

**INSTRUCTIONAL LECTURES & PANEL PRESENTATIONS****AN OVERVIEW OF ADULT SPINAL DEFORMITY****Lawrence G. LENKE, MD***Institution(s):**Professor of Orthopaedic Surgery, Washington University School of Medicine
Chief, Spinal Deformity Surgery, Shriners Hospital for Children - St. Louis, Missouri***INTRODUCTION**

The evaluation and treatment of adult spinal deformity remains a challenging clinical entity. Many factors must be analyzed to help decide the best treatment plan for these patients ranging from conservative care with physical therapy, epidural steroid injections and lifestyle adjustments to major surgical intervention consisting of anterior and posterior spinal fusions, vertebral osteotomy or resection procedures. This manuscript will highlight the essentials of the evaluation, conservative and surgical treatment of patients with all forms of adult spinal deformity.

EVALUATION

The history of a patient presenting with adult spinal deformity must be quite detailed regarding the patient's main complaints, past treatments and future expectations. Patients usually present because of increasing axial, and less commonly appendicular pain. In addition, they may feel their deformity is progressing by the noticing loss of height, altered fitting of clothes, increasing rib or lumbar prominences, or because of comments regarding these features made by family members and/or friends. Rarely do patients present with increasing dyspnea which

obviously manifests itself in a severely neglected thoracic deformity. It is extremely important to identify the primary reason(s) that the patient came to see the spinal deformity physician, as this will be extremely helpful in deciding what level of treatment is necessary to meet the patients' expectations.

There are several basic subdivisions of adult spinal deformity including whether the patient presents with a primary deformity or with a previously treated deformity. In my practice, approximately 50% of patients evaluated have a primary deformity, while 50% have had prior surgery in the past, most commonly in the distant past with first generation (i.e. Harrington rod instrumentation) implants in place. Although the presentation of these patients is somewhat different, the expectations and analyses are quite similar. It is important to try and detail exactly the type of prior surgical intervention the patient has undergone, including how many prior surgeries, type of implants placed, and source of bone graft harvest. This last point is extremely important, since the availability of autogenous posterior iliac crest bone graft is important, not only for future bone graft harvests, but also the placement of iliac screws for additional sacropelvic fixation, which is commonly utilized for long fusions extending to the sacrum.

Additional features of the history that are important include: the patient's prior or current steroid use and antiinflammatory and narcotic usage, etc.; past medical history including any type of cardiac or pulmonary problems; past or current use of tobacco products (lower fusion rate and higher infection rate?); and overall nutritional and exercise status. Also, it is extremely important to understand the patient's psychological and emotional status for those contemplating significant spinal reconstructions. In addition, it is necessary to identify supportive systems available to those patients planning to recover from significant spinal reconstructive surgeries.

RADIOGRAPHIC EVALUATION

The standard radiographic evaluation of patients with adult spinal deformity begins with an upright long cassette (36 inch) frontal and lateral view of the spinal column. Ideally, the entire spinal axis from the occiput to the sacrum will be visualized, but at a minimum from the C7 vertebral body to the sacrum. In addition, recent evaluation of the sacral pelvic alignment with respect to the pelvic incidence will be extremely important. Besides the obvious Cobb measurements of the major and minor curves on the coronal plane films, with the regional thoracic, thoracolumbar and lumbar sagittal angulations should be documented. Probably the two most important radiographic measurements are the coronal vertical alignment (CVA) or coronal plumbline and the sagittal vertical alignment (SVA) or sagittal plumbline. The singular two most important features of adult spinal deformity from a radiographic, as well as clinical evaluation, remains the optimization of coronal and sagittal plane balance. Thus, all efforts should be made to fully evaluate both of these on the

long cassette radiographs, which must be of good quality and sufficient detail to assess.

Additional radiographic evaluations may include short cassette detailed evaluations of the lumbosacral region, including a Ferguson view to assess the lumbosacral region especially in patients with lumbosacral spondylolithesis, which must always be checked for. Almost all patients presenting with any type of lumbar deformity will also require a lumbar MRI exam to evaluate the health of the lumbar discs as well as the presence of any spinal stenosis. In patients with severe lumbar deformity, a CT myelogram will be more helpful to totally evaluate the extent of any stenotic problem. Rarely, a technetium bone scan may be helpful in identifying areas of pseudarthrosis present in those patients who have had prior surgery, or in patients with painful facet joints in the lumbosacral region.

PHYSICAL EXAMINATION

The key elements of the physical exam include: evaluation of the skin integument of the back, especially in those patients with prior surgery (and especially with history of prior infection); overall coronal and sagittal balance standing as well as walking; range of motion of trunk, and neurologic exam to the upper and lower extremities. It is extremely important to assess the patient's overall coronal and sagittal balance while standing and walking, especially noting whether the patient flexes their knees to remain in good sagittal balance. This is a very common adaptive response for those patients with a flexible or fixed sagittal imbalance syndrome. Evaluating the patient both standing and prone on an exam table can identify postural abnormalities that are flexible and thus easily correctable versus fixed deformities that do

not change from an upright to prone position. For patients with kyphotic deformities, lying them supine over a bolster for a period of time (5-10 minutes) will often identify areas of flexibility to regions of the spine thought to be somewhat 'autofused'. This same evaluation can be performed radiographically by obtaining hyperextension lateral films of the entire spinal column, if necessary, to aide in this evaluation.

A standard upper and lower extremity neurologic exam consisting of motor, sensory and reflex testing should be undertaken. It is fairly rare in patients with scoliosis deformities to have significant thoracic myelopathy, but certainly they may have lumbar stenosis and/or radiculopathy present, especially at the with kyphotic malalignments can present with tenting of the spinal cord over the spinal column producing myelopathy and/or a stenosis type of pathology. Any abnormalities in the neurologic exam warrant thorough neuro-radiographic evaluation to completely understand. Discography may also play a role in the evaluation of the painful lumbosacral spine, but this is being utilized less frequently because of the excellent technology available now with the MRI evaluations.

CONSERVATIVE TREATMENTS

The hallmark conservative treatment of adult spinal deformity is observation with intermittent radiographic and clinical examinations over time. The frequency of examinations is based on the age of the patient, the degree of the deformity, and the symptomatic presentation of the patient. Usually, evaluation yearly or at 3-5 year intervals will be required. It is extremely important to have access to previous radiographs when the patient returns to recognize any progressive tendencies, including increasing oste-

oporosis. Progression of spinal deformity over time is one of the main indications for considering operative intervention in patients who are symptomatic or even asymptomatic. Thus, it is essential to have radiographs available for comparative purposes.

The most commonly prescribed active intervention with patients with a spinal deformity is an active and passive physical therapy program. The active component consists of muscle strengthening, flexibility, and aerobic conditioning which can be quite important not only for current but also future considerations. In addition, those patients with active musculoskeletal mechanical symptoms require passive therapy including heat; massage, ultrasounds, etc. and can be quite helpful in alleviating current symptomatology. If musculoskeletal mechanical pain is a major component to the patient's chronic condition, assistance with a pain management service may be required, especially in those patient who are narcotic dependent.

In patients with active radiculopathy and/or stenosis, nerve root and/or steroid injections can be quite helpful in both the diagnostic and therapeutic approach to these problems. Often these will be temporizing and not curative injections. However, they do play an important role in the overall evaluation and treatment. Rarely, behavioral and/or psychological counseling will be required for patients with conservatively treated spinal deformity problems. The psychological impact of long standing spinal deformity is not very well understood and probably is much more problematic than has been realized in the past. It is human nature not to want to be deformed or different. Spending one's life with a major deformity may, over time impart psychological ramifications that are poorly understood.

SURGICAL TREATMENT

Consideration of surgical treatment in patients with adult spinal deformity is extremely complex and challenging. There are many variables to consider including: whether the deformity is based in the coronal plane, sagittal plane or both; whether its is a primary or revision procedure; whether the deformity is flexible, fixed or a combination; the location of the major deformity (thoracic, thoracolumbar, lumbar or combined); the age and overall health of the patient; the degree of osteoporosis present; nature and degree of any type of spinal stenosis causing neurologic abnormalities present; the overall wishes and desires of the patient; and the experience and skills in the treating spinal deformity surgeon. All these conditions, as well as others must be maximally understood and evaluated when planning surgical intervention.

The hallmark treatment of patients with adult spinal deformity consists of a posterior instrumentation and fusion. With thoracic coronal plane deformities, this remains the most commonly utilized method for correction and stabilization. For the lumbar region, occasionally and isolated anterior instrumentation and fusion may be performed for major thoracolumbar or lumbar scoliosis deformities. The majority of patients with larger deformities, especially in the older age group, require circumferential procedures on the lumbar spine for realignment, stabilization and fusion. For patients with combined thoracic and lumbar deformities, a circumferential approach would be performed for the lumbar deformity but not for the thoracic deformity as it is extremely rare to do a combined anterior approach for both thoracic and lumbar deformities. Rigid stabilization with multi-segmented pedicle screws is the current instrumentation of choice. Having a variety of modular systems available, especially in complex

deformities can be quite helpful to the treating surgeon. Abundant autogenous bone graft remains the gold standard for production of a solid fusion. Success in these procedures is multi-factorial and includes: rigid internal fixation, thorough decortication and fusion, and optimization of segmental, regional and global coronal and sagittal alignment.

In patients undergoing revision surgery, additional techniques may be required including: various types of osteotomies and/or resections procedures especially in patients with fixed deformities that are imbalanced. The most common adult spinal deformity procedure that we perform is extension of a previous Harrington instrumentation and fusion to the lower lumbar spine and often the sacrum. This requires anterior structural lordosing cages/grfts down to and including the lumbosacral disc, in addition to posterior instrumentation and fusion of the entire thoracic fusion mass to the lumbosacral region. Smith-Peterson (SPO) and/or pedicle subtraction osteotomies (PSO) are commonly performed to optimize sagittal as well as coronal alignment. Rigid lumbosacral fixation will also be required, especially in those patients who are imbalanced preoperatively. We prefer 4-point sacropelvic fixation with bilateral S1 and iliac screws. In addition, multi-level lumbar segmental pedicle screw fixation will optimize final rigidity and thus fusion consolidation. In our institution, the pedicle subtraction osteotomy has been a major help in realigning the deformed sagittal plane in the last decade. We have experience with well over 60 of these procedures and the 2-year follow-up results will be reported in the American Journal of Bone and Joint Surgery in the near future. The average sagittal correction was approximately 35° more lordosis at a single level and improving overall sagittal balance by 10-12 cm with the PSO.

Rarely, a vertebral column resection will be required for rigid and fixed adult deformities that are significantly imbalanced in the coronal and/or sagittal plane. One can either perform a circumferential procedure or an AL posterior procedure. Traditionally, we have preferred a circumferential procedure, which tends to be somewhat safer to the neural elements. These are significant spinal reconstructions and should be performed only by those surgeons comfortable doing complex osteotomy procedures.

CONCLUSIONS

The evaluation and treatment of adult spinal deformity continues to evolve but still remains a

challenging area. Current initiation of a prospective multi-center study spearheaded by the Spinal Deformity Study Group (SDSG) in North America will powerfull proveding better clinical research for both conservative and surgically treated patients. Although it is somewhat difficult, if not impossible to perform a randomized clinical study of patients with either conservative or surgically treated adult deformity, prospective evaluation of all patient presenting to spinal deformity surgeons with their deformity should provide sound scientific information to treating surgeons. Dedication and commitment to spinal deformity patients is important for the optimal evaluation and treatment of these complex spinal problems.