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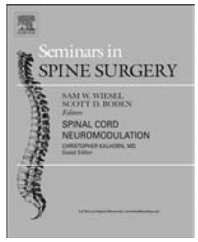

Spinal stenosis and spondylolisthesis

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A B S T R A C T

Degenerative lumbar spinal stenosis (LSS) and lumbar spondylolisthesis (DS) can lead to significant disability and impaired quality of life. In select patients with predominantly leg-dominant symptoms that have exhausted nonoperative treatment, surgical treatment can provide significant improvement in symptoms. The present paper reviews the clinical evaluation, radiographic findings, and surgical decision making of both spinal stenosis and degenerative spondylolisthesis using the current best available evidence.

1. Introduction

Degenerative lumbar spinal stenosis (LSS) and degenerative lumbar spondylolisthesis (DS) are major causes of disability and decreased quality of life in the aging population. Although the etiologies of these conditions are very different, their effect on patients' quality of life is similar. Patients with either condition often present to their physicians with complaints of activity-related back pain, leg pain or weakness. They also may report radicular pain, muscle weakness, altered gait, and bowel or bladder dysfunction.

LSS occurs when there is decreased space in the spinal canal, leading to compression of vascular and neural elements. Most often this is caused by age-related degenerative changes to the spinal canal. The normally plump intervertebral disc dries out and thins with aging. This creates a loss of disc height and a change in the biomechanics of the spine. There is increased stress on posterior elements of the spine, specifically the facet joints, which in turn become hypertrophied, accelerates osteophyte formation, and causes ligamentum flavum in folding and hypertrophy.[1] These changes occur at varying degrees during the course of the condition, but the end result is a narrowing of the spinal canal.

DS represents a complex and multifactorial condition in which there is an acquired anterior slip/ displacement of one vertebral body on another. Usually occurring in patients older than 40 and at the L4/L5 level, this displacement causes a functional narrowing of the spinal canal with symptoms similar to LSS. The exact cause of this condition is not well elucidated but is often attributed to patient anatomic and genetic factors. Major anatomical culprits include ligamentous laxity, disc pathology, facet joint arthrosis, and hormonal factors. Estrogen is believed to have at least some part in the development of DS as evidenced by the high prevalence of females with this condition; numerous studies have linked the association between estrogen receptor activation and location and DS.[2–5]

As both of these conditions have considerable morbidity and negatively impact health-related quality of life, much research has been performed to identify the optimal treatment for each condition. Recent data has provided insight into the utility of spinal fusion in these cases. This paper will provide an evidence-based update on the current treatments and recommendations for LSS and DS.

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2. Clinical evaluation

Patients with LSS or DS often exhibit overlapping features with vascular claudication so it is imperative to perform a thorough history and physical examination to differentiate the two conditions. Patients with spinal stenosis note postural alleviation of symptoms, unlike those with vascular claudication. Patients suffering from both illnesses report a diminished capacity to walk, with a pain distribution commonly in the buttock, thigh and calf region. Patients with neurogenic claudication are often flexed forward as the cross-sectional area of the spinal canal is increased in this position, often maintaining this flexed posture as a palliative measure with ambulation. Patients with vascular claudication are unable to alter their walking ability with changes in posture as the pathology is related to the increased blood requirements with increase in activity. Physical assessment includes meticulous strength and gait testing, as well as thorough evaluation of the skin of the lower extremities.

3. Radiographic findings

In most instances radiographic evaluation begins with upright radiographs of the lumbar spine. Standing AP and lateral views of the spine can provide valuable information such as presence of deformity, spondylolisthesis, significant osteophytes, subchondral sclerosis, and facet hypertrophy.[6] Lateral flexion and extension radiographs are obtained to determine the presence of a mobile spondylolisthesis as static images such as an MRI can miss them.[7] Currently there is no consensus regarding radiographic evaluation of instability of spondylolisthesis, but many surgeons use motion greater than 3 mm as measured on flexion-extension radiographs as a sign of instability.[8] In evaluation of the spinal canal advanced imaging techniques such as CT, CT myelogram and MRI are indicated. An MRI is often the preferred test for evaluating spinal stenosis because it best shows herniation or degeneration of the discs, ligamentum flavum hypertrophy and/ or buckling, narrowing of the central canal and lateral recess. Schinnerer et al. was able to show that the presence of fluid in the facets on T2 weighted images likely indicates instability.[9] Although many researchers have attempted to assess the severity of stenosis based upon radiographic parameters, there currently is no universally accepted classification system.[10] This potentially complicates ideal treatment algorithms for patients with LSS and DS and limits a clinician's ability to primarily Level 4 and 5 evidence, case series and expert opinion respectively.

4. Surgical indications, decision making, and techniques

After patients have exhausted nonoperative measures such as physical therapy, activity modification, steroid injections and medications, surgical treatment should be considered. In select patients with LSS or DS and primarily leg-dominant symptoms, surgical treatment may result in long-term resolution of symptoms.[11] Numerous factors must be considered when deciding the optimal surgical procedure in these patients. The following section provides rationale and evidence for aiding the surgeon in selecting the optimal treatment for patients.

After exhausting conservative treatment options, the ideal patient for surgical intervention in the setting of spinal stenosis has predominantly leg symptoms in the setting of neurogenic claudication.[12] Also those patients who received a transforaminal epidural steroid injection (TFESI), and had greater than fifty percent of pain relief for one week were reported to have higher probability of leg relief following surgical decompression.[13]

The current standard of care for the treatment of LSS is the use of a facet sparing decompressive laminectomy for those patients with radiographically-proven stenosis in the central, lateral recess, and foraminal regions.[14] Historically surgeons, out of fear of destabilizing the spine, have performed fusions when complete laminectomies are required, particularly in multilevel stenosis.[15] This practice came into question because additional fusion levels did not come without risks.[16] Additional fusion levels significantly prolong operative times, increase surgical morbidity, hospital stays, and postoperative complications. Sub-analyses of Spine Patient Outcomes Research Trial (SPORT) data concluded that fusion may not be necessary in those patients with less than four millimeters of translation as evidenced on dynamic radiographs.[16] Another study investigated risk factors for slip progression in a single population and noted that facets oriented in the sagittal plane, lack of disc height, and MRI findings of fluid in facet joints all increased risk of slip progression.[17]

Recently there has been much debate about the necessity of fusion for spinal stenosis with or without spondylolisthesis given two recent Level 1 contrasting studies both published in the New England Journal of Medicine.[18,19] Försth et al. performed a randomized controlled trial in Sweden in which patients with lumbar spinal stenosis with or without spondylolisthesis were randomly assigned to either surgical decompression or decompression and fusion from 2006–2012.[18] Patients ranging in ages from 50–80 years with symptoms of neurogenic claudication lasting greater than 6 months, and MRI findings consistent with LSS, were eligible for enrollment. The types of decompression or fusion were left up to the surgeon performing the intervention. In total 113 patients underwent decompression and fusion, and 120 patients underwent decompression alone. Two patients from the fusion group and 3 patients from the decompression group were lost to follow up. Outcomes at two years were analyzed and demonstrated no statistical difference between the ODI of the two groups ($p = 0.24$). At 2 years ODI scores had decreased from baseline in both groups as well ($p = 0.36$). A subgroup analysis was performed comparing only patients with a 7.4 mm spondylolisthesis or more who underwent each intervention. There were 35 patients in the decompression plus fusion group, and 32 patients in the decompression alone group. Comparison of ODIs and VASs between each group were not significant, ($p = 0.98$) and ($p = 0.55$) respectively. In analysis of the 5 year data the results continued to show no difference between the two groups in regards to ODI, ($p = 0.086$). There was a 22% reoperation rate in the fusion group, as compared to a 21% rate in the decompression alone group. The authors concluded that in patients with LSS with or without degenerative spondylolisthesis

that decompression with fusion was not superior in terms of clinical outcomes as compared to decompression alone. Further, the decompression and fusion group incurred an additional $6800 increase in cost per procedure.

This study is contrasted to a recently published American randomized controlled trial. Ghogawala et al. , attempted to compare the effectiveness of decompression and fusion versus decompression alone in patients with symptomatic grade 1 spondylolisthesis.[19] Patients eligible for enrollment were aged 50–80, had symptomatic degenerative spondylolisthesis (3–14 mm), and were randomized to either decompression alone, or decompression and fusion groups. 66 patients underwent randomization, with 28 patients being assigned to undergo decompression and fusion and 29 to undergo decompression alone. Important to note, unlike the Swedish study, the surgical procedures were standardized, the patients undergoing decompression received a complete laminectomy with partial removal of medial facets. In those patients receiving a fusion, iliac crest bone autograft was harvested and titanium alloy rods were used across the level of the listhesis. The primary outcome measurement of this study was a change in SF-36 physical component summary score 2 years after surgery. Baseline SF-36 in decompression alone versus fusion was 34.7 versus 31.5, respectively. The authors reported a statistically significant change in SF-36 scores between the two groups, with an increase of 9.5 in decompression group, and an increase of 15.2 in decompression and fusion, (p = 0.046). This treatment effect was maintained throughout the duration of the study (4 years). ODI scores were also measured and demonstrated a reduction in both groups, 7.9 for decompression alone compared to 26.3, these differences were not significant, (p = 0.06). Baseline level ODIs were 36.3–38.8, decompression alone and fusion rates respectively. However, at the 4-year mark the values did become significant with a reduction of 14.7 in decompression alone versus a 23.7 in decompression plus fusion group, (p = 0.05). It should be noted that 30% of the patients were lost to follow up at this point. It was also noted that those patients undergoing fusion had higher hospital costs, blood loss, and length of stay. The authors also noted higher rates of revisions on those patients who underwent decompression alone as compared to fusion, 34% versus 14% respectively. Thus the authors concluded that patients with LSS and mobile degenerative grade 1 spondylolisthesis may be best treated with decompression and fusion, though Ghogawala does mention that the cost-benefit with the addition of fusion is questionable given the marginal benefit.

The official recommendations of the North American Spine Society (NASS) currently note that for symptomatic single level grade 1 (<20%) spondylolisthesis without lateral foraminal stenosis that decompression is equivalent to decompression and fusion, level of evidence B.

5. SPORT data at 8-year follow-up

The largest and most comprehensive study of its kind, the Spine Patient Outcomes Research Trial (SPORT) recently published data regarding 8-year outcomes.[21] Briefly the trial was conducted at 13 US medical centers in an attempt to compare outcomes regarding surgical and non-surgical treatments for some of the most common spinal conditions; lumbar disc herniations, spinal stenosis, and degenerative spondylolisthesis. The study was arranged so that there was a randomized cohort and a concurrent observational cohort for each condition. Primary outcome measures included SF-36 and the ODI. Regarding the lumbar spinal stenosis arm a total of 289 patients were entered into the randomized cohort and 365 patients in the observational cohort. In the randomized cohort 138 were assigned to surgery and 151 were assigned to nonsurgical treatment. In the observational cohort, 219 patients chose to undergo surgery, while 146 opted for nonoperative treatment. Back in 2008 the first published data on spinal stenosis was released and demonstrated that patients with this condition, when treated surgically, had substantially greater improvements in pain and function as compared to the nonoperative branch of the trial with effects seen as early as 6 weeks.[20]

In 2015, 8-year data was released which showed that 52% of patients (78/151) initially randomized to nonoperative care, had undergone surgery, and 27% (40/146) of those opting for non-surgical treatment, had undergone surgery.[21] Of note, only 55% of the randomized group's data was available compared to 52% of the observational group data, as dropouts, missed clinical visits, or deaths occurred. The authors concluded that in the randomized group the as-treated results for surgical and nonoperative treatment converged at 5 years and continued for years 6–8. In the observational group, surgery maintained an advantage at that 8-year mark. The author's note that in the entire study this is the only time there was a divergence in outcomes between the two cohorts. The authors suggest that this may be due to greater baseline differences in the observational groups than the randomized groups. They also note that because the randomized groups were very similar that, the advantage of surgery in LSS likely does diminish over time.

6. Posterolateral fusion versus interbody fusion in spondylolisthesis

A recent study examined the effectiveness of interbody fusion (IF) (Fig. 1) compared to posterolateral fusion (PLF) in patients with degenerative spondylolisthesis.[22] Patients enrolled had single level degenerative spondylolisthesis and were enrolled between the years 2007 and 2012 and ranged in age from 55 to 74. This study was not randomized, patients meeting the criteria for posterolateral fusions included 1 or more of the following; increase in listhesis on flexion/extension radiographs or between supine to upright lateral x-rays, Meyerding grade II spondylolisthesis, severe foraminal stenosis, and surgical disc level having greater than 10 ° of asymmetric disc collapse (kyphosis or scoliosis). Those patients not meeting the criteria above were selective to undergo either posterolateral or transforaminal interbody fusion. In this cohort, a total of 87 patients underwent lumbar fusions, 29 selected for PLF, and 58 for interbody fusions. Reductions in ODI were obtained and showed no statistical difference between each group at 2 years (p = 0.626). Reoperation rates between PLF group and IF groups were 3.4% and 10.3% respectively, (p = 0.416).

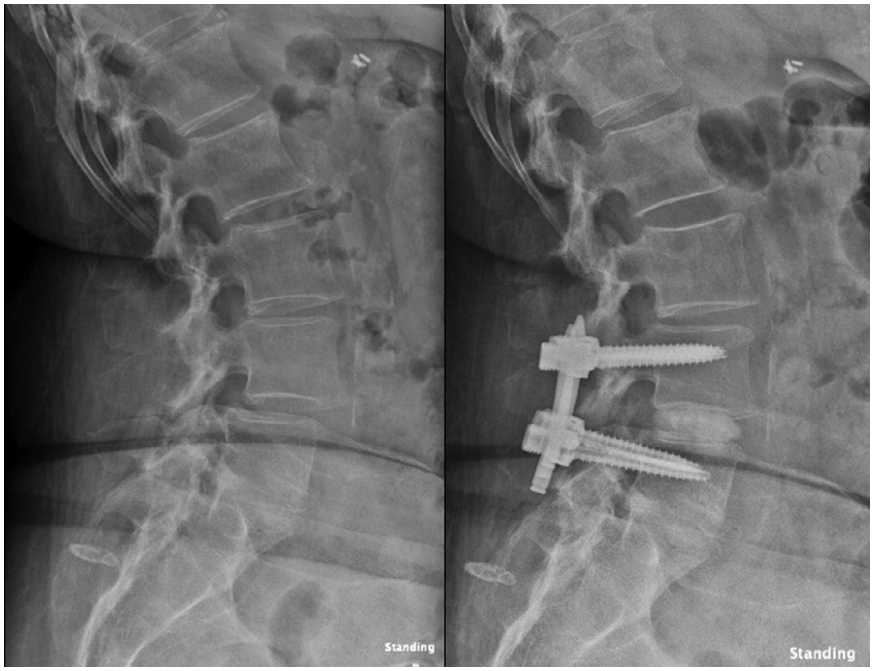

Fig. 1 – Grade 1 L45 spondylolisthesis pre and postoperative lateral radiograph of transforaminal lumbar interbody fusion.

The authors concluded that the type of fusion performed does not affect outcomes or complication rates.

An additional study proposed that the benefits of IF include indirect decompression of neural elements, improved reduction of spondylolisthesis, improved lordosis, and increased likelihood of fusion. Unfortunately these benefits, while achieving increased fusion rates when IF was coupled with PLF, did not translate to any clinically significantly benefit to the patients.[23]

7. Summary

Degenerative lumbar spinal stenosis and spondylolisthesis are significant contributors of impaired quality of life and increased morbidity in the elderly population. Patients commonly present with back and/or leg pain with neurogenic claudication. Symptoms are caused by a cascade of degenerative anatomical changes ultimately leading to stenosis of the spinal canal. Nonoperative treatment consists of oral anti-inflammatory medications, physical therapy and epidural steroid injections. The SPORT study demonstrated that patients with LSS have better outcomes with surgery out to 4 years, but marginal improvements were observed in years 6–8.[21] They also found that up to one-quarter of patients that undergo nonoperative management require operative treatment within 8 years of presentation. A Cochrane Review of 5 studies found no clear benefits of surgical versus nonsurgical management of LSS.[24] However, this study was limited by low quality evidence due to high risk of bias, study design and incomplete outcome data.[25] Based on the current best available evidence, it is recommended that patients with LSS and no radiographic instability or deformity presenting with leg-dominant symptoms that have exhausted nonoperative treatment pursue surgical decompression only, without fusion. Patients should be informed about the potential limitations of surgery, including possible diminishing benefits of surgery over time. Fusion should be considered in the presence of spinal deformity or evidence of instability.

Regarding degenerative spondylolisthesis, for Grade 1 slips there is no definite consensus on whether decompression or decompression and fusion leads to better outcomes; in light of recent data, however, limitations and costs of fusion must be considered and weighed against decompression only. Lumbar fusion procedures require longer operative times, increased hospital LOS, higher costs, and increased blood loss in comparison to decompression alone. For grade 1 spondylolisthesis without lateral foraminal stenosis, Ghogawala et al. found that decompression and fusion has significantly lower revision rates than decompression alone (14% versus 34%) and increased functional outcomes at 4 years after surgery.[19] Försth et al. demonstrated no benefit to fusion after decompression at 2 years, though they did not clarify spondylolisthesis grade nor obtain flexion/ extension radiographs.[18] Reoperation rates were similar in decompression and fusion (22%) versus decompression alone (21%). This may be explained by different thresholds to re-operate between spine surgeons in the US and Europe. For grade 2 spondylolisthesis and higher, it is recommended that patients undergo decompression and fusion. A paper by Urquhart et al. found that interbody fusion and posterolateral fusion lead to equivalent outcomes and similar complication rates.[22] Another study proposed that IF leads to improved reduction, alignment and likelihood of fusion but these radiographic measures did not confer any clinical benefit.[23]

Degenerative lumbar spinal stenosis and spondylolisthesis impair quality of life. Given the lack of conclusive data

regarding the treatment of LSS and DS, it is imperative for physicians to utilize the best available evidence and integrate it with specific patient factors to decide on the optimal treatment strategy.

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