The management of adult spinal deformity remains a challenging and controversial endeavor. It is estimated that adult degenerative scoliosis affects greater than 15% of the current United States population older than 60 years of age. The need for evidence based strategies to care for this condition has intensified as the baby boomers age and the prevalence of this condition continues to mount. In the current health care environment, with cost containment and resource limitations, physicians have had to develop new ways to treat this growing problem with a “less is more” approach. At UPMC, we have developed a treatment strategy to this debilitating condition where in fact we can achieve “more with less”—less invasive that is.

Adults with spinal scoliosis typically present with chronic back pain due to asymmetrical degeneration of the spine. They can also have associated leg pain or weakness caused by the concurrent narrowing of the spinal canal and nerve root exit holes that contemporaneously occurs with the structural deformity. Conservative management under the guidance of a spine care professional is the mainstay of treatment for this condition, yet its efficacy is limited in both its functional as well as its aesthetic value. Although there is no consensus as to the optimal surgical management of spinal deformity, those treated operatively have shown a significantly greater improvement in their pain and overall quality of life when compared to their non-operative equivalents.

When symptoms remain progressive and refractory to conservative treatment, surgical correction is considered; the specific goals of which are to obtain pain relief by providing decompression of the nerves, optimizing spinal balance, and achieving a solid fusion. In many cases, these patients require treatment strategies that address both the front and back of the spinal column to release the spine and make it more flexible and then correct the deformity and lock it in place.

Traditional approaches to accomplish this task have involved surgery through the abdomen to obtain access to the front of the spine, followed by a surgery from the back. These interventions have been associated with not only large unsightly scars but a complication risk ranging between 30 and 80%. As the contemporary treatment of this condition has evolved, spine surgeons have employed numerous strategies to minimize those risks—the incorporation of minimally invasive spinal techniques is the most recent of such innovations.

Surgery for adult scoliosis is now performed at UPMC in a staged fashion. A posterior approach is initially performed to remove the rigid bones that have grown across the joints while decompressing the nerve roots and restoring flexibility to the spinal column. After a few days, stage 2 is performed employing minimally invasive techniques (i.e., XLIFs) to gain lateral access to the disc spaces in the front of the spine.

Images at right: A 65-year-old woman’s spine with degenerative scoliosis reveals 3D reconstructed CT digital images (1a) before and (1b) after her two-staged deformity correction surgery. Note the rotation and collapse of the lumbar vertebrae that compress the nerves as they exit the spinal canal. Stage 1 of the surgery is performed from the back to decompress the nerves and improve the flexibility of the spine as well as place screws for later fixation. During Stage 2 of the procedure, minimally invasive lateral removal of the degenerated discs is performed through one-inch incisions and replaced with synthetic bone grafts filled with the latest biologic bone simulators preventing the need for donor hip or cadaver bone grafts of yesteryear. Note the significant increase in space between the vertebral bones before (2a) and after (2b) graft placement, enabling the nerves to pass freely to the legs without deformity or compression.
Neurosurgery 2050

What will neurosurgery be like in the year 2050? Given the unpredictable direction of ingenuity and discovery, delineating such forecast is likely to be flawed. Unclear is where a prediction might be overambitious, or fall short as we have in the treatment of certain types of illnesses (i.e. glioblastoma, spinal cord injury). Technology and basic science will surely advance. A key question is which advance will deliver real benefits for our patients. What will really change and what will remain the same? I will delineate several questions and provide an opinion on where I see our neurosurgical future.

There will be a new “app” on your mobile device that will monitor your overall health status. Your mobile device will not be an external device but rather an implanted body temperature driven, self-charging device. In addition to having all the communication capabilities, it will execute a continuous screen targeting detection of life threatening events.

Miniaturized mass spectrophotometers will analyze interstitial body fluid biomarkers identifying tumor cells prior to their becoming an invasive malignant neoplasm. An automatic message will be delivered to your health care manager who will coordinate the next therapeutic step. There will be an “app” in development where the appropriate therapy will be automatically instituted (2060 technology in development).

Tumors will be treated by using remotely and self-operated nano-tumor destroyers. Using a combination micrometabolite detection and image-targeted technology, these microscopic devices target tumors and deliver lethal doses of thermal energy. The osmotic gradient detection device will drive the nano surgical device to target each infiltrating malignant glial cell. The nano neurosurgery device binds to the tumor specific cell surface receptors and—with absolute precision—selectivity kills one tumor cell at a time.

A challenge in the management of asymptomatic neurovascular lesions, is predicting which will have a benign course and which ones will result in devastating and often lethal hemorrhages or strokes. Therefore predicting the natural history of intracranial aneurysms, AVMs and carotid plaques provides the opportunity to only treat hazardous lesions. The personalized biosensor will be able to detect specific soluble metalloproteases which predict aneurismal and AVM rupture, and novel reactive inflammatory markers indicating high risk of stroke due to carotid plaque rupture. A timely alert message will be delivered to the health care manager who will institute appropriate therapies.

Management of neurological diseases will be occurring in mechanism-specific rather than diseases-specific clinics. Neuroprotection clinics will address diseases featuring neuronal cell death. Drugs, which target neuronal cell death, will be delivered by sub-specialty clinicians. This approach will be aimed at preventing neurodegeneration in acute (i.e. stroke, head trauma, spinal cord injury) as well as chronic (i.e. amyotrophic lateral sclerosis, Alzheimer’s, Parkinson’s, and Huntington’s disease) neurodegenerative disorders. Patients with extensive or advanced neurodegeneration will be treated in the Neuroregeneration clinic. Therapies which stimulate endogenous neural stem cells will repopulate injured areas of the brain and spinal cord. The Neurorepair clinic will complement and enhance the recovery potential by implanting neural augmentation devices. These implanted devices will be able to drive artificial limbs allowing seamless upper and lower extremity function.

Many of the above-described approaches could appear to be far into the future, or even science fiction. However, efforts to achieve many of these goals are currently under way both within our department and within the University of Pittsburgh and UPMC. In a coordinated fashion, we are working towards accomplishing what only a few years ago was considered to be impossible.

Coordinated basic scientific and technology driven approaches will allow us to reach unprecedented progress and enable us to treat our patients in revolutionary and novel manners. ‘Life Changing Medicine,’ the new motto of UPMC, is the driving force behind our engine and institutional strategic efforts to make these dreams a reality. Our history and commitment for innovation will lead in novel and exciting directions enabling us to treat untreatable diseases.

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Extreme lateral interbody fusion: The forefront of minimally invasive spine surgery

by Matthew B. Maserati, MD; Matthew J. Tormenti, MD; Adam S. Kanter, MD

Surgeons at the University of Pittsburgh Medical Center have been performing an inimitable minimally invasive technique for spinal fusion known as eXtreme Lateral Interbody Fusion (XLIF) in innovative ways for a plethora of spinal pathologies. Interbody fusion, in which adjacent lumbar vertebrae are caused to fuse to one another by performing radical removal of the intervertebral disk followed by insertion of a “cage” filled with bone, has traditionally been performed either through a traditional posterior approach to the lumbar spine or through an anterior trans-abdominal approach.

The extreme lateral approach differs from these conventional approaches in that it allows access to the intervertebral disk without the need for muscle dissection—which is required for posterior approaches—or for mobilization of critical neurovascular structures encountered in the anterior approach to the spine.

The XLIF technique involves a “muscle splitting” approach, in which the muscles of the lateral abdominal wall and spine are progressively dilated to allow placement of a tubular retraction device (figure 1). The retractor is secured to the operating table following which the entire procedure is then performed through this narrow portal (figure 2). The neural and vascular supply to these muscles is consequently preserved resulting in decreased tissue trauma, scarring and pain. XLIF is thus not only “minimally invasive”—typically performed through a single or series of incisions less than one inch in length—but more importantly, “minimally disruptive.” This decreased disruption of the stabilizing paraspinal muscles has translated into decreased post-operative pain, shorter hospital stays, and greater patient satisfaction.

The novelty of the XLIF procedure lies in the mating of the trans-psoas approach—itself an old idea—with the latest nerve monitoring technology and retracting tissue portals, making it possible to safely and effectively perform lumbar discectomy and interbody fusion from the lateral trajectory. Fiber optic light cables illuminate the small operating corridor, while an integrated electrophysiologic monitoring system provides real-time feedback that allows the surgeon to avoid injury to the nerves of the lumbar plexus during dilation of the psoas muscle and insertion of the retractor. Following an XLIF procedure, patients typically spend one to two nights in the hospital, depending on the number of levels fused.

Over the past several years, surgeons at UPMC have performed XLIF for the treatment of a wide range of spinal disorders, including symptomatic lumbar intervertebral disk degeneration causing back or leg pain (figure 3), myelopathy due to thoracic intervertebral disk herniation, traumatic thoracolumbar fractures, spine tumors, and even adult degenerative scoliosis. In some cases, such as in the correction of complex thoracolumbar kyphoscoliotic deformities, XLIF is performed in conjunction with an open posterior approach in which rigid long-segment fixation of the spine is performed with pedicle screws and rods (see article on page 1). Even when used as part of a combined two-stage procedure, the XLIF has resulted in decreased blood loss, shorter operative times, and fewer procedure-related complications.

XLIF has proven to be a powerful tool whose use in select patients allows safe access to the anterior spine for the purposes of discectomy, corpectomy, interbody fusion and even lateral fixation, while causing minimal disruption to muscles and other stabilizing structures of the spine. Our surgeons continue to explore new indications for XLIF, and will continue to bring similar cutting-edge technologies to our patients as we pursue our goal of offering the best possible spine care.
Over the past decade, spinal fusion with or without instrumentation has become a common technique in the surgical treatment of symptomatic degenerative disease of the lumbar spine. Technological advances have resulted in increased fusion rates, while decreasing the need for post-operative immobilization and brace therapy. However, while many patients have benefited from fusion procedures, successful fusion has not always been accompanied by clinical improvement. There is a concern that spinal fusion may lead, in some cases, to secondary, delayed effects that negatively affect the final clinical outcome.

Evidence is growing that fusion of a portion of the lumbar spine may in fact have undesirable long-term effects on the remainder of the spine, particularly on the immediate adjacent motion segments. This phenomenon is thought to be due to the altered biomechanics of the fused spine, wherein abnormal forces acting upon the intervertebral discs and facet joints adjacent to the fused segment precipitate the accelerated failure of these stabilizing elements. From this evidence for adjacent-segment degeneration emerged the concept of “dynamic” or nonfusion stabilization of the lumbar spine.

Dynamic stabilization was conceived in order to stabilize the spine without fusion, thus relieving the patient’s symptoms but avoiding the negative affects of fusion. Posterior dynamic stabilization, in which pedicle screw fixation is coupled with a flexible longitudinal connecting system, presumably allows for the normalization of inter-segmental motion. This stands in contrast to traditional fusion surgery, in which the goal is complete and immediate elimination of motion and, ultimately, arthrodesis. The dynamic stabilization is intended to address the underlying pathology of microinstability, but to do so in a more physiological manner.

Given our success with posterior dynamic stabilization that successfully avoided the need for lumbar spinal fusion in some patients, in 2008 we began exploring the ability to implant a new hybrid dynamic stabilization system for patients with advanced degenerative disease requiring fusion who already have signs of adjacent segment degeneration. This new advanced technology joins together a traditional rod and screw fusion construct with a dynamic stabilization system immediately adjacent to the fusion. The Dynesys Dynamic Stabilization System (Zimmer Spine) is combined with the Optima traditional screw and rod construct. The idea behind this technique is to slow the progression of degeneration at the adjacent vertebral segment without the drawbacks of including yet another vertebral level in the fusion.

Our preliminary experience with the DTO Hybrid construct was recently published in the journal Neurosurgery Focus and featured in a podcast in June 2010. The DTO Hybrid system represents a unique new technology that allows for the coupling of arthrodesis with dynamic stabilization at adjacent levels in the lumbar spine. It is an example of how technological advances in spine surgery are allowing for smarter and better operations for our patients with the goal of preventing the need for future surgical interventions.
A new minimally invasive treatment strategy for vertebral body tumors

by Peter C. Gerszten, MD, MPH; Edward A. Monaco III, MD, PhD

During the past decade there has been an evolution in the development of minimally invasive surgical techniques applied to the field of spine surgery. Such techniques follow a natural trend in surgery to minimize the injury to normal tissue while obtaining the same or better surgical outcome than more invasive techniques. Along these lines, there has been significant interest in applying minimally invasive techniques to the field of spine oncology. The goals for the treatment of spinal tumors include the prevention of local disease progression, preservation of spinal structural stability, preservation of neurological function, and the abolishment of pain. Traditionally, achieving these goals has involved treatment by surgery, radiation therapy, and chemotherapy, alone or in combination.

Patients with symptomatic pathologic compression fractures require spinal stabilization surgery for mechanical back pain control and radiation therapy for the underlying malignant process. Patients with spine tumors are often debilitated and at a high risk for surgical morbidity. For patients with limited life expectancies from their underlying disease, high surgical complication rates with subsequent decrease in quality of life are most unacceptable. As part of this trend, there has been a steady increase in the past decade in the use of percutaneous vertebral body injection of polymethylmethacrylate (PMMA) for the treatment of symptomatic cancer-associated compression fractures. Recent publications have supported the role for techniques such as balloon kyphoplasty for these pathological fractures.

Percutaneous cement augmentation may be contraindicated, however, in lesions with spinal canal compromise due to the risk of displacement of tumor resulting in spinal cord or cauda equina injury. Recent technological advances have allowed for the capability to perform direct tumor removal via the Kyphoplasty cannula, thus decreasing this aforementioned risk. Prior to bone cement placement, a device called the Cavity SpineWand is placed directly through the working cannula, and the tumor is removed in a circumferential manner under fluoroscopic guidance. The goal of this procedure is to create a cavity within the effected vertebral body prior to Kyphoplasty balloon insertion. The bone cement is then placed directly into the cavity under fluoroscopic visualization. The entire vertebral body can thus be safely filled, allowing for a better clinical outcome.

Radiosurgery is defined as the precise delivery of a highly conformal, large radiation dose to a specific target via a stereotactic approach. Recent publications have supported the use of radiosurgery for the treatment of spine tumors. Spine radiosurgery provides excellent long-term radiographic control as well as symptomatic response for vertebral metastases. The Kyphoplasty fracture fixation procedure may be followed by spine radiosurgery that allows for the delivery of a tumoricidal dose to control local disease progression. The radiosurgery treatment is delivered using either the CyberKnife or Synergy S platforms, both available at our institution.

This technique of complete percutaneous treatment of vertebral body tumors causing spinal canal compromise uses transpedicular cavitation, bone cement augmentation, and radiosurgery. This new combination of three unique minimally invasive procedures avoids the morbidity associated with open surgery while providing spinal canal decompression and immediate fracture stabilization followed by the delivery of a single-fraction tumoricidal radiation dose.

From top: (A) KyphX balloon inflated; (B) Case example of a 74-year-old man with a symptomatic L1 thyroid carcinoma metastasis; (C) Under fluoroscopic guidance, the device is inserted through an 8-gauge working channel and advanced in multiple directions to remove tumor tissue from within the vertebral body; (D and E): Sagittal and axial projections of the isodose lines of the radiosurgery treatment plan demonstrating methylmethacrylate within the vertebral body.
Novel expandable intervertebral fusion device for degenerative spine disease

by Pawel G. Ochalski, MD; Matthew B. Maserati, MD; John J. Moossy, MD

Improvements in both technology and technique have greatly advanced the field of spinal surgery. As a result, conventional open surgical approaches have been challenged in favor of less invasive approaches. These newer approaches have been shown to minimize tissue manipulation while at the same time improve patient outcomes and reduce approach related complications. An example of this type of change is in the treatment of spinal disease in the use of intervertebral graft implantation. Originally developed in 1950 by Dr. Cloward, the technique consisted of a posterior open approach using an iliac autograft. Although effective in achieving fusion, this technique was associated with a significant recovery period and neurologic risk. Over the next 50 years, less “invasive” lateral approaches were developed which offered greater access to the disc space to allow for graft implantation while reducing approach related complications. These surgical techniques combined with the introduction of novel implants seem to improve outcomes. Nevertheless, additional improvements are necessary to optimize patient outcomes.

Recently, UPMC neurosurgeons at the VA hospital have implemented the use of a new FDA-approved intervertebral fusion device called OptiMesh (Spinology, St. Pail, MN) in selected patients. OptiMesh is a conformable, porous, polymeric bone containment device (figure 1). The mesh can be easily deployed into the intervertebral disc space via an 8mm minimal access working portal and then packed tightly with an allograft bone mixture. Once tightly packed, the filling process creates a structural, load-bearing construct capable of distracting the vertebrae and restoring alignment (figure 2C).

We have used the device in patients with degenerative disc disease resulting in back and or leg pain with good results. All patients had mechanical back pain with a unilateral lower extremity radiculopathy. All patients underwent a microdiscectomy with partial medial facetectomy followed by implantation of the OptiMesh expandable intervertebral fusion device as shown in figure 3. Patients also underwent a posterior instrumented pedicle screw fusion. In terms of patient outcomes, the mean pre-operative VAS score was 5.3 versus 1.5 at the 3-month follow-up visit. The disc space distraction post-operatively measured on standing lateral x-rays averaged to 4.5mm (range 1.9 mm to 7.9 mm). The mean length of stay was 3.5 days and intra-operative blood loss average was 362 cc. No complications were encountered. Intraoperatively, surgeons have noticed a significant decrease in the need for nerve root retraction during the implantation due to the small portal used for graft deployment. In addition, once inside the disc space and fully packed, the graft can produce disc space distraction allowing for indirect nerve root decompression and restoration of alignment (figure 3).

All neurosurgeons who have used the technique found it to be especially helpful in obese patients where access to the deep vertebral elements is always difficult. Additionally, using the portal in redo operations has been very effective in reducing the need for neural element retraction especially in cases where scarring limits disc space access as well as nerve root exposure. Overall, surgeons have found that the OptiMesh expandable device and implantation technique offers the benefits of a smaller access corridor into the disc space requiring less bony removal and less neural retraction. With the continued use of the device surgeons believe they can achieve fewer neural retraction complications, lower blood loss, shorten the hospital stay and reduce operative time as a result of this new minimal access technique.
Department Ranks First in Academic Output

The Department of Neurological Surgery ranked first in academic output in top-tier specialty journals among all departments of neurosurgery across the United States and Canada, according to a study published recently in the Journal of Neurosurgery.

Researchers from the Barrow Neurological Institute in Phoenix and the neurosurgery division of the University of Toronto applied the h-index, which reflects the number of papers and citations of an individual, to 99 American and 14 Canadian neurosurgery departments with residency programs.

The results showed that Pitt’s Department of Neurological Surgery had the highest h score for the number of papers published by its faculty in the Journal of Neurosurgery and Neurosurgery from 2000 to 2009; it ranked 7th when all journal publications were included in that time frame, and 8th when there were no time constraints.

“I am extremely proud that the University of Pittsburgh ranked so well on all these measures,” said department chair Robert M. Friedlander, MD “We have a great balance of accomplished academicians and gifted clinicians who are clearly making a difference in the field.”

The researchers noted that the h indices exhibit significant correlations with other measures of institutional scholarship and productivity, such as NIH funding, number of faculty, and the academic degrees held by faculty.

Center to Host International Gamma Knife Event

The University of Pittsburgh Center for Image Guided Neurosurgery will host the first ever “Gamma Knife Radiosurgery in the Americas,” September 17-19, 2011. The meeting, sponsored by the North American Gamma Knife Consortium, is intended to help encourage collaborative research related to the use of the Leksell Gamma Knife and is open to representatives from Gamma Knife sites throughout North, Central, and South America. For more information, please contact Douglas Kondziolka, MD, at (412) 647-6782.

Maroon Finishes With Personal Best in Ironman

Joseph Maroon, MD, completed a personal best time of 15 hours, 40 minutes and 31 seconds in the 2010 Ironman World Championship Triathlon held October 9 in Kona, Hawaii.

The Hawaiian Ironman event is widely considered one of the most grueling endurance competitions in the world and consists of a 2.4-mile swim in the ocean, followed by a 112-mile bike ride through the Hawaiian lava fields, and then a 26.2-mile full-marathon.

Dr. Maroon’s time placed him 17th in his age division (70-74) and 1,725th overall.

In The Media

• Dr. Friedlander was quoted in a research brief on the Alzheimer Research Forum website that dealt with a report that blocking apoptosis in ALS model mice keeps motor neurons alive, suggesting apoptosis is a central part of the pathological process.

• Adam Kanter, MD, was featured in an October 4 Pittsburgh Post-Gazette article discussing the sudden sensory and motor deficits in the arms or the legs of injured athletes and the differences between spinal concussion and spinal shock.

• Peter Gerszten, MD, and the UPMC Synergy team were featured in the August 2010 issue of Wavelength Magazine, an industry trade magazine. The article talked about the success the UPMC team has in using the Synergy S stereotactic radiosurgery system to treat spine and paraspinal lesions.

Dr. Gerszten was also noted in a August 2010 Spinal News International article that highlighted his recent clinical trial demonstrating patients treated with plasma disc decompression products experience reduced pain and better quality-of-life scores compared to patients treated with the current standard of care.

• Dr. Maroon authored an article entitled “Triathlons For Stress Reduction,” for the Summer 2010 issue of CNS Quarterly, the official magazine of the Congress of Neurological Surgeons. The article discusses how exercise—particularly running—can help strengthen psyche and fulfill our life.

Dr. Maroon was also a guest on the KDKA Radio Morning News (Pittsburgh) October 19, discussing head injuries in sports.

Honors & Congratulations

• David O. Okonkwo, MD, PhD, received the Brain Injury Association of America’s 2010 Young Investigator Award at the Annual National Neurotrauma Society Symposium in June.

• L. Dade Lunsford, MD, was an honored guest of the Taiwan Gamma Knife Society, September 16; Dr. Lunsford was also the honored guest professor at the French Speaking Practical Course on Radiosurgery, October 25-27.

• Congratulations to Connie Rivera, radiology scheduler, for her selection as a 2010 UPMC Clinical Trial Participants Sought

• The CERN Foundation is currently enrolling patients into its open adult and pediatric ependymoma clinical trials. For details on the trials, or for more information about the CERN Foundation in general, visit www.cern-foundation.org.

• University of Pittsburgh researchers are seeking participants ages 18 and older with epilepsy to compare the effectiveness of Gamma Knife® radiosurgery with temporal lobectomy in the treatment of patients with drug-resistant temporal lobe epilepsy. For more information, please call (412) 683-7279.

Welcome

Oxana Baranov, researcher; Sergei Baranov, PhD, research associate; Diane Carlisle, PhD, research assistant professor; Wei Huang, PhD, research associate; Zhihong Huang, MD, research assistant professor; Chunfeng Huo, researcher; Michele Perpetua, lab manager; Hiroko Yano, PhD, assistant professor; George Zenonos, research fellow; Yu Zhang, assistant professor; Bobbie Ragsdale, medical secretary to Drs. Abla & Wecht; Marcella Staropoli, medical secretary to Drs. Horowitz and Jankowitz; Elizabeth Cable, medical record clerk.

Personal Congratulations

• Johnathan Engh, MD, and wife Kelley, had a baby daughter (Evelyn Ann) on July 16.
Minimally invasive advancements modernize adult scoliosis surgery

(continued from page 1)

The collapsed discs are removed and replaced with height restoring cages and biologic agents to enhance the nerve root decompression and augment spinal realignment. This approach not only limits the surgical scars, but also the blood loss, pain and many of the complications associated with the large abdominal approaches of years past. Screws and rods are then placed through the initial incision in the back to finalize the deformity correction and fortify the final structure and position of the spine.

In sum, we have developed a unique, multi-staged approach to the surgical treatment of the very complex and all too often incapacitating condition of adult degenerative scoliosis. We continue to gather data and employ scientific prudence while treating every patient as an individual with a unique set of needs, employing contemporary surgical techniques at the forefront of innovation and practice—an example of which is apparent in the case of a 65-year-old woman who presented with progressive spinal deformity rendering her minimally functional and maximally debilitated.

At right: In the final portions of the second stage in the deformity correction, the patient is returned to the prone position for final rod placement and fixation with the application of morselized bone (collected during stage one of the procedure) to the back of the spine to encourage added fusion and long-lasting strength and stability.