6	20	+
57	F	8	33	5	20	5	18	5	18	+
54	F	7	38	4	20	4	18	5	22	+
52	F	6	39	3	30	3	20	3	16	
54	M	8	40	4	20	4	18	2	18	
53	M	9	36	5	18	3	18	3	18	
61	F	7	38	3	29	3	22	3	20	
73	M	8	38	2	19	2	14	2	14	
74	M	6	34	6	15	5	14	2	14	
48	F	8	32	1	22	1	18	1	18	
52	F	7	34	2	15	2	14	2	14	
54	M	8	38	2	20	2	18	2	16	
60	M	9	37	3	22	3	22	3	22	
59	F	7	31	4	18	4	18	2	18	
58	F	8	37	2	20	2	16	2	16	
57	F	7	36	3	26	3	22	3	22	
56	M	8	34	3	23	3	20	3	20	
55	F	7	38	4	27	4	21	4	14	
54	M	8	39	2	36	2	30	5	30	+
53	M	6	42	2	22	2	18	2	16	
52	M	9	34	3	23	3	18	3	18	
51	F	10	38	6	26	6	22	6	22	
54	F	9	36	8	36	8	36	8	36	+
61	F	9	34	4	26	4	26	5	24	+
73	M	8	36	4	30	3	26	4	22	

F: Female, M: Male, VAS: Visual analog scale score, ODI: Oswestry Disability Index

Table 2. Shows characteristics and results of combined (transformainal + caudal) injection group

Age	Gender	TFI level/ side	Baseline VAS	Baseline ODI	2nd week VAS	2nd week ODI	3rd month VAS	3rd month ODI	6th month VAS	6th month ODI	Additional injection
57	F	L1/L	7	42	4	28	3	18	3	18	
55	F	L2/L	8	38	2	24	2	16	2	14	
60	F	L2/R	7	40	2	22	2	14	3	16	
65	F	L3/R	6	32	3	23	2	17	2	14	
67	M	L3/L	7	20	2	14	2	12	2	12	
54	M	L3/L	8	42	2	22	3	18	3	18	
64	M	L3/R	9	42	2	32	3	34	3	30	+
55	F	L4/L	6	36	3	21	3	16	2	14	
70	M	L5/R	7	37	4	24	2	18	2	16	
68	M	L5/L	5	31	3	26	3	17	3	14	
66	F	L5/R	7	32	2	16	2	14	2	16	
60	M	L5/L	8	31	3	17	3	15	3	15	
61	F	L5/L	9	33	5	31	4	18	2	14	
64	F	L4/R	8	43	6	32	3	35	5	33	+
62	F	L4/R	9	34	7	27	3	20	3	14	
56	F	L3/R	8	32	5	21	4	22	3	14	
57	F	L5/R	8	28	5	20	3	16	5	18	
54	F	L4/R	9	27	4	22	4	14	3	12	
52	F	L5/L	7	30	3	28	3	18	3	16	
54	M	L5/R	6	27	3	22	4	16	2	18	
53	M	L3/R	8	35	5	18	3	18	3	18	
61	F	L3/L	8	36	3	29	3	22	3	20	
73	M	L2/R	7	34	2	19	2	14	2	14	
74	M	L2/L	8	35	4	14	3	14	2	14	
48	F	L1/R	9	37	1	22	1	18	1	18	
52	F	L2/L	6	30	2	15	2	14	2	14	
54	M	L3/R	9	40	2	20	2	18	2	16	
60	M	L3/L	8	33	3	22	3	16	3	22	
59	F	L2/R	7	31	4	18	4	18	2	18	
58	F	L1/L	9	37	2	18	2	16	2	16	
57	F	L4/L	7	36	3	26	3	14	3	22	
56	M	L4/R	8	34	3	23	3	16	3	20	
55	F	L4/L	9	40	4	27	3	14	2	14	
54	M	L5/L	8	39	2	34	2	28	5	30	+
53	M	L5/R	6	40	2	22	2	14	2	16	
52	M	L5/L	9	34	3	23	3	16	3	18	
51	F	L5/R	10	38	5	26	6	14	3	22	
54	F	L5/L	9	36	6	30	8	36	8	36	+
61	F	L4/R	9	34	4	26	4	26	5	24	+
73	M	L4/L	8	36	4	28	3	24	5	22	+

F: Female, M: Male, VAS: Visual analog scale score, ODI: Oswestry Disability Index, TFI: Transforaminal injection, R: Right, L: Left

series), Stolker et al.[40] administered only hyaluronidase to their patients without hypertonic saline solution, and they described more than 50% reduction in pain in 64% of the patients at the end of the first year. Based on this result, they argued that the main effect of adhesiolysis is through hyaluronidase. Heavner et al.[41] performed lesion-specific adhesiolysis in 59 patients with chronic intractable low back pain in their prospective randomized study and grouped the patients into four groups; 1) hyperyonic saline + hyaluronidase, 2) hypertonic saline, 3) isotonic saline, 4) isotonic saline + hyaluronidase. The need for additional interventions for pain control was found the lowest in the hypertonic saline + hyaluronidase group.

In 2004, Manchikanti et al.[42] implemented a one-day adhesiolysis protocol (targeting with epidurography) in patients with chronic low back and/or leg pain. The first of the 3 separate groups they formed was defined as the control group, and adhesiolysis was not applied. Adhesiolysis was applied to the targets determined in the second and third groups. 0.9% normal saline was given to the second group and 10% hypertonic saline to the third group. At the end of the 12-month follow-up, a 50% improvement was reported in 72% of the patients in the third group, and this rate was reported as 60% in the saline group[36]. Our study was composed of two groups. Those who had the caudal approach were included in group 1, and the patients whose fluoroscopy did not reveal any contrast passage through the foramen were placed in the combined caudal/transforaminal adhesiolysis group (group 2). A significant improvement ($p<0.001$ for all results) was observed in the walking distance of the patients in both groups, and this rate constituted 72.5% (29 patients) and 75% (30 patients) of the

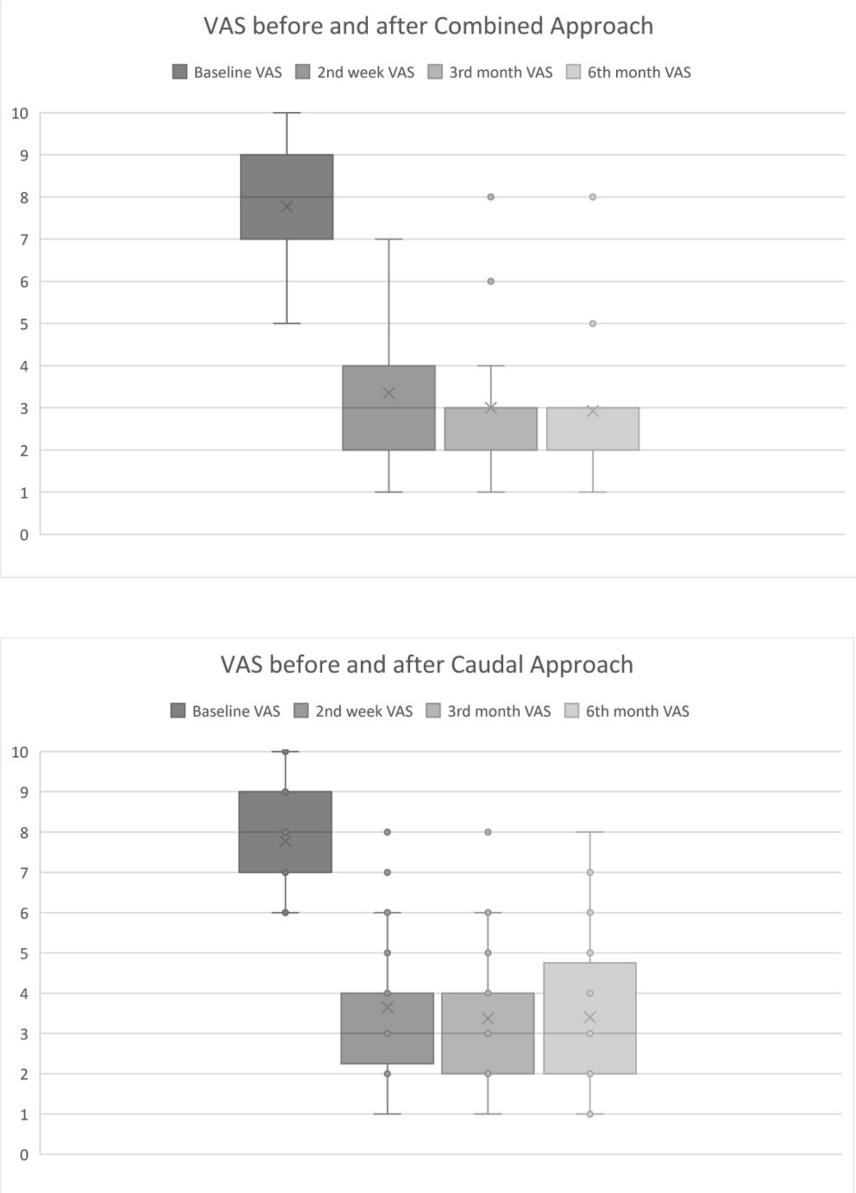

Figure 5. Graphs show changes in VAS scores before and after injection in both the caudal and combined injection groups
VAS: Visual analog scale score

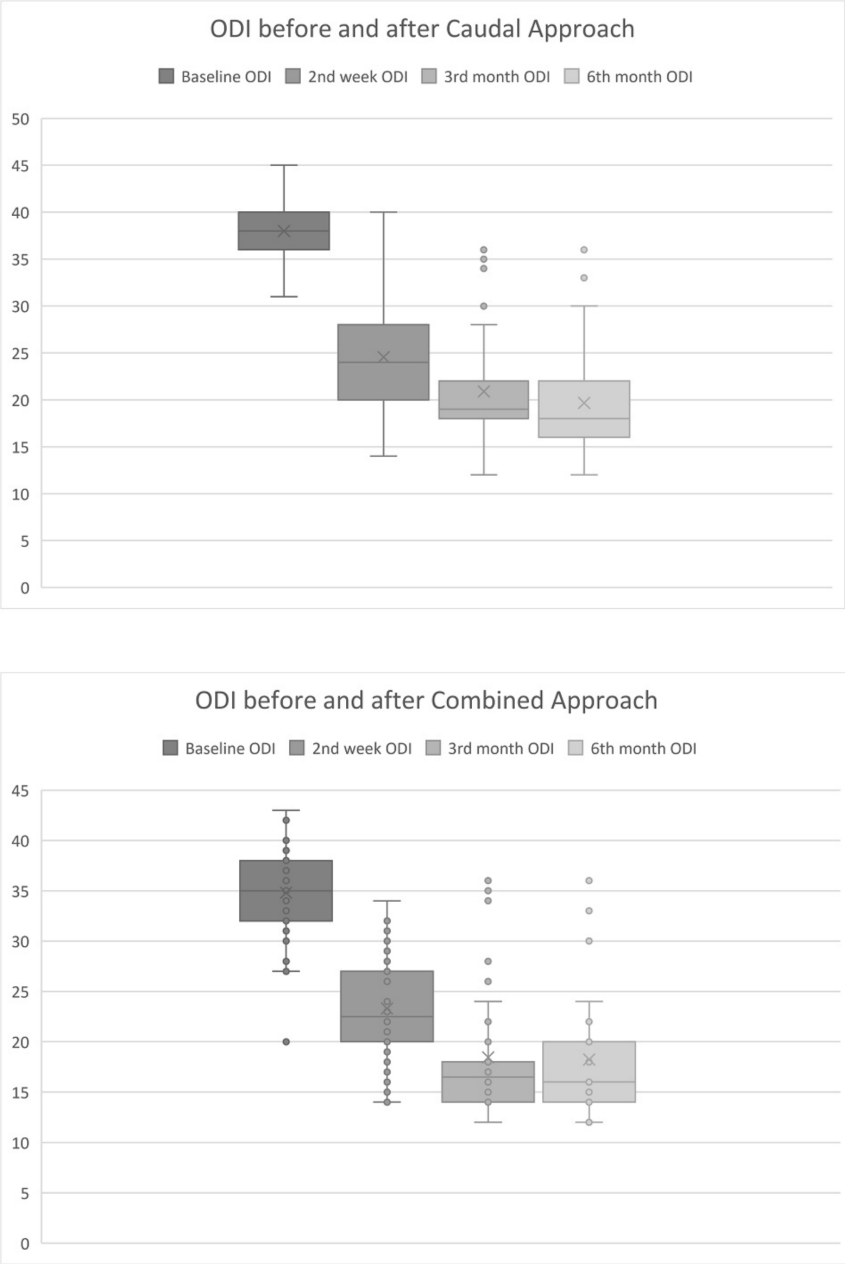

Figure 6. Graphs show changes in ODI scores before and after injection in both the caudal and combined injection groups
ODI: Oswestry Disability Index

patients in group 1 and group 2, respectively. The improvement in walking distance means that the limitations in the daily life of the patients are reduced. This was also observed in the ODI results, which inquire about personal care, sleep, social life, and traveling. The improvement in ODI values at the sixth month was 97.5% in both groups ($p<0.001$ for all results). When the duration of the symptoms is long, central stenosis becomes severe and mainly in these patients, the contrast medium does not reach the root, so the outcome after the caudal approach alone is likely to be poor[43]. Similarly, in our study, radicular pain was more prevalent in this group of patients before the procedure. However, our study design does not allow those patients to be treated with the caudal approach alone, and therefore, we did not find any significant differences between these two groups. On the other hand, although there is no statistically significant difference between those two groups, we found a tendency of recurrence and the need of an additional injection in the group 2. We consider that it is related to severe anatomical changes in these patients. Our study showed that a combined caudal and transforaminal approach may result in considerable good results in the vast majority of patients even in the presence of foraminal stenosis. As mentioned above, epidural adhesiolysis by the caudal approach is a proven and safe method that has been in use over the last three decades. It is a relatively easy technique to acquire, that enables catheter insertion and performing epiduroscopy, which gives an overall

view, assessment, and continuous treatment (if needed) option for the stenotic vertebral level. Adding transforaminal injection is always possible when necessary. Both approaches provide similar results for the control of radiating pain in case of foraminal stenosis[44]. A recent meta-analysis showed slightly better results in favor of transforaminal injection; however, the level of evidence was found to be low and therefore, transforaminal injections could be only weekly recommended over caudal injections[45]. The transforaminal injection is also a safe and efficient method in the management of radiating pain due to foraminal stenosis. However, it does not have similar effects on the pain-related central canal stenosis. In most of the patients, not an isolated foraminal or isolated central canal stenosis is encountered, it is mostly a combination of both clinical conditions. Therefore, we found it rationale to perform first a caudal injection and then adding transforaminal injection in case needed.

Study Limitations

This study has some limitations due to the study design. We do not have a control group in case of foraminal stenosis, that inhibits contrast medium passage, where the patients were treated with the caudal approach only since it is known that is associated with poor outcome. We used the caudal approach to distinguish patients with foraminal stenosis. This resulted in automatically grouped patients, and group 2 consisted of patients with some anatomical disadvantage. Therefore, the comparison between these two patient groups can be criticized by this means.

CONCLUSION

Caudal neuroplasty adhesiolysis is an effective method for treating chronic low back pain due to symptomatic LSS, and the addition of the transforaminal neuroplasty adhesiolysis to the caudal approach increases the success in cases where foraminal contrast passage is not observed in epidurography.

Ethics

Ethics Committee Approval: The study was conducted with the approval of the Demiroğlu Bilim University Ethics Committee (no: 44140529, date: 23.06.2020).
Informed Consent: An informed consent form of the procedure was obtained from all patients.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.O.A., S.Ç., Concept: M.O.A., A.A., S.Ç., Design: M.O.A., A.A., S.Ç., Data Collection or Processing: A.A., S.Ç., Analysis or Interpretation: M.O.A., A.A., S.Ç., Literature Search: M.O.A., A.A., Writing: M.O.A., A.A., S.Ç.
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REFERENCES

1. Deer TR, Kim CK, Bowman RG 2nd, Ranson MT, Yee BS. Study of percutaneous lumbar decompression and treatment algorithm for patients suffering from neurogenic claudication. Pain Physician. 2012;15:451-60.
2. Porter RW. Spinal stenosis and neurogenic claudication. Spine (Phila Pa 1976). 1996;21:2046-52.
3. Amundsen T, Weber H, Nordal HJ, Magnaes B, Abdelnoor M, Lilleås F. Lumbar spinal stenosis: conservative or surgical management?: A prospective 10-year study. Spine (Phila Pa 1976). 2000;25:1424-35.
4. Arbit E, Pannullo S. Lumbar stenosis: a clinical review. Clin Orthop Relat Res. 2001;137-43.
5. Thomas SA. Spinal stenosis: history and physical examination. Phys Med Rehabil Clin N Am. 2003;14:29-39.
6. Doorly TP, Lambing CL, Malanga GA, Maurer PM, Rashbaum RF. Algorithmic approach to the management of the patient with lumbar spinal stenosis. J Fam Pract. 2010;59:S1-8.
7. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am. 1990;72:403-8.
8. Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. N Engl J Med. 1994;331:69-73.
9. Genevay S, Atlas SJ. Lumbar spinal stenosis. Best Pract Res Clin Rheumatol. 2010;24:253-65.
10. Manchikanti L, Cash KA, McManus CD, Pampati V, Fellows B. Results of 2-year follow-up of a randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections in central spinal stenosis. Pain Physician. 2012;15:371-84.
11. Racz G, Holubec J. Lysis of adhesions in the epidural space. In: Raj P. ed. Techniques of neurolysis, Boston: Kluwer Academic; 1989;pp:57-72.
12. Akbas M, Elawamy AR, Salem HH, Fouad AZ, Abbas NA, Dagistan G. Comparison of 3 Approaches to Percutaneous Epidural Adhesiolysis and Neuroplasty in Post Lumbar Surgery Syndrome. Pain Physician. 2018;21:E501-8.
13. Arnoldi CC, Brodsky AE, Cauchoix J, Crock HV, Dommisse GF, Edgar MA, et al. Lumbar spinal stenosis and nerve root entrapment syndromes. Definition and classification. Clin Orthop Relat Res. 1976;115:4-5.
14. Park CH, Lee SH. Effectiveness of percutaneous transforaminal adhesiolysis in patients with lumbar neuroforaminal spinal stenosis. Pain Physician. 2013;16:E37-43.
15. Hasegawa T, An HS, Haughton VM, Nowicki BH. Lumbar foraminal stenosis: critical heights of the intervertebral discs and foramina. A cryomicrotome study in cadavera. J Bone Joint Surg Am. 1995;77:32-8.
16. Jenis LG, An HS. Spine update. Lumbar foraminal stenosis. Spine (Phila Pa 1976). 2000;25:389-94.
17. Rydevik B, Brown MD, Lundborg G. Pathoanatomy and pathophysiology of nerve root compression. Spine (Phila Pa 1976). 1984;9:7-15.
18. Olmarker K, Rydevik B, Holm S. Edema formation in spinal nerve roots induced by experimental, graded compression. An experimental study on the pig cauda equina with special reference to differences in effects between rapid and slow onset of compression. Spine (Phila Pa 1976). 1989;14:569-73.
19. Campbell MJ, Carreon LY, Glassman SD, McGinnis MD, Elmlinger BS. Correlation of spinal canal dimensions to efficacy of epidural steroid injection in spinal stenosis. J Spinal Disord Tech. 2007;20:168-71.

20. Grubb SA, Lipscomb HJ, Coonrad RW. Degenerative adult onset scoliosis. Spine (Phila Pa 1976). 1988;13:241-5.
21. Simotas AC. Nonoperative treatment for lumbar spinal stenosis. Clin Orthop Relat Res. 2001;384:153-61.
22. Botwin KP, Gruber RD. Lumbar spinal stenosis: anatomy and pathogenesis. Phys Med Rehabil Clin N Am. 2003;14:1-15.
23. Sirvanci M, Bhatia M, Ganiyusufoglu KA, Duran C, Tezer M, Ozturk C, et al. Degenerative lumbar spinal stenosis: correlation with Oswestry Disability Index and MR imaging. Eur Spine J. 2008;17:679-85.
24. Spivak JM. Degenerative lumbar spinal stenosis. J Bone Joint Surg Am. 1998;80:1053-66.
25. Boswell MV, Trescot AM, Datta S, Schultz DM, Hansen HC, Abdi S, et al. Interventional techniques: evidence-based practice guidelines in the management of chronic spinal pain. Pain Physician. 2007;10:7-111.
26. Vanderlinden RG. Subarticular entrapment of the dorsal root ganglion as a cause of sciatic pain. Spine (Phila Pa 1976). 1984;9:19-22.
27. Manchikanti L, Cash KA, McManus CD, Pampati V. Assessment of effectiveness of percutaneous adhesiolysis in managing chronic low back pain secondary to lumbar central spinal canal stenosis. Int J Med Sci. 2013;10:50-9.
28. Byröd G, Otani K, Brisby H, Rydevik B, Olmarker K. Methylprednisolone reduces the early vascular permeability increase in spinal nerve roots induced by epidural nucleus pulposus application. J Orthop Res. 2000;18:983-7.
29. Lee HM, Weinstein JN, Meller ST, Hayashi N, Spratt KF, Gebhart GF. The role of steroids and their effects on phospholipase A2. An animal model of radiculopathy. Spine (Phila Pa 1976). 1998;23:1191-6.
30. Pasqualucci A, Varrassi G, Braschi A, Peduto VA, Brunelli A, Marinangeli F, et al. Epidural local anesthetic plus corticosteroid for the treatment of cervical brachial radicular pain: single injection versus continuous infusion. Clin J Pain. 2007;23:551-7.
31. Ji RR, Woolf CJ. Neuronal plasticity and signal transduction in nociceptive neurons: implications for the initiation and maintenance of pathological pain. Neurobiol Dis. 2001;8:1-10.
32. Pasqualucci A. Experimental and clinical studies about the preemptive analgesia with local anesthetics. Possible reasons of the failure. Minerva Anestesiol. 1998;64:445-57.
33. Arnér S, Lindblom U, Meyerson BA, Molander C. Prolonged relief of neuralgia after regional anesthetic blocks. A call for further experimental and systematic clinical studies. Pain. 1990;43:287-97.
34. Lavoie PA, Khazen T, Filion PR. Mechanisms of the inhibition of fast axonal transport by local anesthetics. Neuropharmacology. 1989;28:175-81.
35. Cassuto J, Sinclair R, Bonderovic M. Anti-inflammatory properties of local anesthetics and their present and potential clinical implications. Acta Anaesthesiol Scand. 2006;50:265-82.
36. Lee F, Jamison DE, Hurley RW, Cohen SP. Epidural lysis of adhesions. Korean J Pain. 2014;27:3-15.
37. Day M, Racz G. Technique of caudal neuroplasty. Pain Digest. 1999;9:255-7.
38. Racz GB, Heavner JE, Diede JH. Lysis of epidural adhesions utilizing the epidural approach. In: Interventional pain management. Waldman SD, Winnie AP (Eds.). WB Saunders, Philadelphia (PA). 1996;pp:339-51.
39. Manchikanti L, Pakanati RR, Bakhit CE, Pampati V. Role of adhesiolysis and hypertonic saline neurolysis in management of low back pain: evaluation of modification of the Racz protocol. Pain Dig. 1999;9:91-6.
40. Stolker RJ, Vervest ACM, Groen GJ. The management of chronic spinal pain by blockades: a review. Pain. 1994;58:1-20.
41. Heavner JE, Racz GB, Raj P. Percutaneous epidural neuroplasty: prospective evaluation of 0.9% NaCl versus 10% NaCl with or without hyaluronidase. Reg Anesth Pain Med. 1999;24:202-7.
42. Manchikanti L, Rivera JJ, Pampati V, Damron KS, McManus CD, Brandon DE, et al. One day lumbar epidural adhesiolysis and hypertonic saline neurolysis in treatment of chronic low back pain: a randomized, double-blind trial. Pain Physician. 2004;7:177-86.
43. Kim JY, Yang S, Kim D, Park Y, Kim YH. Correlation Between the Extent of Injectate Spread and Clinical Outcomes in Cervical Interlaminar Epidural Injection. Pain Physician. 2022;25:E1229-38.
44. Kim HJ, Rim BC, Lim JW, Park NK, Kang TW, Sohn MK, et al. Efficacy of epidural neuroplasty versus transforaminal epidural steroid injection for the radiating pain caused by a herniated lumbar disc. Ann Rehabil Med. 2013;37:824-31.
45. Lee JH, Shin KH, Bahk SJ, Lee GJ, Kim DH, Lee CH, et al. Comparison of clinical efficacy of transforaminal and caudal epidural steroid injection in lumbar and lumbosacral disc herniation: A systematic review and meta-analysis. Spine J. 2018;18:2343-53.