Lumbar Spinal Stenosis

Introduction

Lumbar spinal stenosis is defined as reduction in the diameter of the spinal canal, lateral nerve canals or neural foramina. The stenosis may involve multiple level of the spinal canal or may be localized or segmental.

The natural history of spinal stenosis and degenerative spondylolisthesis is unclear because of a lack of prospective studies following the course of patients who have been untreated. A review of the literature shows progression of symptoms in approximately 20% of untreated patients with spinal stenosis. Because most studies are not randomized or prospective, it is difficult to predict the natural history of the disease and to compare the available treatment options. A slow progression may be expected to occur in most affected patients. Even with significant canal narrowing, patients are unlikely to develop acute cauda equine syndrome in the absence of a significant disc herniation. One study that concentrated on the natural course of lumbar spinal stenosis reported on 32 patients who were followed for an average of 49 months (range, 10 to 103 months). The condition of 15% of these patients improved, 70% remained the same and 15% were worse. On clinical examination, 41% were improved, 18% were worse and 41% were unchanged. The authors concluded that severe progression was unlikely.

Lumbar Spinal Stenosis

The decreased diameter of the canal or neural elements may be caused by bone or ligamentous hypertrophy, disc protrusion, spondylolisthesis or any combination of these conditions. Pain in the back and leg (or legs) is the main symptom. Patients often present with few objective physical findings; up to 95% of patients treated surgically have only subjective symptoms, usually pain. Vascular claudication must be considered in the differential diagnosis, as well as peripheral neuropathy.

Spinal stenosis usually affects patients older than 50 years and is uncommon in younger patients unless they are predisposed to the disease by a congenitally narrowed canal, previous trauma or deformity. Patients typically report pain, paresthesias, weakness or heaviness in the buttocks radiating into the lower extremities as a result of prolonged standing or walking. Importantly, there is a relationship of symptoms to posture. Symptoms occur with extension and are relieved with flexion. Patients can walk farther with less pain when leaning forward (such as when using a grocery care while shopping).

The physical examination of patients with lumbar stenosis is often normal or shows only nonspecific findings. Many older patients have reduced spinal mobility, with or without spinal stenosis. Extension is usually more limited than flexion, and may reproduce lumbar or lower extremity symptoms of pain and/or paresthesias. Some patients assume a characteristic “simian stance,” with their hips and knees flexed and the trunk forward. This posture may allow patients to stand or walk longer distances. Hamstring tightness is common and may produce a false-positive straight-leg raising test. The neurologic examination typically is normal or may show subtle weakness, sensory changes and reflex abnormalities. Weakness of the muscles innervated by the L5 nerve root may occur. A positive lumbar extension test is strongly predictive of spinal stenosis. The patient is asked to stand with the spine hyperextended for 30 to 60 seconds; a positive test is defined by reproduction of buttock or leg pain.

The differential diagnosis of spinal stenosis is broad, and many conditions must be ruled out. Peripheral neuropathy, vascular disease and disorders of the hip are common disorders with similar symptoms. Significant weight loss and intractable night pain should raise the suspicion of possible malignancy. Fever with localized back tenderness, recent infection or after an invasive procedure should raise the suspicion of a spinal infection. Patients with vascular claudication may have diminished pulses and are not expected to have both pain with standing and relief of pain with flexion as should be the case for those

with spinal stenosis. Patients with peripheral neuropathy usually have a stocking-glove distribution of pain or paresthesias. Vibratory sensation is often diminished, and numbness is typically constant in patients with peripheral neuropathy. A careful examination of the hips and surrounding soft tissues should be done to exclude significant hip arthritis and gluteal or trochanteric bursitis from the diagnosis.

Overall, no objective criteria for using the patient history and results of the physical examination have been reported as a means of diagnosing lumbar spinal stenosis. The only quantitative evidence correlating diagnostic information with outcomes is imaging findings. Radiographic studies usually begin with routine AP and lateral radiographs. Degenerative changes include disc space narrowing, endplate irregularities, osteophytes, traction spurs and facet hypertrophy. Noninvasive vascular studies are required if the patient has diminished peripheral pulses or symptoms consistent with vascular claudication.

Further imaging studies are indicated for patients with persistent back pain that is unresponsive to nonsurgical treatment, significant radicular pain or neurologic decompensation. Imaging studies include CT, myelography, contrast enhanced CT and MRI. The degree of spinal stenosis is best evaluated by MRI. If an MRI scan cannot be obtained (because of pacemaker or cardiac stent implantation), a lumbar myelogram followed by CT is helpful to visualize the degree of neural compression. A decreased cross-sectional area of the spinal cord is often noted on imaging studies.

Nonsurgical Treatment

Nonsurgical treatment for patients with spinal stenosis is similar to conservative treatment for low back pain. Careful use of nonsteroidal anti-inflammatory drugs may give partial relief of symptoms. Narcotic prescriptions should be used only on a short-term basis. Physical therapy is often prescribed as the initial form of nonsurgical intervention. Although improvement in lumbar range of motion and axial muscle strength can be achieved, these passive and active modalities have little effect on the natural history of symptom progression. A series of epidural steroid injections may give temporary relief of radicular symptoms and are frequently used for those patients who may not be candidates for surgery.

Surgical Treatment

There are a variety of procedures that are commonly used for the surgical treatment of lumbar spinal stenosis and these are often divided into decompressive procedures with or without concomitant fusion. The decompressive procedures may be limited to single-level unilateral laminotomy for isolated neurologic compression to much larger global procedures including multi-level bilateral laminectomy with bilateral facetectomies and foraminotomies. Multi-level laminotomies may be most appropriate for patients with degenerative lumbar spinal stenosis with predominantly radicular pain. In these patients, the narrowing is usually maximal at the level of the facet joints and discs, whereas the canal is otherwise patent. In contrast, laminotomies are generally not appropriate in patients with congenital stenosis and global spinal canal narrowing.

The fusion procedures are equally varied and include posterolateral or intertransverse fusion, posterior fusion, posterior lumbar interbody fusion, transforaminal lumbar interbody fusion and anterior lumbar interbody fusion, or some combination of these procedures. Neural decompression can be accomplished indirectly via anterior lumbar interbody fusion or posterior lumbar interbody fusion/transforaminal lumbar interbody fusion if disc space distraction and/or spondylolisthesis reduction occurs, which would enlarge the central canal as well as the involved foramina.

Laminectomy

The most common surgical procedure for patients with lumbar spinal stenosis is decompressive lumbar laminectomy. Because spinal stenosis is often a global degenerative process that involves multiple levels and nerve roots bilaterally, a multi-level bilateral laminectomy is often required. For bilateral

laminectomy, the spinous processes and the lamina and ligamentum flavum are removed on either side of the stenotic level, laterally to the lateral recesses. Typically, decompression begins at the distal extent of the neurologic compression and proceeds in a caudal-to-cranial manner. Entry to the spinal canal is often obtained by the use of dissection with a small curette between the ligamentum flavum and the lamina at the inferior aspect of the involved lamina. Decompression is extended laterally from the midline until the lateral edge of the nerve root is observed and determined to be free of compression.

The presence of a concomitant disc herniation should be determined and removed because it can contribute to neural compression. However, discectomy in the presence of laminectomy should generally be avoided unless the disc herniation contributes to significant neurologic compression because subsequent instability is more likely to occur when both anterior and posterior supporting structures are violated. This factor may be more importance when significant amounts of the disc and annulus material are removed. When laminectomy is accompanied by a significant amount of discectomy, fusion at the time of surgery should be considered.

After decompression centrally and at the lateral recesses, the lateral decompression of the foramina is performed. Decompression is believed to be complete when a bent probe can be easily passed out of the neural foramen, both dorsal and ventral to the nerve root; the nerve root can be gently retracted approximately 1cm medially; and there is no significant tension on the nerve root.

Controversy exists on whether to decompress levels that appear to be stenotic and do not seem to correlate with the patient's symptoms. When there is double regarding the symptomatic level, further diagnostic studies (such as a diagnostic nerve root block), which may help identify symptomatic level, should be considered. The risk of decompressing an apparently asymptomatic level and causing symptoms or complications must be weighed against the possible risk of further degeneration. Because spinal stenosis is a degenerative process that is believed to progress over time, it is possible that asymptomatic stenotic levels may eventually become symptomatic. Several studies have indicated that inadequate decompression results in long-term deterioration in clinical outcome following initially successful surgery, and may be a cause of failed back surgery and/or may necessitate additional spinal procedures.

Laminectomy Alternatives

Alternatives to laminectomy and hemi-laminectomy have been described to avoid removal of normal, noncompressing structures. These alternative procedures include hemi-laminotomy and are believed to minimize the risk of postoperative instability and scarring. Hemi-laminotomy involves a more limited decompression than hemi-laminectomy. The procedure involves removing only ligamentum flavum and smaller adjacent caudal and cranial portions of the two hemi-laminae, as opposed to removing the entire hemi-laminae. This procedure is commonly performed in younger patients with unilateral focal neural compression. It may, however, also be considered in older patients with localized stenosis.

Results of Surgical Treatment

Although a large number of studies have been performed to assess the results of surgical treatment for patients with spinal stenosis, a recent review of the literature did not identify a randomized controlled trial comparing surgical versus nonsurgical treatment. An attempted meta-analysis of the literature on surgical outcomes for patient with lumbar spinal stenosis concluded that the poor scientific quality of the literature precluded conducting the intended meta-analysis. Of 625 articles that were identified as potentially relevant, only 74 (12%) met inclusion criteria for the study. Only 3 of the 74 studies were prospectively designed, 7 had an independent rating of outcome and none were randomized. The average proportion of good to excellent outcomes was 72%. There was no statistically significant relationship between outcome and patient age, gender, presence of previous lumbar spinal surgery or number of levels operated on. An important finding of this attempted meta-analysis was that there was no statistically significant difference

in the outcome of decompression, with or without concomitant fusion, for patients with lumbar spinal stenosis. This finding has been corroborated in other surveys of the literature for outcomes following lumbar spinal fusion for a variety of diagnoses. This information is particularly important because of the obvious increased morbidity associated with lumbar fusion.

In a recent prospective, nonrandomized study, a cohort group of patients with spinal stenosis who were treated surgically or nonsurgically were followed for 1 year. Seventy-one of 81 patients (88%) who had surgery had a decompressive lumbar laminectomy. At 1-year follow-up, 28% of the nonsurgical group reported definite improvement in predominant symptoms compared with 55% of the patients treated with surgery. After adjustment for covariates, surgery was believed to increase the relative odds of definite improvement by 2.6-fold when compared with nonsurgical treatment. Unfortunately, this study included only a 1-year follow-up period, was nonrandom in nature and examined only 22% of those eligible to be enrolled. Also, no standardization of nonsurgical methods was used. Although the results of the study should be interpreted with caution, some indication is provided of the expected short-term outcomes for patients receiving decompressive lumbar laminectomy for lumbar spinal stenosis.

Although decompressive lumbar laminectomy in the treatment of spinal stenosis is a well-recognized form of treatment, the role of fusion in the treatment of spinal stenosis remains controversial. In patients with stenosis and no associated degenerative spondylolisthesis or other deformity in the sagittal or coronal plane, most studies indicate that decompression alone is the preferred method of surgical treatment. In a prospective randomized study of 45 patients who underwent either decompression alone or decompression with fusion for lumbar spinal stenosis without associated instability, there were no significant differences in the outcome between the groups. The authors concluded that surgical decompression altered the natural history of spinal stenosis and resulted in a generally favorable outcome with improved quality of life in most patients. They also reported that arthrodesis in patients with lumbar spinal stenosis was not justified in the absence of radiographically proven segmental instability. Similarly, for patients with associated degenerative spondylolisthesis or degenerative scoliosis, concomitant fusion is recommended. The use of supplementary spinal instrumentation remains unresolved.

Predictors of outcome after spinal surgery for lumbar spinal stenosis have been studied. A retrospective review of 88 patients who underwent decompressive lumbar laminectomy for lumbar spinal stenosis found that 6% of patients required a second operation by 1 year after surgery and 17% required a second operation by the time of the last follow-up (between 2.8 and 6.8 years). Several predictors of poor outcome were identified, such as increasing length of time since surgery, single-level decompression and increased number of comorbidities; only the latter was significant after adjusting for multiple comparisons. In patients with the highest comorbidity scores, only 40% had a good outcome at final follow-up compared with 75% of patients with the lowest comorbidity scores. The most common comorbidities included osteoarthritis (32%), cardiac disease (22%), rheumatoid arthritis (10%) and chronic pulmonary disease (7%). No single comorbidity was significantly associated with worse outcome; this fact was interpreted to indicate that comorbidities may be additive. In a subsequent study by the same authors, comorbidity was found to be second only to preoperative reports of predominant low back pain as a determinate of disability in lumbar spinal stenosis.

Degenerative Spondylolisthesis

Anterior displacement of one vertebral body on another without a fracture (see spondylolisthesis) is termed degenerative spondylolisthesis. This condition may be a source of low back pain, as well as radicular or referred leg pain. Degenerative spondylolisthesis occurs five to six times more frequently in woman and usually occurs after the age of 40 years. The L4-5 interspace is 6 to 10 times more frequently involved than adjacent levels.

The degenerative lesion is believed to be the result of long-standing spine instability. Degeneration of the disc accompanied by degeneration of the facet joints allows vertebral translation. The facet joints may be sagittally or horizontally oriented and therefore parallel to each other, or they may be anomalous in their orientation and asymmetric. In both of these instances, the articular processes are free to glide forward one on the other, causing slippage as the joints degenerate. The slip seldom exceeds 30% of the width of the vertebral body unless there has been prior surgical intervention.

A thorough patient history and physical examination are always the first steps in the diagnosis. Back pain is the most commonly reported symptom, often follows a variable course, and is usually unrelated to trauma. The back pain is mechanical and is usually relieved by rest. Radiation of pain into the posterolateral thighs is common. Leg pain is usually diffuse, involving dermatomes and muscles innervated by the L4, L5 and S1 nerve roots. The leg pain is classically accentuated by walking and relieved by rest. Patients may have "drop episodes" characterized by unexpected falls during ambulation.

The results of a physical examination in patients with degenerative spondylolisthesis may be nonspecific. Hamstring tightness is a common finding and patients may have a type of waddling gait. When stenotic symptoms are severe, a fixed forward-flexed posture may be observed. Except in very thin patients, the deformity is not usually appreciated on examination or palpation. Although a neurologic examination is critical, results are often normal and/or nonspecific. Findings may include bilaterally absent reflexes, spotty sensory loss and possible muscle weakness or atrophy.

Surgical Treatment

Decompression without Fusion

The surgical treatment of lumbar spinal stenosis with associated degenerative lumbar spondylolisthesis involves either decompression alone or decompression with lumbar fusion. A meta-analysis of the literature from 1970 to 1993 included 11 articles that met inclusion criteria on decompression without fusion. Overall, only 69% of patients were found to have satisfactory results following surgical decompression without concomitant fusion. Thirty-one percent of the patients in nine studies in which slip progression was recorded showed an increase in the degree of slip. However, in most studies, there was no correlation between clinical outcome and the amount of slip progression.

In a prospective, randomized study comparing decompression alone and combined decompression with non-instrumented fusion for degenerative spondylolisthesis, only 11 of 25 patients (44%) having decompression without fusion had satisfactory results. This group also had significantly more post operative low back and leg pain than the fusion group, and had an average increase of 50% in slip from preoperative levels.

Decompression with Fusion

A meta-analysis of the literature on degenerative spondylolisthesis found only six studies that met the inclusion criteria for treatment using decompression with fusion. In these studies, 79% of patients reported satisfactory outcome following decompression without fusion. Only three of the studies were prospective and randomized; the most widely quoted study compared decompression alone to decompression with spinal fusion in the treatment of L3-4 and L4-5 degenerative spondylolisthesis with spinal stenosis. The authors reported improved results when concomitant intertransverse process fusion was performed in addition to decompression when compared with decompression alone. Ninety-six percent good to excellent results were noted in the group and only 44% good to excellent results in the group. Thirty-six percent of those undergoing had a pseudoarthrosis; however, all had either an excellent or good result. The authors concluded that the results of surgical decompression with in situ fusion were superior to those of decompression alone in the treatment of spinal stenosis associated with L3-4 and L4-5 degenerative spondylolisthesis. The authors also concluded that the decision to perform fusion should be

based on the presence or absence of preoperative spondylolisthesis rather than other factors such as patient age or gender, disc height or the amount of bone resected during decompression.

The relationships between bone regrowth following surgical decompression for lumbar spinal stenosis and long-term outcome have also been evaluated. In general, satisfactory outcome has been found to be inversely related to the amount of bone regrowth. Although patients with degenerative spondylolisthesis do show some bone growth following lumbar decompression and fusion, the degree of regrowth is less than in those patients who undergo decompression alone without fusion. These results are also reflected in the outcome following surgery; outcome was shown to be significantly improved in patients undergoing decompression with spinal fusion. Although this study was retrospective, results suggest that fusion stabilizes the spine, resulting in less bone regrowth and subsequent recurrent stenosis.

Decompressive lumbar laminectomy with fusion is generally recommended for patients with spinal stenosis associated with degenerative spondylolisthesis. In elderly, low demand patients with more pain resulting from radiculopathy than from pseudoclaudication, laminotomies without fusion may be performed. This procedure may have less risk of subsequent slip progression if there is significant collapse of the disc spaces and vertebral osteophyte formation.

Multiple studies have shown a higher fusion rate with the addition of rigid spinal instrumentation. To date, no study has determined what radiographic criteria can be identified preoperatively to predict the probability of a successful noninstrumented fusion. If a clinician believes that a noninstrumented fusion will lead to a successful fusion, pedicle screw instrumentation should be used in those patients who are determined to be at risk for pseudoarthrosis following a noninstrumented fusion.

Summary

The natural history of untreated spinal stenosis either with or without degenerative spondylolisthesis is relatively benign but progressive. The literature to date suggests that the natural history of spinal stenosis, with or without degenerative spondylolisthesis is characterized by improvement in approximately one third of patients and deterioration in approximately 10% of patients. The remaining patients have a generally static clinical course over time, with little if any improvement.

There are few data to support the routine use of fusion in the surgical treatment of patients with lumbar spinal stenosis that is not associated with degenerative spondylolisthesis. Support exists for the use of decompression and fusion in the treatment of lumbar spinal stenosis associated with degenerative spondylolisthesis. Many studies indicate that the fusion rate is improved in patients undergoing instrumented fusion. The future role of bone graft substitutes and/or bone morphogenic proteins in spinal fusion continues to be studied. These biologic agents will likely have an increased role in the future of the surgical treatment of patients with these complicated spinal ailments.

Annotated Bibliography

General

Sengupta D, Herkowitz H: Lumbar spinal stenosis treatment strategies and indications for surgery. *Orthop Clin North Am* 2003;34:281-295.

This review article describes the natural history and treatment options, both nonsurgical and surgical, for patients with lumbar spinal stenosis. Important discussions on degenerative spondylolisthesis, iatrogenic instability, recurrent or junctional stenosis and treatment algorithms are also included.

Lumbar Spinal Stenosis

Arinzon A, Adunsky A, Fidelman Z, Gepstein R: Outcomes of decompression surgery for lumbar spinal stenosis in elderly diabetic patients. *Eur Spine J* 2004;13:32-37.

This retrospective study on decompressive surgery for spinal stenosis compared elderly diabetic patients with gender and age-matched controls. The authors found poorer results for diabetic patients with regard to basic activities and pain improvement after surgery. The outcome for patients with diabetes depends on the presence of other comorbidities, concurrent diabetic neuropathy, duration of diabetes and insulin treatment.

Epstein NE: Lumbar laminectomy for the resection of synovial cysts and coexisting lumbar spinal stenosis or degenerative spondylolisthesis: An outcome study. *Spine* 2004;29:1049-1055.

This article reviews the outcomes of surgical treatment for patients with synovial cysts and stenosis, with or without concomitant spondylolisthesis. The author noted the high percentage of patients who had postoperative development or progression of spondylolisthesis after laminectomy. Because synovial cysts reflect disruption of the facet joint and some degree of instability, the author recommended consideration of primary fusion to improve surgical results for patients in both categories.

Gunzburg R, Keller TS, Szpalski M, Vandeputte K, Spratt KF: A prospective study on CT scan outcomes after conservative decompression surgery for lumbar spinal stenosis. *J Spinal Disord Tech* 2003;16:261-267.

The postoperative CT scans of patients who underwent conservative lumbar laminarthrectomy were analyzed in this prospective study. This procedure involved decompressing the central and nerve root canals while respecting the integrity of the neural arches, facet joints and most muscle attachments. The authors noted a statistically significant increase in inter-facet bony canal diameter of the operated levels.

Gunzburg R, Keller TS, Szpalski M, Vandeputte K, Spratt KF: Clinical and psychofunctional measures of conservative decompression surgery for lumbar spinal stenosis: A prospective cohort study. *Eur Spine J* 2003;12:197-204.

The authors prospectively evaluated psychometric and functional outcomes for patients who had conservative lumbar laminectomy. With short-term follow-up, the authors reported outcomes to be as successful as standard more aggressive decompressive procedures presented in the literature. The authors noted that even in a highly organic disorder such as spinal stenosis, illness behavior plays an important role in predicting surgical outcomes.

Ragab AA, Fye MA, Bohlmann HH: Surgery of the lumbar spine for spinal stenosis in 118 patients in 70 years of age or older. *Spine* 2003;28:348-353.

A consecutive case retrospective review evaluating the outcome of lumbar spine surgery for spinal stenosis in elderly patients is presented. The authors report on a 2-year follow-up of 118 patients from 70 to 101 years of age who were surgically treated for lumbar spinal stenosis. Advanced age did not increase the morbidity associated with this surgery when compared with other studies of a younger population, nor did advanced age decrease patient satisfaction or return to activities.

Degenerative Spondylolisthesis

Kornblum MB, Fischgrund JS, Herkowitz HN, Abraham DA, Berkower DL, Ditkoff JS: Degenerative lumbar spondylolisthesis with spinal stenosis: A prospective long-term study comparing fusion and pseudoarthrosis. *Spine* 2004;29:726-733.

This article presents the result of a prospective, randomized study on patients who underwent posterior lumbar decompression with bilateral posterior fusion for degenerative spondylolisthesis and spinal stenosis to determine the long-term influence of pseudoarthrosis. The authors showed that a solid fusion improves long-term clinical results for back and lower limb symptomatology compared with prior shorter-term studies, which indicated no significant difference in clinical outcome between solid fusion and pseudoarthrosis.