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## What's New in Spine Surgery.

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## SPECIALTY UPDATE

## What's New in Spine Surgery

Keith H. Bridwell, MD, Paul A. Anderson, MD, Scott D. Boden, MD, Alexander R. Vaccaro, MD, PhD, and Jeffrey C. Wang, MD

### What's New in the Treatment of the Cervical Spine

#### Diagnostic Evaluation

The Spurling test is performed to test the irritability of a cervical nerve root by hyperextending the neck and compressing downward, which, when positive, reproduces a specific dermatomal pain pattern. Based on the gold standard of computed tomography (CT) or magnetic resonance imaging (MRI), this simple test has high sensitivity (95%) and specificity (95%) for identifying nerve root compression.

Evaluation of the cervical spine in patients with blunt trauma remains controversial. Clearing the spine in asymptomatic patients with normal mentation and no distracting injuries on the basis of National Emergency X-Radiography Utilization Study (NEXUS) clinical criteria without radiographs was questioned by investigators in Virginia. In a three-year study, the investigators found that twenty-five of 2606 patients had fractures that were missed when cervical spines were cleared with use of the NEXUS criteria. Two fractures required surgery, and one required halo-vest treatment. Clearing the cervical spine in the obtunded patient is more difficult, and CT and other modalities are often recommended. A meta-analysis involving >14,000 patients in which CT alone was compared with CT plus another modality demonstrated that CT alone had 99.9% sensitivity and specificity and a 100% negative predictive value. The authors concluded that CT alone is adequate to clear the cervical spine in obtunded patients.

The use of CT for clearing the cervical spine is not without risk. Low-dose ionizing radiation, such as diagnostic CT, can induce neoplasia. The thyroid has the highest growing incidence of cancer and is particularly sensitive to radiation. Furthermore, females and children have increased sensitivity of the thyroid to radiation. Muchow et al. evaluated 617 children with level-1 or 2 trauma who had CT or radiographs for cervical

spine clearance. The radiation dose and the excess relative risk of cancer induction were calculated, with CT having sixty times higher radiation exposure than radiographs. The excessive lifetime thyroid cancer risk of a single CT was increased 25% for females and 13% for males. The authors concluded that this risk needs to be considered when ordering CT imaging for pediatric patients.

#### Disc Arthroplasty

The results of five cervical disc arthroplasty trials with five-year follow-up have been reported. The studies showed equal or better clinical outcomes compared with those following anterior discectomy and fusion for single-level radiculopathy and myelopathy. The reoperation rates at the index intervertebral disc level generally were equivalent to those following fusion. There was variation in the reoperation rates at adjacent levels, with some studies showing equivalency and others favoring arthroplasty over fusion. Failures due to loosening or inflammatory reactions to wear debris have been reported as small case reports, with an incidence of <1% in randomized trials.

#### Outcomes

The measurement of patient satisfaction on the basis of meeting patient expectations is becoming increasingly utilized and will become an important measure of the quality of care. In cervical and lumbar spine surgery, meeting expectations is associated with greater satisfaction and better functional outcomes. However, higher preoperative patient expectations are associated with lower satisfaction, despite these patients having better outcomes. Discussion of expectations during the informed consent process based on patient preferences is important to maximize satisfaction.

#### Posterior Surgery

The use of recombinant human bone morphogenetic protein-2 (rhBMP-2) for posterior cervical surgery is not approved by the

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U.S. Food and Drug Administration (FDA), but this “off-label” use has been reported to produce excellent fusion rates. However, safety has been questioned. In a large retrospective cohort study of adults with degenerative disc conditions, investigators found no differences in terms of complications (including wound drainage and infection) but found that patients had more chronic neck pain. In a large case series of forty-five children who were managed with upper cervical spine fusion with rhBMP-2, five patients developed seroma (two of whom required emergency drainage because of obstructive hydrocephalus) and one patient developed hypertrophic bone formation and compression of the cervicomedullary junction.

### *Cervical Myelopathy*

The best treatment for cervical spinal stenosis in asymptomatic or mildly affected patients is unknown. A randomized controlled trial comparing nonoperative with operative treatment showed no difference in outcomes between these two groups at ten years of follow-up. The authors were unable to predict which patients in the nonoperative treatment group would develop progressive neurologic deficits. Additional guidelines by The Japanese Orthopaedic Association do not support prophylactic surgery for patients with ossification of the posterior longitudinal ligament associated with absent or only mild symptoms. Furthermore, no association between the severity of ossification of the longitudinal ligament and the risk of spinal cord injury has been identified.

Neuroprotection with use of anti-glutamatergic, antioxidant, or antiapoptotic strategies are being used and tested with the aim of slowing degeneration of the central nervous system associated with amyotrophic lateral sclerosis. Similar agents are being studied for the treatment of cervical myelopathy. In a phase-1 and 2a trial, granulocyte colony-stimulating factor (5 and 10 mcg/kg/day) was administered to patients with progressive cervical myelopathy. All patients had improvement, and no adverse events were reported. A new trial of riluzole, a sodium-glutamate blocker that has neuroprotective actions, is being planned to reduce the chance of neurologic deterioration and to enhance recovery in patients undergoing surgery for the treatment of myelopathy due to cervical spine disease.

### **What's New in Biologic Topics for the Spine**

In 2011, biologics continued to be a major focus in spine research for the treatment of spinal disorders. The majority of clinical attention in the past year focused on the frequency of rhBMP-2-related complications and the potential under-reporting of such complications in the original clinical trials. In addition, laboratory efforts continue to investigate the role of biologics in retarding or reversing intervertebral disc degeneration and in facilitating disc tissue engineering strategies. The use of autogenous iliac crest bone graft continues to decline, and the use of biologics is on the rise. Recent surveys have estimated that BMPs were used in >50% of spine fusion pro-

cedures and that >80% of that use was physician-directed (off-label) as this use is not approved by the FDA.

### *Recombinant Osteoinductive Proteins*

A primary concern with physician-directed use of recombinant BMPs continues to focus on local adverse events. The most commonly reported local side effects are heterotopic bone formation in the surgical approach track, transient radiculitis, transient vertebral body bone resorption when used near exposed cancellous bone, and sterile seroma fluid collections and/or local edema. Most of these local side effects are believed to be related to the use of excessive BMP by surgeons, either through increasing the concentration of the growth factor or through overstuffing the defect, which can result in a higher concentration or leakage of BMP into surrounding tissues. These side effects mostly occur three to seven days following surgery, with the exception of cancellous bone resorption, which is evident at three to six months and can persist beyond one year.

In June 2011, a series of articles, editorials, press releases, and letters to the editor alleged that major safety risks from rhBMP-2 were under-reported in original studies that were largely co-authored by consultants from the product's sponsor. In the months that followed, numerous articles were published in an attempt to address some of the issues that had been raised in relation to rhBMP-2-related complications. Many of the original complications were reported in association with off-label use of rhBMP-2 for anterior cervical discectomy and fusion. Although the authors of the original FDA pilot study, which involved a very low dose of rhBMP-2, did not report complications of local edema, seromas, airway obstruction, and dysphagia, subsequent reports involving unspecified and often much higher doses continued to highlight these issues, which appear to be largely (although not entirely) related to the use of excessive rhBMP-2 doses in the anterior cervical spine.

The three main allegations in June 2011 were that (1) rhBMP-2 increased the rate of retrograde ejaculation when used for anterior lumbar interbody fusion (the FDA-approved indication), (2) rhBMP-2 resulted in increased radiculitis when used for posterior spinal fusion, and (3) rhBMP-2 was associated with a higher cancer incidence. Whether rhBMP-2 increases the incidence of retrograde ejaculation is still not clear, although an alternative explanation seems to be related to surgical exposure (transperitoneal versus retroperitoneal) and surgical technique. More studies are due out shortly to address this issue more definitively.

The issue of radiculitis, presumably due to neuroinflammation, was raised on the basis of a reanalysis of relatively small clinical trials. Two recent large database studies (including one involving >55,000 patients from the Scoliosis Research Society [SRS] database and one involving >15,000 patients from the Medicare database) demonstrated no increase in overall complications, wound infection, or hematoma/seroma for thoracic or lumbar deformity surgery and

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single-level lumbar fusions. Seromas do occasionally occur in association with the use of rhBMP-2 for posterior spine fusion and can result in dural compression if not detected early. Another issue recently has been raised on the basis of a rodent spinal cord injury model that showed that rhBMP-2 penetrated the spinal cord and resulted in potentially detrimental inflammatory changes. A clinical review of >1000 patients receiving rhBMP-2 revealed a dural tear in the lumbar spine in 5.6% of the patients, but none of those patients experienced new postoperative radiculopathy, so the effect on lumbar and peripheral nerves may be different from the effects on the spinal cord. Local side effects related to rhBMP-2 typically occur at least two to five days after implantation.

Perhaps the most concerning issue raised is the potential association between rhBMP-2 and cancer. The approved formulation of 6 to 12 mg of rhBMP-2 delivered on an absorbable collagen sponge (ACS) was not associated with an increased incidence risk of cancer on the basis of the manufacturer's analysis of all spine clinical trial data, although an external analysis of publicly available data, which may be incomplete, led to a different conclusion. The larger question remains on the yet-to-be-approved higher dose formulation, which would be 40 mg of rhBMP-2 delivered on a biphasic ceramic collagen sponge. A recent review of 93,000 lumbar fusion patients in the Medicare database showed no increased risk of pancreatic cancer with use of BMP.

Another unanswered question associated with rhBMP-2 is whether repeat exposure will compromise efficacy due to antibody generation. Fewer than 10% of patients who are managed with rhBMP-2 develop antibodies transiently, and none have been neutralizing. A study of second rhBMP-2 exposure in a rabbit spine fusion model did not show any diminished efficacy of rhBMP-2.

#### **Other Bone Graft Substitutes**

Although much focus remains on recombinant osteoinductive proteins, their relatively high cost has continued to encourage research involving other bone graft solutions. Demineralized bone matrix continues to be utilized for spine fusion. A small prospective, randomized trial showed that Grafton DBM (Demineralized Bone Matrix) with local bone had fusion rates comparable with those associated with autogenous iliac crest bone graft.

#### **Biologic Treatments for Intervertebral Disc Degeneration**

Progress toward biologic treatments to prevent or retard intervertebral disc degeneration or to heal annular defects continues at a slow pace. Trials of OP-1 (osteogenic protein-1) and GDF-5 (growth differentiation factor-5) are reportedly under way, but no results have been published to date. Tissue engineering strategies involving the use of chondrocytes or mesenchymal stem cells (MSCs) on collagen, hydrogel, biphasic silk composite, and gellan gum-based microparticle/hydrogel matrices are all being investigated. One study suggested that

transplanted MSCs seemed to be an acceptable substitute for nucleus pulposus cells in a rabbit model of intervertebral disc degeneration.

Realistically, the use of biologics to treat disc degeneration is a long way from clinical application, but it remains worth monitoring developments in this area, which could ultimately become a disruptive technology for the treatment and prevention of many degenerative spine disorders.

#### **What's New in Spinal Deformity Surgery**

One hundred and sixteen papers were presented from the podium at the annual meeting of the Scoliosis Research Society, which was held from September 14 to 17, 2011 in Louisville, Kentucky.

#### **Idiopathic Scoliosis**

Current studies have suggested that all-screw constructs lead to a decrease in thoracic kyphosis and an increase in proximal junctional kyphosis. It is not clear how much of the problem is the utilization of only screws as opposed to the maneuvers being performed. The most common maneuver is pushing down on the convex apical screws to derotate the spine. Although this may provide some derotation, it reduces thoracic kyphosis. The reported prevalence of proximal junctional kyphosis has ranged from 5% to 15%.

There is also renewed interest in the impact of sagittal correction of the thoracic spine on both the cervical and lumbar spine. The hypokyphotic thoracic spine will often present with a somewhat hypolordotic cervical and lumbar spine. If a component of thoracic kyphosis is surgically dialed into the correction maneuver for the thoracic curve, the surgeon will often observe more cervical and lumbar lordosis. Is this producing favorable lordosis or unfavorable compensatory hyperextension?

One multicenter prospective study analyzed improvement in pulmonary function at two years after scoliosis surgery. The authors observed greater absolute and percentage improvement in forced expiratory volume in one second (FEV-1) and forced vital capacity (FVC) for impaired patients as compared with normal controls ( $p < 0.002$ ), but the absolute and percent predicted pulmonary function values for the impaired patients still lagged behind those for the normal controls (70% versus 85% predicted;  $p < 0.0001$ ) in spite of similar correction in curve magnitude in coronal and sagittal planes.

#### **Adult Spinal Deformity**

At least one study suggested the use of hooks at the top of the construct appeared to reduce proximal junctional kyphosis, to some extent, when compared with the use of screws as the proximal anchor for adult spinal deformity surgery. In spite of a prevalence of proximal junctional kyphosis of as high as 22% in one study, it appears that, in most cases, if the proximal junctional kyphosis is mild, there are no significant differences in SRS or Oswestry Disability Index (ODI) scores between

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proximal junctional kyphosis compared with non-proximal junctional kyphosis patients.

One multicenter study assessed the prevalence and cause of symptomatic rod fractures following posterior spinal fusion with instrumentation for the treatment of adult spinal deformity. The authors found a high prevalence of early rod fractures in patients having pedicle subtraction osteotomy, particularly if not performed through a prior fusion mass.

On the basis of several studies, it is clear that revision surgery for the treatment of adult spinal deformity will result in a high complication rate and that the rate of additional surgery after revision may be as high as 20%. Furthermore, a higher complication rate should be expected in patients over the age of sixty years as compared with younger patients, but it appears that the benefit in terms of improvement in SRS and ODI scores in patients over the age of sixty years is identical to that in patients under the age of sixty years.

#### *Growing Rod/Growing Spine Techniques*

One study that was presented at the annual meeting of the SRS compared the effect of early fusion for the treatment of early-onset scoliosis with the effect of treatment with a dual growing rod system for several years. The authors found that spine elongation throughout treatment and the lung space that was gained between the preoperative and postoperative periods were significantly less in the early fusion group. Proximal junctional kyphosis is a substantial problem associated with distraction-based growing rods. The authors of one study quoted a prevalence of 56% and stated that proximal junctional kyphosis was twice as common with dual rods as compared with single rods. The authors of another study suggested that serial casting is a viable alternative to surgical techniques in patients with moderate to severe early-onset scoliosis and reported that 74% of their cohort of patients who were managed with serial casts avoided surgery for an average of 3.1 years.

#### *Three-Column Osteotomy*

Many reports have substantiated the high blood loss associated with three-column surgical procedures and also the high prevalence of neuromonitoring changes during the procedures. Neuromonitoring changes often result in changes in surgical strategies. Most neurologic catastrophes can be avoided if neuromonitoring potentials improve with maneuvers such as reducing the degree of correction, enhancing temporary stabilization of the spine, and raising blood pressure and potentially transfusing the patient with blood.

#### *Neuromuscular Deformities*

For patients with cerebral palsy, it would appear that the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) questionnaire is a meaningful outcome measure of the effectiveness of surgical treatment of spinal deformity in children with severe cerebral palsy.

#### *Miscellaneous Topics*

One biomechanical study of human cadaver spines showed that anterior release generated more potential for thoracic derotation than Ponte osteotomy did. To some extent, that goes against the clinical trend of performing more Ponte osteotomies and fewer anterior releases.

At least one study on the surgical treatment of high-grade lytic dysplastic spondylolisthesis demonstrated that aggressive reduction did not improve the fusion rate, increased neurologic complications, and resulted in a higher reoperation rate. It is clear that patients with high-grade spondylolisthesis present with poorer SRS scores in the presence of positive sagittal balance.

#### **What's New in Spinal Cord Injury**

##### *Early Versus Delayed Surgery for Spinal Cord Injury*

The potential benefit of early spinal cord decompression in patients with spinal cord injury has long been a topic of interest, and there is ample evidence in the basic science literature supporting the benefit of early decompression in rat, feline, canine, and primate models of spinal cord injury. The Surgical Treatment of Acute Spinal Cord Injury Study (STASCIS) has been completed, and early results specifically evaluating the timing of surgery in patients with cervical spinal cord injury were presented at the meeting of the Cervical Spine Research Society in December 2011. One hundred and thirty-five patients who underwent early decompression less than twenty-four hours (average, 14.2 hours) after the injury were compared with ninety-six patients who underwent delayed decompression more than twenty-four hours (average, 48.4 hours) after the injury. Early surgery performed at less than twenty-four hours after the injury resulted in a significant increase in the likelihood of a 2-grade improvement in the American Spinal Injury Association (ASIA) Impairment Scale (AIS), with an associated odds ratio of 2.6. After adjustment for preoperative neurologic status and steroid administration, this odds ratio increased to 2.8. While these results are encouraging, longer follow-up will more definitively characterize the benefit of early intervention in patients with traumatic spinal cord injury.

##### *Translational Research*

Basic science research into neuronal regeneration and recovery continues to spawn clinical studies investigating the safety and efficacy of pharmacologic and biologic treatments for patients with spinal cord injury. Although animal models of spinal cord injury often demonstrate promising results, the jump from rodent models to human trials reveals fundamental differences between animals and humans in terms of the regenerative capacity and plasticity of the spinal cord. Nonetheless, many treatments that have shown potential in preclinical studies are currently under investigation for human use.

Oligodendrocyte progenitor cells attracted attention as a potential therapeutic biologic intervention under the premise that remyelination of injured but structurally intact axons

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could improve recovery. After animal models demonstrated improved recovery of locomotion after implantation of these cells, Geron (Menlo Park, California) initiated a human clinical trial of oligodendrocyte progenitor cells (GRNOPC1) (clinicaltrials.gov identifier NCT01217008). The trial was halted by the FDA in 2007 because of concerns about local cyst formation at the injection site and then was resumed in 2010. Despite great excitement in the regenerative medicine community, the trial was halted in November 2011 because of a funding shortage, unrelated to any adverse events, according to statements from Geron executives. There are no other ongoing studies utilizing human stem cells for patients with spinal cord injury in the United States.

A trial utilizing purified human neural stem cells in patients with ASIA grade-A injuries was recently initiated in Switzerland by StemCells (Newark, California) and will be watched closely as the only ongoing trial using cellular therapy, but data are not yet available (clinicaltrials.gov identifier NCT01321333). Finally, Neuralstem (Rockville, Maryland) has submitted an application to begin a human trial of use of human spinal cord stem cells for patients with spinal cord injury but is still awaiting approval.

Myelin inhibits neurite growth, and several myelin proteins have potent *in vivo* ability to inhibit functional neuronal recovery, including Nogo-A, a transmembrane protein. After primate models of incomplete spinal cord injury demonstrated greater functional recovery in animals treated with an anti-Nogo antibody, a human phase-I clinical study was undertaken by Novartis (Basel, Switzerland) with intrathecal administration of an anti-Nogo antibody known as ATI355 (clinicaltrials.gov identifier NCT00406016). Enrollment in the study was completed in September 2011 with a total of fifty-two patients, although no results have been released.

Riluzole is a sodium channel blocker that is thought to prevent spinal cord injury through the prevention of cytotoxicity related to increasing calcium concentration and presynaptic release of glutamate. Riluzole has been shown to be beneficial in preclinical spinal cord injury models and is additionally attractive as a potential treatment for spinal cord injury because it is already FDA-approved as a therapy for amyotrophic lateral sclerosis (ALS), for which patients take it indefinitely. On the basis of these factors, a phase-I clinical trial was initiated in April 2010 and completed enrollment of thirty-six patients in June 2011 (clinicaltrials.gov identifier NCT00876889). Patients who were enrolled in the study were managed with riluzole at a dose of 50 mg/day for fourteen days, half the typical dose given to patients with ALS and for a much shorter period of time. Results from this trial have not been released.

### What's New in the Treatment of the Lumbar Spine

Lumbar spinal pathology stills persists as one of the leading musculoskeletal issues that plague patients. Recent studies that were presented over the past year have demonstrated advancements in treatments.

### Vertebral Augmentation

Vertebral augmentation for compression fractures remains a topic of interest. Over the past year, several studies continued to explore the merits of this procedure. One study examined the hospital outcomes of vertebroplasty, kyphoplasty, and nonoperative treatment for vertebral compression fractures with use of a national healthcare database that included data on 20% of all inpatient hospitalizations in the United States. This study included patients with both neoplastic disease (86,810 patients) and non-neoplastic disease (370,933 patients). After adjusting for covariates, the vertebral augmentation group had a significantly higher likelihood of routine discharge to home and a lower risk of discharge to a skilled nursing facility in comparison with the nonoperative treatment group. The patients in the operative treatment group also had a lower risk of in-hospital mortality, pressure ulcer formation, pneumonia, and infection as compared with those in the nonoperative treatment group. The operative treatment group had a higher risk of surgical complications and medical care. The only surgical difference between vertebroplasty and kyphoplasty was the rate of infection, which was lower in the kyphoplasty group.

Another multicenter prospective randomized trial compared kyphoplasty with nonoperative management for patients with neoplastic disease. This study included 134 patients who were followed for a minimum of one year. The patients in the operative treatment group showed significant improvement in all Short Form-36 (SF-36) subscales at the one-month period. After one month, 59% of patients in the nonoperative treatment group crossed over into the operative treatment group. Patients who remained in the nonoperative treatment group did not improve. The average increase in vertebral height was 3.1 mm at the one-year follow-up time point. The authors concluded that patients with cancer-related vertebral compression fractures that were treated with kyphoplasty showed significant improvements in terms of quality of life at one month as compared with nonoperatively managed patients.

Another group of authors presented a meta-analysis of randomized and nonrandomized controlled studies comparing kyphoplasty, vertebroplasty, and nonoperative management. Twenty-seven of 1539 studies met the inclusion criteria. The studies included patients with osteoporotic compression fractures. The results showed significant pain reduction in association with operative intervention, with no differences between the two procedures. There was a higher risk of subsequent fracture and less improvement in terms of disability in the nonoperative treatment group. Kyphoplasty demonstrated superiority over vertebroplasty in terms of improvement in quality of life, the rate of cement extravasation, vertebral body height restoration, and kyphotic angle correction. The authors concluded that operative treatment was superior to nonoperative treatment in terms of pain reduction and the rate of subsequent vertebral fractures.

### Complications of Sexual Dysfunction

Several recent studies focused on complications, and one focused on the problem of erectile dysfunction in patients with

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spinal disease. A prospective study examined the prevalence of erectile dysfunction in patients under the age of fifty years with non-fracture-related lumbar spine disease requiring operative decompression. None of the sixty-one patients in the study had any other known risk factors for this problem. The prevalence of erectile dysfunction in this group was 34%. The postoperative improvement in terms of back and lower limb pain did not correlate with improvement in terms of erectile dysfunction. One of the identified risk factors for erectile dysfunction at six months postoperatively was a North American Spine Society (NASS) neurogenic symptom score of >70, which may be a reflection of more permanent neurologic dysfunction resulting from lumbar spine stenosis.

### Complications

A study that was presented during the past year examined the use of large doses of tranexamic acid to decrease blood loss during complex spinal surgery. This retrospective comparison study assessed the efficacy and safety of tranexamic acid for non-pediatric patients undergoing posterior spinal corrective surgery. Twenty-six patients received large doses of tranexamic acid, and thirty-three patients did not receive tranexamic acid. There were no significant differences between the two groups in terms of demographic or surgical traits. The tranexamic acid group had significantly less blood loss compared with the control group and required less blood transfusions during surgery.

Another study on complications examined disc puncture and injection performed with discography as a potential cause of lumbar disc damage. In this study, seventy-five patients who had undergone provocative discography were compared with seventy-five control patients. The two groups were matched at baseline with regard to MRI findings and other clinical and demographic features. At ten years of follow-up, fifty-seven patients in the discography group and fifty-three patients in the control group had completed all evaluations. There were sixteen lumbar spine surgical procedures in the discography group, compared with four in the control group. The use of CT and MRI studies was more frequent in the discography group. The discography group also had more adverse events that increased over time. Events included serious episodes of low back pain, work loss, medical care visits, and increased medical utilization costs.

### Evidence-Based Orthopaedics

Over the past year, the editorial staff of *The Journal* reviewed a large number of recently published research studies related to the musculoskeletal system that received a Level of Evidence grade of I. Over 100 medical journals were reviewed to identify these articles, which all have high-quality study design. In addition to the articles already cited in this Update, twenty-six level-I articles were identified that were relevant to spine surgery. A list of these titles is appended to this review following the standard bibliography. We have provided a brief commentary about each of these articles to help to guide your further reading, in an evidence-based fashion, in this subspecialty area.

### Upcoming Meetings and Events Related to Spine Surgery

The Forty-seventh Annual Meeting of the Scoliosis Research Society (SRS) will be held on September 5 through 8, 2012, in Chicago, Illinois. Web site: [www.srs.org](http://www.srs.org)

The EuroSpine annual meeting will be held on October 2 through 4, 2013 in Liverpool, United Kingdom. Web site: [www.eurospine.org](http://www.eurospine.org)

The Twenty-seventh Annual Meeting of the North American Spine Society (NASS) will be held on October 24 through 27, 2012, in Dallas, Texas. Web site: [www.spine.org](http://www.spine.org)

The Fortieth Annual Meeting of the Cervical Spine Research Society (CSRS) will be held on December 6 through 8, 2012, in Chicago, Illinois. Web site: [www.csrs.org](http://www.csrs.org)

The Annual Meeting of the American Association of Neurological Surgeons/Congress of Neurological Surgeons (AANS/CNS) Section on Disorders of the Spine and Peripheral Nerves will be held on March 6 through 9, 2013, in Phoenix, Arizona. Web site: <http://spinesection.org>

The Federation of Spine Associations will present the spine program at Specialty Day at the Annual Meeting of the American Academy of Orthopaedic Surgeons (AAOS) on March 23, 2013, in Chicago, Illinois. Web site: [www.aaos.org](http://www.aaos.org)

The Thirteenth Annual Meeting of the International Society for the Advancement of Spine Surgery (ISASS) will be held on April 2 through 5, 2013, in Vancouver, British Columbia, Canada. Web site: [www.isass.org](http://www.isass.org)

The Thirty-ninth Annual Meeting (Fortieth Anniversary) of the American Spinal Injury Association (ASIA) will be held on May 6 through 8, 2013, in Chicago, Illinois. Web site: [www.asia-spinalinjury.org](http://www.asia-spinalinjury.org)

The Annual Meeting of the International Society for the Study of the Lumbar Spine (ISSLS) will be held on May 13 through 17, 2013, in Scottsdale, Arizona. Web site: [www.issls.org](http://www.issls.org)

The Twentieth Annual Meeting of the International Meeting on Advanced Spine Techniques (IMAST) will be held on July 10 through 13, 2013, in Vancouver, British Columbia, Canada. Web site: [www.imastonline.com](http://www.imastonline.com)

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## Suggested Reading List

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## Evidence-Based Articles Related to Spine Surgery

**Artus M, van der Windt DA, Jordan KP, Hay EM.** Low back pain symptoms show a similar pattern of improvement following a wide range of primary care treatments: a systematic review of randomized clinical trials. *Rheumatology (Oxford)*. 2010;49:2346-56. Epub 2010 Aug 16.

Putative treatments for nonspecific low back pain are abundant. This meta-analysis showed that nonspecific low back pain symptoms seem to decrease in a similar pattern in clinical trials of active and inactive treatments, highlighting the prevalence of a placebo effect in these trials.

**Berg S, Tropp HT, Leivseth G.** Disc height and motion patterns in the lumbar spine in patients operated with total disc replacement or fusion for discogenic back pain. Results from a randomized controlled trial. *Spine J*. 2011;11:991-8. Epub 2011 Oct 5.

Using a precise method, distortion-compensated Roentgen analysis (DCRA), the investigators measured index and adjacent-level motion segments

before and two years after lumbar fusion and intervertebral disc arthroplasty. At two years, 70% of patients in the fusion group had no motion whereas 85% of patients in the arthroplasty group had motion. At the adjacent segments, more anteroposterior translation and angular motion occurred in patients in the fusion group as compared with the arthroplasty group. None of these radiographic findings were associated with differences in clinical outcome.

**Cheng L, Nie L, Li M, Huo Y, Pan X.** Superiority of the Bryan disc prosthesis for cervical myelopathy: a randomized study with 3-year followup. *Clin Orthop Relat Res*. 2011;469:3408-14. Epub 2011 Oct 14.

In this prospective study in which the Bryan disc replacement prosthesis was compared with traditional anterior cervical discectomy and fusion in patients with cervical myelopathy, the Bryan prosthesis was an effective treatment. Although the duration of follow-up was three years, the size of the study and the duration of follow-up were not sufficient to make conclusions regarding adjacent-segment degeneration.



## WHAT'S NEW IN SPINE SURGERY

**Daubs MD, Patel AA, Willick SE, Kendall RW, Hansen P, Petron DJ, Brodke DS.** Clinical impression versus standardized questionnaire: the spinal surgeon's ability to assess psychological distress. *J Bone Joint Surg Am.* 2010;92:2878-83. Epub 2010 Nov 12.

This article won the "best paper" award at the Scoliosis Research Society annual meeting in the past. The authors commented that 64% of patients presenting for spine evaluation have some level of psychological distress. This may impact the outcome of surgical treatment. The study did not help answer whether the psychological distress is primary or secondary.

**Delamarter R, Zigler JE, Balderston RA, Cammisia FP, Goldstein JA, Spivak JM.** Prospective, randomized, multicenter Food and Drug Administration investigational device exemption study of the ProDisc-L total disc replacement compared with circumferential arthrodesis for the treatment of two-level lumbar degenerative disc disease: results at twenty-four months. *J Bone Joint Surg Am.* 2011;93:705-15. Epub 2011 Mar 11.

In this prospective randomized trial, a lumbar intervertebral disc arthroplasty device was compared with fusion at two levels in the lumbar spine after two years of follow-up. Both groups had significant improvement from baseline ODI scores, and the arthroplasty group had significantly better results in terms of mean percentage improvement. The arthroplasty group also had better SF-36 physical scores, better visual analog scores for satisfaction, and less narcotic usage.

**Engbert K, Weber M.** The effects of therapeutic climbing in patients with chronic low back pain: a randomized controlled study. *Spine (Phila Pa 1976).* 2011;36:842-9.

This was a prospective randomized study of twenty-eight patients with chronic low back pain who underwent a four-week program of either a therapeutic climbing regimen or a standard exercise program. The study results showed comparable outcomes between the two groups, with the exception that the therapeutic climbing group had better improvements in two of the subscales of the SF-36 (perceived health and physical functioning). The study showed that therapeutic climbing is equivalent and partly superior to standard exercise therapy for patients with chronic low back pain.

**Garrido BJ, Wilhite J, Nakano M, Crawford C, Baldus C, Riew KD, Sasso RC.** Adjacent-level cervical ossification after Bryan cervical disc arthroplasty compared with anterior cervical discectomy and fusion. *J Bone Joint Surg Am.* 2011;93:1185-9.

This Level-I clinical trial showed that, after four years of follow-up, patients who had been managed with cervical disc arthroplasty had a lower incidence of adjacent-level ossification than patients who had been managed with arthrodesis and plate fixation. The clinical relevance of this finding is unclear.

**Gatti R, Faccendini S, Tettamanti A, Barbero M, Balestri A, Calori G.** Efficacy of trunk balance exercises for individuals with chronic low back pain: a randomized clinical trial. *J Orthop Sports Phys Ther.* 2011;41:542-52. Epub 2011 Jun 7.

This randomized clinical trial included seventy-nine patients with chronic low back pain who underwent either trunk balance and flexibility exercises or trunk flexibility exercises alone. Patients who underwent both balance and flexibility training demonstrated superior results with respect to Roland-Morris Questionnaire scores and SF-12 physical component summary scores. These results should be interpreted with caution, however, as the interventions only lasted five weeks.

**Gottschalk A, Durieux ME, Nemergut EC.** Intraoperative methadone improves postoperative pain control in patients undergoing complex spine surgery. *Anesth Analg.* 2011;112:218-23. Epub 2010 Apr 24.

In this prospective randomized study, patients who received methadone before surgical incision were compared with those who received a continuous infusion of sufentanil. The single bolus of methadone seemed to decrease postoperative pain for patients undergoing complex spine surgery. A substantial limitation of this study was that only twenty-nine patients were enrolled.

**Grunnesjö MI, Bogefeldt JP, Blomberg SI, Strender LE, Svärdsudd KF.** A randomized controlled trial of the effects of muscle stretching, manual therapy and steroid injections in addition to 'stay active' care on health-related quality of life in acute or subacute low back pain. *Clin Rehabil.* 2011;25:999-1010. Epub 2011 Aug 10.

Patients with acute or subacute low back pain responded best to multimodality therapy in addition to "stay active" care. The results were significant in a ten-week trial.

**Iles R, Taylor NF, Davidson M, O'Halloran P.** Telephone coaching can increase activity levels for people with non-chronic low back pain: a randomised trial. *J Physiother.* 2011;57:231-8.

In this small randomized controlled study, standard physical therapy was compared with standard physical therapy plus telephone coaching aimed to improve exercise. The addition of telephone coaching significantly improved function and recovery expectations.

**Jawahar A, Cavanaugh DA, Kerr EJ 3rd, Birdsong EM, Nunley PD.** Total disc arthroplasty does not affect the incidence of adjacent segment degeneration in cervical spine: results of 93 patients in three prospective randomized clinical trials. *Spine J.* 2010;10:1043-8. Epub 2010 Sep 24.

Ninety-three patients were randomized to either anterior cervical discectomy and fusion (n = 34) or total disc arthroplasty (n = 59). This comparative study demonstrated that total disc arthroplasty was equivalent to anterior cervical discectomy and fusion for providing relief of symptoms. Furthermore, the risk of developing adjacent-disc segment degeneration was equivalent after both procedures but was significantly greater for patients who had concurrent substantial disc degeneration of the lumbar spine.

**Jensen C, Jensen OK, Christiansen DH, Nielsen CV.** One-year follow-up in employees sick-listed because of low back pain: randomized clinical trial comparing multidisciplinary and brief intervention. *Spine (Phila Pa 1976).* 2011;36:1180-9.

The number of sick leave days due to low back pain was compared between a multidisciplinary hospital-based intervention and a brief advice session with a rehabilitation physician and a physical therapist in this randomized clinical trial. The authors found no difference in terms of return to work or in terms of other outcome measures, leading them to suggest that brief interventions may offer similar results with less cost and commitment on the part of both patients and physicians.

**Lafage V, Schwab F, Vira S, Patel A, Ungar B, Farcy JP.** Spino-pelvic parameters after surgery can be predicted: a preliminary formula and validation of standing alignment. *Spine (Phila Pa 1976).* 2011;36:1037-45.

To predict postoperative spinopelvic parameters (pelvic tilt and sagittal balance) after deformity correction in adult patients, a set of predictive criteria was developed with use of regression analysis. These criteria were then used to predict the pelvic tilt and sagittal balance for a prospective cohort undergoing surgery. The study demonstrated that pelvic tilt could be predicted from a combination of parameters: pelvic incidence, maximal lordosis, and maximal kyphosis. The sagittal balance could be predicted from the same parameters in addition to the predicted pelvic tilt.

**Lee JH, Lee SH.** Comparison of clinical effectiveness of cervical transforaminal steroid injection according to different radiological guidances (C-arm fluoroscopy vs. computed tomography fluoroscopy). *Spine J.* 2011;11:416-23.

This prospective, randomized study compared the use of CT fluoroscopy with regular fluoroscopy for the administration of transforaminal cervical epidural injections in patients with cervical disc herniations. The authors concluded that the use of CT fluoroscopy was superior because of better improvements in arm pain scores and functional status, with fewer complications.

**Masiero S, Bonaldo L, Pigatto M, Lo Nigro A, Ramonda R, Punzi L.** Rehabilitation treatment in patients with ankylosing spondylitis stabilized with

## WHAT'S NEW IN SPINE SURGERY

tumor necrosis factor inhibitor therapy: a randomized controlled trial. *J Rheumatol.* 2011;38:1335-42. Epub 2011 Apr 1.

This randomized controlled trial of sixty-two patients with ankylosing spondylitis who were receiving anti-TNF (tumor necrosis factor) agents demonstrated that a rehabilitation program combined with an educational/behavioral program was more effective than either the educational/behavioral program alone or no additional therapy for controlling spinal pain and preserving chest and spine range of motion.

**Memtsoudis SG, Vougioukas VI, Ma Y, Gaber-Baylis LK, Girardi FP.** Perioperative morbidity and mortality after anterior, posterior, and anterior/posterior spine fusion surgery. *Spine (Phila Pa 1976).* 2011;36:1867-77.

In this study from the National Inpatient Sample, the incidence of procedure-related complications was 18.8% for anterior fusion, 15.7% for posterior fusion, and 23.8% for anteroposterior fusion. The mortality rate was approximately half following posterior fusion as compared with anteroposterior fusion ( $0.26 \pm 0.01$  versus  $0.51 \pm 0.04$ ).

**Morris S, Morris TP, McGregor AH, Doré CJ, Jamrozik K.** Function after spinal treatment, exercise, and rehabilitation: cost-effectiveness analysis based on a randomized controlled trial. *Spine (Phila Pa 1976).* 2011;36:1807-14.

The cost-effectiveness of four postoperative treatment groups (rehabilitation only, booklet only, rehabilitation plus booklet, or usual care only) was compared. No treatment proved more cost-effective using commonly accepted thresholds.

**Podichetty VK, Varley ES, Lieberman I.** Calcitonin treatment in lumbar spinal stenosis: a meta-analysis. *Spine (Phila Pa 1976).* 2011;36:E357-64.

This meta-analysis of the use of calcitonin for the treatment of lumbar spinal stenosis demonstrated that there was no statistical evidence that calcitonin reduced the symptoms of spinal stenosis. This conclusion was based on four studies with 255 patients that met inclusion criteria.

**Rendant D, Pach D, Lüdtke R, Reissauer A, Mietzner A, Willich SN, Witt CM.** Qigong versus exercise versus no therapy for patients with chronic neck pain: a randomized controlled trial. *Spine (Phila Pa 1976).* 2011;36:419-27.

In this randomized controlled trial, 123 patients with chronic neck pain were managed with either qigong, exercise therapy (eighteen sessions over six months), or no treatment. The results were similar for both the qigong and exercise therapy groups, and qigong was more effective than no treatment in terms of pain scores, neck pain and disability, and SF-36 results.

**Staples MP, Kallmes DF, Comstock BA, Jarvik JG, Osborne RH, Heagerty PJ, Buchbinder R.** Effectiveness of vertebroplasty using individual patient data from two randomised placebo controlled trials: meta-analysis. *BMJ.* 2011;343:d3952. doi: 10.1136/bmj.d3952.

This meta-analysis combined data from two previously published randomized controlled trials comparing vertebroplasty with placebo treatment. The study failed to show that vertebroplasty had any benefit in comparison with a placebo procedure with respect to outcome measures at one month after surgery, including pain scores, Roland-Morris questionnaire scores, and narcotic usage.

**Suri P, Rainville J, Kalichman L, Katz JN.** Does this older adult with lower extremity pain have the clinical syndrome of lumbar spinal stenosis? *JAMA.* 2010;304:2628-36.

Spinal stenosis is often a clinical diagnosis. The absence of pain when seated and improvement of symptoms when bending forward are the most useful individual clinical findings to predict the diagnosis of spinal stenosis in patients with lower extremity pain.

**Tosteson AN, Tosteson TD, Lurie JD, Abdu W, Herkowitz H, Andersson G, Albert T, Bridwell K, Zhao W, Grove MR, Weinstein MC, Weinstein JN.** Comparative effectiveness evidence from the spine patient outcomes research trial: surgical versus nonoperative care for spinal stenosis, degenerative spondylolisthesis, and intervertebral disc herniation. *Spine (Phila Pa 1976).* 2011;36:2061-8.

The costs and quality-adjusted life years (QALYs) were calculated at four years of follow-up of patients who had undergone operative or nonoperative treatment for disc herniation, spinal stenosis, and spondylolisthesis. The number of QALYs gained was greater in all three surgically treated groups and the cost per QALY gained was \$59,000, \$64,300, and \$20,600 for the patients with spinal stenosis, spondylolisthesis, and disc herniation, respectively. The surgical treatments proved cost-effective for three defined groups.

**Umetsa RS, Avanzi O.** Techniques of lumbar-sacral spine fusion in spondylosis: systematic literature review and meta-analysis of randomized clinical trials. *Spine J.* 2011;11:668-76. Epub 2011 Jun 8.

This systematic review included eight studies that examined perioperative and postoperative outcomes associated with various surgical interventions for lumbar-sacral spondylosis. The study demonstrated that patients who underwent interbody fusion had less blood loss and higher fusion rates, whereas those who underwent posterolateral fusion had shorter operative times and fewer complications. Page: 35. The wide variety of indications for surgical treatment with lumbar-sacral fusion makes the interpretation and generalization of these results problematic.

**van Middendorp JJ, Hosman AJ, Donders AR, Pouw MH, Ditunno JF Jr, Curt A, Geurts AC, Van de Meent H; EM-SCI Study Group.** A clinical prediction rule for ambulation outcomes after traumatic spinal cord injury: a longitudinal cohort study. *Lancet.* 2011;377:1004-10. Epub 2011 Mar 4.

In order to assist clinicians in setting realistic rehabilitation goals and to provide better prognostic information to patients, logistic regression was used to build a model based on early physical examination attributes to predict the potential for ambulation. The final model included such variables as age, motor strength of the quadriceps and gastrocnemius-soleus muscles, and light touch sensation in the L3 and S1 dermatomes.

**Walker BF, French SD, Grant W, Green SA.** Cochrane review of combined chiropractic interventions for low-back pain. *Spine (Phila Pa 1976).* 2011;36:230-42.

This Cochrane systematic review of randomized controlled trials was performed to determine the effects of chiropractic interventions on adults with low back pain. The review included twelve studies involving 2887 participants. The authors concluded that chiropractic interventions led to slight improvement in terms of pain and disability in the short term, and improvement in terms of pain in the intermediate term, for both acute and subacute low back pain. There was no evidence to support or refute that these interventions provide any clinical meaningful difference for pain or disability for low back pain compared with other interventions.