Pain Medicine

Pain Medicine 2011; 12: 45–50
Wiley Periodicals, Inc.

Preliminary Research Report

Radiculopathy in Degenerative Lumbar Scoliosis: Correlation of Stenosis with Relief from Selective Nerve Root Steroid Injections

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Abstract

Objective. The purpose is to define the origin of radiculopathy of patients with degenerative lumbar scoliosis-stenosis and to assess the correlation between percentage of initial radicular leg pain relief with selective nerve root injections and lateral canal dimensions.

Design. Retrospective clinical study.

Setting and Patients. Thirty-six consecutive patients (average age 72) from Twin Cities Spine Center with degenerative lumbar scoliosis (average major curve 25°) and radicular symptoms were studied.

Interventions. Patients underwent 46 selective steroid injections of nerve roots concordant with clinical symptomatology.

Outcome Measures. Radiographic measurements included major and lumbosacral curve Cobb angle. Computerized measurements of magnetic resonance imaging (MRI) included minimum subarticular height and foramen cross-sectional area of the nerve roots that were injected. Initial response from the nerve root injections was also rated.

Results. Twenty-five percent of nerve root symptoms were coming from the major curve, 72.2% from the lumbosacral hemicurve and 2.8% from both ($P < 0.001$). The affected nerve roots were more frequently the L4 (34.8%) and L5 (28.3%) nerve roots. A total of 71.7% of radicular symptoms were originating from the concavity of the curve and 28.7% from the convexity ($P < 0.001$). The relief from injections was more than 50% in 75% of the patients at 15 days postinjection. There was no statistical significant correlation ($P > 0.05$) between the lateral canal dimensions and the initial response to injection of anesthetic plus steroid injection.

Conclusions. In degenerative lumbar scoliotic curves, radicular symptoms are attributed mainly to nerve roots exiting from the concavity of the lumbosacral hemicurve. No evidence was found that the rate of initial relief from selective nerve root injections correlates with the degree of stenosis noted in the MRI.

Key Words. Selective Nerve Root Injections; Transforaminal; Steroid; Scoliosis; Stenosis

Introduction

Lumbar spinal stenosis is a common problem in the older adult population. It is defined as a pathologic condition in which the neural elements are compressed by bone, soft tissue, or both resulting in ischemia of nerve roots [1]. It is distinguished in central stenosis, when there is abnormal narrowing of the spinal canal, and lateral stenosis, when there is lateral recess (subarticular stenosis) or foraminal narrowing (foraminal stenosis) [2]. Symptoms of neurogenic claudication and radiculopathy predominate. Frequently, it is accompanied by degenerative listhesis and degenerative scoliosis. The adjuvant scoliosis complicates neural compression and makes surgical treatment more difficult [3].

An aggressive nonoperative treatment consisting of therapeutic exercise, analgesics, and epidural steroid injections is proposed for patients with degenerative lumbar spinal stenosis [4]. In a randomized prospective study to assess the efficacy of epidural steroids injections vs intramuscular steroid and anesthetic for patients with lumbar stenosis, it was found that even though there was a significant reduction of pain in the short-term, the long-term results did not show any difference in the number of patients that needed surgery [5]. The evidence for lumbar transforaminal epidural steroid injections in managing lumbar radicular pain is strong for short-term and moderate for long-term relief [6–8].

Cooper et al. [9] concluded that fluoroscopic transforaminal epidural steroid injections appear to be an effective nonsurgical treatment option for patients with degenerative lumbar scoliotic stenosis and radiculopathy and should be considered before surgical intervention. However, there is no study correlating radiographic measurements of the nerve root canal stenosis with the relief from the steroids injections. The current study aims to define the origin of radiculopathy in patients with degenerative lumbar scoliotic stenosis and to assess the correlation between percentage of radicular leg pain relief with selective nerve root injections and lateral canal dimensions.

Methods

We retrospectively reviewed 36 consecutive patients (average age 72 years) with the diagnosis of degenerative lumbar scoliosis (Cobb angle > 10°) who met the inclusion and exclusion criteria. Inclusion criteria consisted of:

- Age > 40 years at time of presentation
- Presenting symptomatology of radicular leg pain that necessitated nerve root steroid injection
- Lumbar spine magnetic resonance imaging (MRI) available within 12 months from injection

Patients were excluded for any of the following reasons:

- Back or buttock pain only, cauda equina.
- First sacral nerve root symptomatology.
- Indication of extraforaminal stenosis.
- Previous lumbar spine surgery.
- Spondylolysis or spondylolytic spondylolisthesis.
- Arterial insufficiency in the legs.
- Polyneuropathy.
- Recent spinal trauma or fracture.
- Presence of malignancies.
- Severe rheumatic disease.
- Spinal infection.
- Prior steroid injection within last 3 months.
- Blood coagulation disorder or previous allergic reaction to local anesthetics or corticosteroids.

All 36 patients continued to receive care in our clinic for at least 2 years after their injection. All cases of decompressive lumbar surgery were documented. Patient's charts were reviewed and the clinical presentation of radiculopathy was documented as specific nerve root involvement. The symptomatic nerve roots were determined by pain distribution, neurological findings and immediate resolution of symptoms by selective nerve root anesthetic-steroid injection. In the neurological findings, the L3 sensory area was the lower anterior thigh; L4 area was posterolateral thigh, anterior knee and medial leg; L5 area was anterolateral leg, dorsum of the foot and great toe; S1 area was lateral malleolus, lateral foot, heel, and web of

Figure 1 Anteroposterior radiograph of a patient with degenerative scoliosis and L4 radicular symptoms.

the fourth and fifth toes. The muscle that was controlled by L3 was quadriceps; L4, quadriceps and tibialis anterior; L5, extensor hallucis longus and extensor digitorum longus and brevis; S1, peroneus longus and the brevis, gastrocnemius-soleus complex [10]. Also, the location of exiting nerve root in regard to the concavity or convexity of the major lumbar or compensatory lumbosacral scoliotic curve was added. All patients had both full spine standing plain radiographs and MRI of the lumbar spine within 12 months of presentation.

Anteroposterior standing radiographs were assessed for lumbar and lumbosacral curve Cobb angles (Figure 1). All MRIs were obtained with a consistent protocol at one center, with at least 3 mm cuts. Computerized measurements of MRI included the subarticular height (Figure 2a) in the axial plane T2 sequence. In the sagittal plane, the foramen cross-sectional area (Figure 2b) was measured in T1 sequence. The subarticular height and the foraminal area measurements were done on the same side of radicular symptomatology. The cut within which the aforementioned parameters were measured was selected on the basis of minimum dimension. Measurements were conducted twice in each lumbar level and the average was recorded and analyzed. All radiographic measurements were conducted by one reviewer (AP, spine fellow) under the directions of the radiologist (TG).

Stenosis of the lateral recess was defined as subarticular height less than 2 mm [11]. Foraminal stenosis was

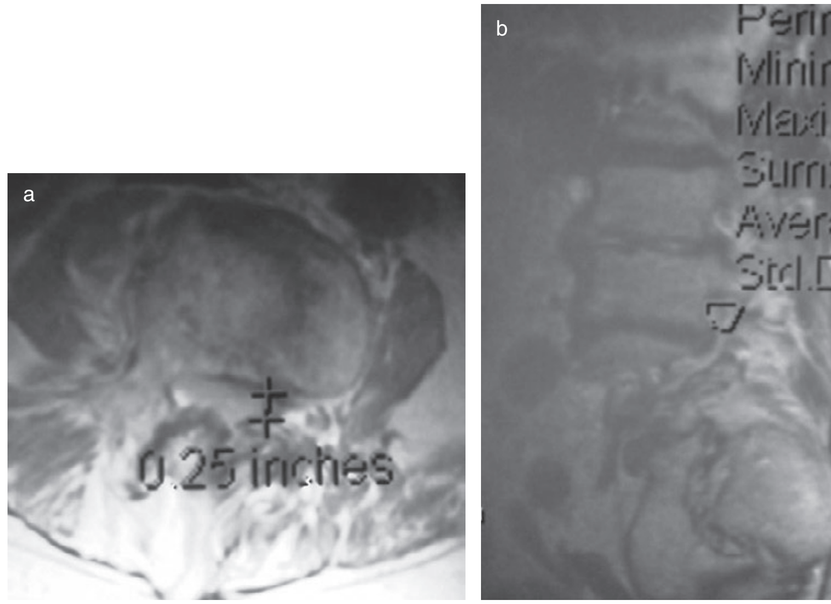

Figure 2 (a) Measurement of L4–L5 subarticular height in a T-2 sequence magnetic resonance imaging (MRI) cut of a patient with degenerative lumbar scoliosis. (b) Measurement of L4–L5 foraminal area in a T-1 sequence MRI cut of a patient with degenerative lumbar scoliosis. The perineural fat around L5 nerve root is obscured.

defined as less than mean minus 2.5 SD of measurements published by Stephens et al. [12] on a healthy, normal population control group, i.e., L5 root foramen < 27 mm^2, L4 root foramen < 45 mm^2, L3 foramen < 59 mm^2, and <61 mm^2 for L2 nerve root foramen.

All patients received a transforaminal selective nerve root steroid injection under fluoroscopic guidance (Figure 3). After the usual sterile prep, drape, and local anesthesia, a 22-gauge, 3.5-in. spinal needle was advanced to the corresponding transverse process, then redirected 1 cm inferior and anterior. Then, the spinal needle was advanced in the so-called "safe triangle" area (composed of a roof made up by the pedicle, a tangential base that corresponds to the exiting nerve root and a side that is made by the lateral border of the vertebral body). Both anterior-posterior and lateral fluoroscopic projections confirmed proper needle placement. On the lateral view, the needle is positioned just below to the pedicle in the ventral aspect of the intervertebral foramen. On the anterior-posterior view, the needle is placed just beneath the midportion of the corresponding pedicle. At each level, 1 to 2 mL of contrast (Omnipaque 240, Amersham Health, Arlington Heights, IL, USA) was injected, and results of the epidurogram and pain provocation response were recorded. If there was no dye flow marking the corresponding nerve root, the needle was repositioned. Once adequate flow of contrast to the target area was documented, 1 mL (6 mg) of betamethasone (Celestone Soluspan, Schering Corporation, Kenilworth, NJ, USA) and 1 mL of 2% lidocaine (preservative free) were injected.

Data collection was performed immediately postinjection (within an hour from injection) and after an interval of approximately 2 weeks. The pain data were reported as percentiles of pain relief after injection. The pain relief was correlated with the unilateral canal dimensions, i.e., the foraminal area at the same level of injection and the subarticular height at the level above.

Statistical Evaluation

Statistical analysis was performed with SPSS 10.0, Chicago, IL, USA. Data were presented as

Figure 3 Fluoroscopic image showing the infiltration of nerve root in the concavity of the lumbosacral hemicurve during L5 selective nerve root injection of the patient in Figure 1.

mean ± standard error. Bivariate correlations were tested using Spearmann's non-parametric correlation as the data was not normally distributed. Comparisons between subgroups in regard of origin of symptomatology and stenosis measurements were tested using Student's *t*-test. All statistical tests were conducted at a 0.05 significance level (*P* value).

Results

Radiographic Measurements of Scoliotic Curve

The average Cobb angle of major curve and lumbosacral curve was 24.8 ± 1.4 and 12.2 ± 0.9, respectively. The average lateral translation at the level with maximum rotatory olisthesis was 6.2 ± 0.5 mm.

Origin of Symptomatology Based on Nerve Root Identification by Clinical Findings

Forty-six injections were performed in 36 patients. In 10 patients, a second injection of a different nerve root was conducted with an interval of at least 3 months between successive injections. In 30 (65.2%) cases the injected nerve root was below the major curve and in 16 (34.8%) cases within the major curve.

L5 nerve root was injected 13 (28.3%) times, L4 16 (34.8%) times, L3 11 (23.9%), times injections, and L2 6 (13%) times.

Thirteen (28.3%) injections were performed in nerve roots exiting within the convexity of the curves while the rest 33 (71.7%) injections were done within the concavity of the curves.

Relief from Selective Nerve Root Injections

The immediate (within first hour) postinjection relief was more than 50% in all cases, indication of correct identification of symptomatic nerve root, and averaged 83.4 ± 2.7. The average relief at 15 days from injection was 70.7 ± 4.8 and ranged between no relief to 100%. Nine patients (25%) rated the injection's efficacy as less than 50% relief at 2 weeks postinjection.

Fourteen patients (38.9%) underwent surgery from 1 month to 2 years following injection. Six of those patients had a double nerve root involvement that necessitated injection. I of them, the injection relief at 2 weeks was rated less than 50%.

Dimensions of Lateral Canal Dimensions in MRI

The average subarticular height and the average foraminal area of the injected nerve roots were 3.32 ± 0.24 and 95.97 ± 6.50 mm^2, respectively. According to the criteria of subarticular height stenosis by Ciric (defined as less than 2 mm) [11], stenosis was found in 13 (28.26%) cases, i.e., 2 out of 13 L5 cases, 7 out of 16 L4 cases, 4 out of 13 L3 cases and none out of 6 L2 cases. Similarly and for foraminal canal area, stenosis was measured in none out of 13 L5 cases, 3 out of 16 L4 cases, 2 out of 13 L3 cases and 1 out of 6 L2 cases. In total, 6 (13.04%) cases were accompanied by foraminal stenosis and this type of stenosis was borderline significantly less common ($P = 0.05$) than in the subarticular region. In 3 cases, there was both subarticular and foraminal stenosis.

Related to the concavity or convexity of the curve, stenosis was more commonly found ($P < 0.001$) in the concavity of the curve both at subarticular and foraminal area.

Related to the curve site (either within major or within lumbosacral curve), both subarticular height and foraminal area stenosis were detected more often ($P < 0.001$) within the lumbosacral curve.

Correlation of Relief from Steroid Injections and Lateral Canal Dimensions

There was no significant correlation ($P < 0.05$) between subarticular height or foraminal area and the relief from selective nerve root steroid injection of the respective nerve root at two weeks postinjection.

Discussion

It is known that the evidence for short-term (less than 6 weeks) leg pain relief following transforaminal selective nerve root steroid injections in the lumbar spine is strong [6]. The present study was undertaken to define exact source of radicular symptoms within curvature of patients with degenerative scoliosis-stenosis and the correlation between dimensions of lateral canal stenosis and degree of relief from selective transforaminal nerve root injections. Most of the radicular symptoms were attributed to L3, L4 or L5 nerve roots exiting from the concavity of the lumbosacral curve below the major scoliotic curve. However, there was no correlation between the degree of lateral canal stenosis and the short-term pain relief.

Radicular symptoms from nerve root inflammation in degenerative scoliosis patients are more commonly originating in the ventral epidural space at the lateral recess next to the disc and at the exit zone of nerve roots [13]. Transforaminal epidural steroid injections selectively target nerve root that are symptomatic [5,14]. In an area of pathology, injectates are likely to avoid the inflamed site and seek normal tissue that offers little resistance. One solution to this problem is to inject directly into or close to the inflamed site [15]. "Blind" (without fluoroscopy guidance) interlaminar epidural injections reach ventral epidural space only 25 to 31% at the time [16]. Fluoroscopically-guided interlaminar epidural injections will often (64%) fail to reach the ventral epidural space with 84% of injections appeared to result in unilateral flow of contrast [17,18]. In a cadaveric study of injecting a scoliotic cadaver spine with pigmented suspensions by the interlaminar and transforaminal routes, transforaminal injection demonstrated limited spread in the lateral dimension but more spread ventrally compared with interlaminar route. Thus, in our study, the contrast flow within the sheath of nerve root by transforaminal selective nerve root injections proved to be an accurate injection technique.

There are multiple mechanisms of action of pain relief for corticosteroids. These include the inhibition of nerve root edema with improved microcirculation and reduced ischemia, inhibition of prostaglandin synthesis, and also the noninflammatory action of direct inhibition of C-fiber neuronal membrane excitation [19,20]. Duration of steroid action disseminate with time and at 3 weeks postinjection does not have any difference compared with placebo [21]. In our study, efficacy of injections was determined on patient's relief at 2 weeks following injection.

Ciric et al. in retrospective studies of patients proved to have lateral recess stenosis, proved radiographically that when the height of the lateral recess is less than 2 mm the diagnosis of lateral recess stenosis is established [11]. In foraminal morphometric studies of cadaveric spines, it was found that the foramen have variable size between 40 and 160 mm^2 and the normal limits of foraminal cross-sectional area in the sagittal plane were defined [12]. In this study, the spinal canal measurements were chosen to be done in MRI due to the ability of MRI to distinguish the pathology of soft tissue or bone better than CT and less invasiveness and radiation of MRI [3]. Because of the variable rotation and angulation of the lumbar spine, the more reliable measurement of confinement of the structures that pass through the foramen is the minimum cross sectional foraminal area rather than the foraminal height or AP diameter [22]. Subarticular stenosis was found more frequently than foraminal stenosis in our study; however, the total percentage was low compared with the total number of nerve roots affected. This might be explained by the kinking or stretching of symptomatic nerve roots at levels with increased rotatory olisthesis in scoliotic spines [23].

In DLS, it is known that the curve of scoliosis normally ranges from T12 or L1 to L3 or L4 [24]. There is often a short compensatory curve from L3 or L4 to the S1 level. The lower end vertebra (L3 or L4 vertebra) is markedly tilted and a more lateral slip as well as pedicular download are observed [25,26]. Liu et al. [27], in their study of patients with degenerative lumbar scoliosis and stenosis, concluded that L3 and L4 nerve roots are compressed in the foramen or extraforaminally on the concave side of the main curve, whereas the L5 and S1 roots are affected more by lateral recess stenosis at the convex of the lumbosacral fractional curve. But their decision on subarticular or foraminal stenosis was based on imaging findings and not on detailed measurements in the MRI or CT. In our study, the accuracy of stenosis definition was validated by measurements of the injected nerve roots both at the exit zone-foraminal area as well as at the lateral recess one level above where the nerve root originates from the sac. Stenosis was more evident in nerve roots exiting at the concavity of the lumbosacral curve.

In a study comparing lumbar spine canal dimensions with CT between patients with spinal stenosis who underwent decompressive surgery after failure of epidural injection and those who had successful ESI, there was no statistically significant difference in the ratio between the minimum and maximum measurement in any dimension between the surgical and the nonsurgical group [28]. In an MRI study of scoliotic spines, foraminal cross-sectional area enlarges in the convexity and does not decrease in the concavity with increased segmental Cobb angle [23]. In our study of patients with degenerative lumbar scoliosis, radicular symptoms were more commonly originating from nerve roots passing through the concavity of the lumbosacral hemicurve. The degree of relief from transforaminal steroid injections did not correlate with the lateral canal dimensions.

Limitation to our study is that the origin of symptoms is defined by clinical examination together by the successful immediate postinjection pain relief and not by more objective tests, like electromyographic study. However, electromyographic studies can be diagnostic only when there is moderate to severe nerve injury [29]. Another limitation is the short follow-up of injection response. It is known that the action of corticosteroids reaches maximum within the first 2 weeks [21] and, thus, the reported correlation of efficacy of injections and lateral canal dimensions was at this time point.

Conclusions

The clinical symptomatology of radicular pain is originating mainly from the nerve roots coursing toward the concavity of the lumbosacral hemicurve. Selective nerve root injections are successful in the short term and should be performed independently of the degree of MRI stenosis.

Acknowledgments

We thank Jill Wroblewski, MS and Carrie Gustafson, MS for their help in statistical analysis of the data.

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