THE SPINE HEALTH JOURNAL

Fall 2023

A Patient Primer on Adult Spinal Deformity:
Clearing up a Complex & Complicated Condition

Guest Editor in Chief, *Lawrence G. Lenke, MD*

NATIONAL SPINE HEALTH FOUNDATION

The National Spine Health Foundation is a 501(c)(3) nonprofit organization dedicated to improving spinal health care through patient education, patient advocacy and clinical outcomes research. We educate patients and the public about the treatment and prevention of neck and back disorders with unbiased, expert-driven educational resources, supporting patients through peer-to-peer connection on their journey to spinal health. This publication is a service of NSHF that aims to provide a deeper understanding of the science of spine care technology and techniques, serving as a bridge toward knowledge and hope for anyone suffering from spine problems.

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An Introduction from Rita Roy, MD

CEO, *NSHF*

In May of this year, NSHF was bestowed with The Digital Health Awards prestigious prize for our Spine-Talks patient education video titled: "Do No Harm: A Remarkable Conversation Between a Patient and her Surgeon." This award is significant because the program honors the best digital health resources out there. **It's no wonder this video was a winning entry,** it featured Dr. Larry Lenke in an open and honest conversation with his patient, Pat Schellhorn, discussing her complicated journey to finding successful treatment with him for her complex adult spinal deformity. Not only is their conversation remarkable, but moreso is the vision behind making this video possible, and that vision came **from Dr. Lenke.**

I recall standing in the reception hall celebrating Dr. Lenke's receipt of the Walter Blount Humanitarian award from the Scoliosis Research Society at their 57th meeting in Stockholm. It is given to an individual who has 'provided outstanding service for those with spinal deformities, through their generous actions out of a sense of service to larger social and professional goals.' As I congratulated him, Dr.Lenke quickly and enthusiastically said, "*Rita, I have an idea for a video. I will ask one of my patients to join me and we can talk about her journey. Her story is really amazing.*"

That was in September, Dr. Lenke's wonderful staff connected the patient with me, and we filmed in December.

Dr. Lenke is the Surgeon-In-Chief at New York-Presbyterian Och Spine Hospital, Professor of Orthopedic Surgery and Chief of Spinal Deformity Surgery at Columbia University Vagelos College of Physicians and Surgeons. He is world-renowned for the surgical treatment of both pediatric and adult spinal patients with an expertise in the most complex deformities. He and his colleagues of the Harms Study Group developed the Lenke Classification System of Adolescent Idiopathic Scoliosis (AIS), which remains the global gold standard for measuring and classifying spinal curvature. In this edition of our Journal, we show you this system on page 36, not because we think you will learn it, but to demonstrate the depth of technical knowledge required to treat spinal deformity.

When I first met Dr. Lenke at a conference that he organizes called The International Spinal Deformity Symposium (ISDS) I was humbled and nervous to meet this surgeon whose reputation precedes him. He invited us there to film our very first Spine-Talks panel in person just as the Covid pandemic was lifting in December of 2021. It was his idea for us to attend his meeting, invite his colleagues to join us, carve out space and time, and do something that had never been done before; gather world experts on a panel to speak to the public. As we were launching the concept of Spine-Talks, Dr. Lenke was quick to understand our purpose: to give knowledge and hope to anyone suffering from a spinal condition.

Dr. Lenke has been listed in Best Doctors in America for the last 20 years. He has served in numerous leadership positions, making significant contributions to the world's most prestigious professional spine societies. Dr. Lenke's accolades and achievements are numerous: his CV is 312 pages long! But what everyone knows about Dr. Lenke, and what I learned at that first meeting, is there is no need to be nervous: notwithstanding his accomplishments, he is a gentle and kind man who cares deeply not only about each and every patient he sees, but also the many surgeons he has trained, and the field to which he has contributed greatly.

We are honored to have his vision, leadership and compassion as a Board member of NSHF. In the following pages, you will read carefully curated articles that Dr. Lenke has assembled to serve as a primer for those seeking information on adult spinal deformity.

- Rita Roy, MD

Lawrence G. Lenke, MD

Professor of Orthopedic Surgery at CUMC

Co-Director *of Och Spine,* ***Surgeon-in-Chief*** *at the Och Spine Hospital, and* ***Chief of spinal deformity*** *in the Department of Orthopedic Surgery at New York-Presbyterian/Columbia University Irving Medical Center.*

> ***"The goal of this issue is to provide a thorough, unbiased, expert treatise on this unique form of spinal disease..."***

Letter From the Guest Editor

In this fall issue of the National Spine Health Foundation's (NSHF) Spine Health Journal, we are pleased to present, **A Patient Primer on Adult Spinal Deformity: Clearing up a Complex and Complicated Condition.** Adult spinal deformity (ASD) encompasses a spectrum of spinal disorders affecting adults from age 18 and beyond. The most common ASD diagnoses are idiopathic and degenerative scoliosis, or curvatures affecting any region of the thoracic (mid-back) or lumbar (lower back) region, with the lumbar deformities more common in the older population. However, there are many other conditions described under the ASD diagnosis, and these conditions are quite heterogeneous and variable.

In this issue, we will present an in-depth view of what ASD is, how it affects one's quality of life, and what nonoperative and operative treatments are available to help patients with the various forms of ASD. In addition, we will provide a unique insight into what an actual ASD patient experienced while preparing for, undergoing, and recovering from an extensive ASD surgery. The goal of this issue is to provide a thorough, unbiased, expert treatise on this unique form of spinal disease that, although not nearly as common as neck or lower back arthritic issues, can produce substantial health problems with a markedly adverse health status for those afflicted with various ASD conditions.

We are extremely fortunate to have assembled an **expert panel of authors for this ASD journal from leading medical centers around the country.**

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First, **Dr. Martin Pham** from the University of California San Francisco (UCSF) will explain the variety of conditions found under the ASD diagnosis as well as the impact these conditions have on quality of life, to set the foundation for the remaining articles.

2

Next, **Dr. Pat Sugrue** from Advocate Lutheran General and Good Samaritan Hospitals in suburban Chicago will provide insight into the commonly utilized nonoperative treatment modalities that should always be the first line of treatment, often providing substantial if not long-lasting relief and benefit.

3

The decision to consider operative treatment for an ASD condition is often extremely complex and challenging for the patient and their loved ones. We are fortunate that **Dr. Rajiv Sethi** from Virginia Mason Medical Center in Seattle, Washington provides a detailed view into what prospective operative patients need to know as they consider having surgery, as well as how best to prepare for this type of surgical intervention.

4

Next, **Dr. Ronald Lehman** from Columbia University/Och Spine Hospital in New York City will describe the most common surgical procedures for both younger and older adults with ASD, to emphasize the serious nature of these surgical reconstructions that are being more routinely performed around the US over the past decade for those who have failed nonoperative treatment and/or have progressive and debilitating ASD conditions.

5

What better way to provide experienced-based information on undergoing a major ASD spinal reconstruction than to have someone who personally experienced this type of life altering procedure share their story? Thus, we are very pleased that an actual ASD surgical patient has provided her story, in her own words, with guidance from Angela Smith, RN a clinical nurse specialist for both pediatric and adult patients undergoing spinal deformity surgeries at Columbia University and the Och Spine Hospital.

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Lastly, **Dr. Jeff Gum** from the Norton Leatherman Spine Institute in Louisville, Kentucky will describe current outcomes for ASD surgical patients and how things have improved over time due to the many surgeons and clinical researchers who have been working tirelessly to identify ASD patients who should consider surgery, limit intraoperative and postoperative complications, and provide the optimal postoperative care and recovery to ultimately produce the best outcomes.

We are all fortunate that the NSHF provides an avenue for dissemination of this type of patient-centered information. Although there are many avenues now for knowledge acquisition both online and in various social media platforms and chat groups, the NSHF is committed to providing cutting edge, unbiased and factual information from spinal experts practicing around the country. **We feel this issue focusing on ASD has kept up that important tradition, and we hope you agree!**

- Lawrence G. Lenke, MD

Thomas C. Schuler, M.D.

Chairman, *Medical & Scientific Board, National Spine Health Foundation*

> ***"The reality is that as life proceeds, so does the wear and tear on the discs in our backs."***

CHAIRMAN'S NOTE

Spinal Motion Throughout a Lifetime

It has been said that **motion is life**. Motion is an essential part of living an active and engaged life. The amazing anatomic structure that is the human spine is at the center of our mobility and function. Thirty-three bones plus discs, facet joints, and ligaments provide the protection for our nervous system to reach all aspects of our body while providing structural support to stand upright and the flexibility to conduct all aspects of daily life and sport. This is truly a wonderful creation in its complexity and various functions. Spine mobility coupled with core strength and flexibility enables us to live, work, and play everyday.

Life is a **degenerative process**, unfortunately. Our hair turns gray as we age, and so do the discs and ligaments that comprise our spine. The reality is that as life proceeds, so does the wear and tear on the discs in our backs. Genetic predisposition, bad ergonomics, smoking, and traumatic events are a few of the things that affect the health of the discs and ligaments that make up our spine. As degeneration occurs, people can experience a wide array of symptoms ranging from neck or back pain to arm and leg symptoms.

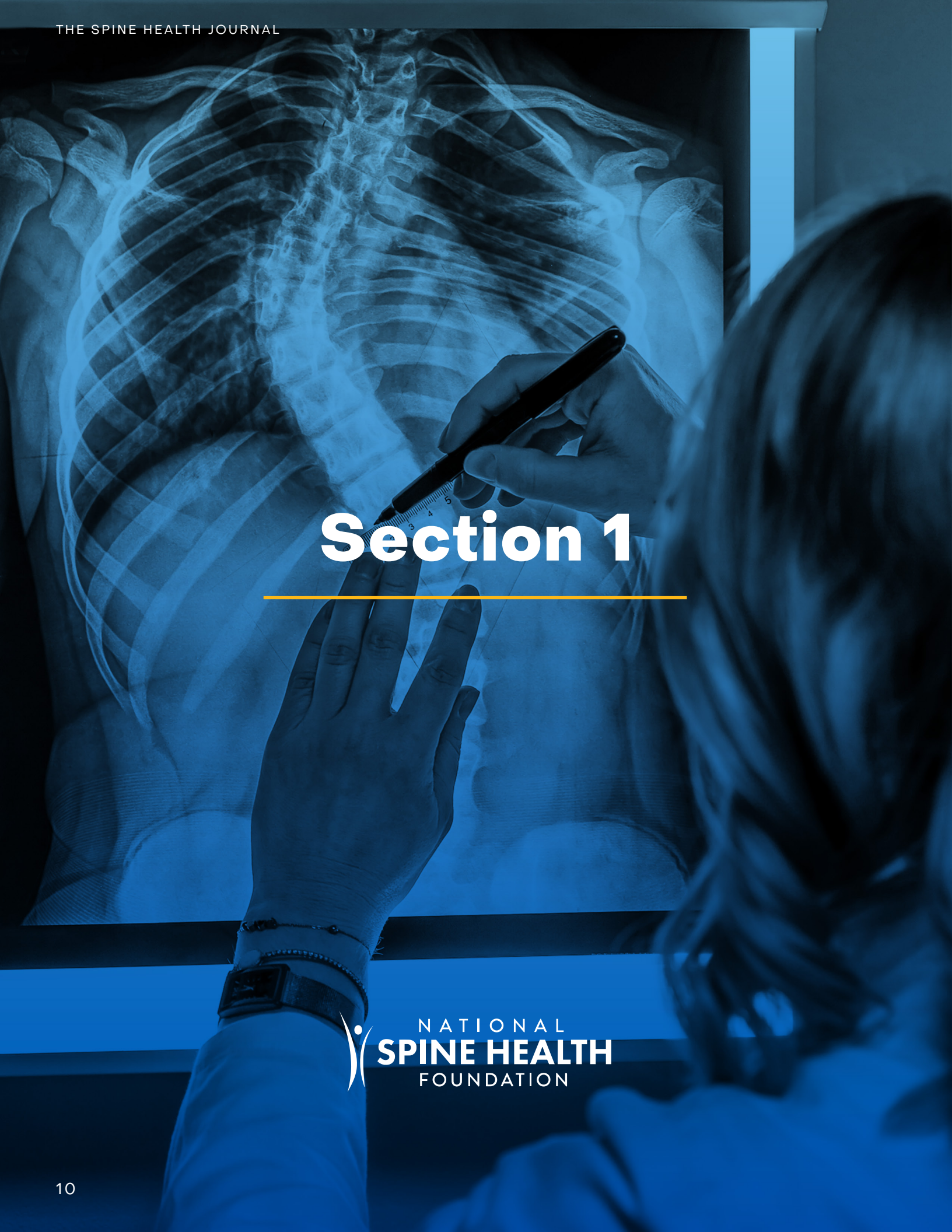
The breakdown of spinal discs and facet joints can lead to **adult spinal deformity,** including degenerative scoliosis (a curvature of the spine), as a result of an asymmetric collapse of the discs. The incidence of adult degenerative scoliosis in 40 - 60 year olds is 13%. By 65 years of age and older, adult degenerative scoliosis is present in 2/3 of the population. This demonstrates the structural impact of the degenerative process. Degeneration of the spine can cause pinched nerves, arthritic pain, and loss of mobility. The bottom line is that degeneration of spinal structures can lead to significant structural problems as well as severe pain.

We are blessed to live in a time where we have **amazing technology** and knowledge that enable us to continue to function and move as a result of great nonoperative care and/or life restoring surgery if needed. Nonoperatively, **quality physical therapy** focusing on core strengthening, soft tissue release, joint mobility and global strengthening empower the vast majority of patients to avoid surgery while restoring a mobile and pain free quality of life. Regenerative medicine is further advancing the success of nonoperative treatments. If surgery is needed, today we are able to segmentally treat just one level of the spine or multiple levels to get the desired result.

Surgical implants and techniques have evolved completely over the past 30 years to provide exceptional clinical results to patients and surgeons today. During these three decades we have developed minimally invasive surgical techniques, artificial discs, robotic surgery, augmented reality, and better spinal implants to realign and stabilize the spine. The ability to restore life and mobility is a **miracle of modern spine medicine.** The future will only be brighter as technological evolution continues.

A patient should not have surgery if his or her problem can be solved with appropriate nonoperative care. However, living in pain or immobilized by spinal issues is not healthy either. Weight gain, depression, severe pain and societal disengagement are significant risks with untreated conditions. One should always focus on nonoperative care first, but understand that if the desired result is not obtained by that approach, then modern surgical intervention can be life restoring. Staying fit and mobile is the best way to avoid or delay surgery, however if surgery is necessary, **life improving technologies are available today.** We are fortunate to live in a time of these wonderful innovations and technologies.

- Thomas C. Schuler, M.D.



Section 1

NATIONAL SPINE HEALTH FOUNDATION

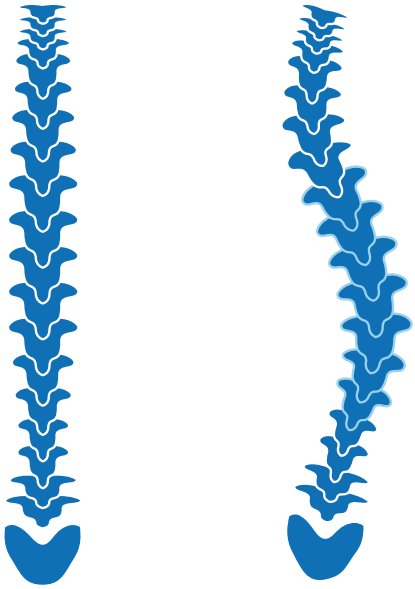
Adult Spinal Deformity Conditions Impact Overall Health

By Martin H. Pham, MD

Adult spinal deformity refers to abnormal curvatures or malalignments of the spine that occur in adulthood. These can encompass a variety of conditions and overall can have a significant impact on an individual's health and well-being. While much of adult spinal deformity is on a spectrum and many diagnoses can overlap, they all share the fact that the spine is no longer in its appropriate alignment and because of that, people can experience significant detriments in their quality of life. In this primer, we will explore some common diagnoses that comprise adult spinal deformity and how they can affect health status.

Scoliosis

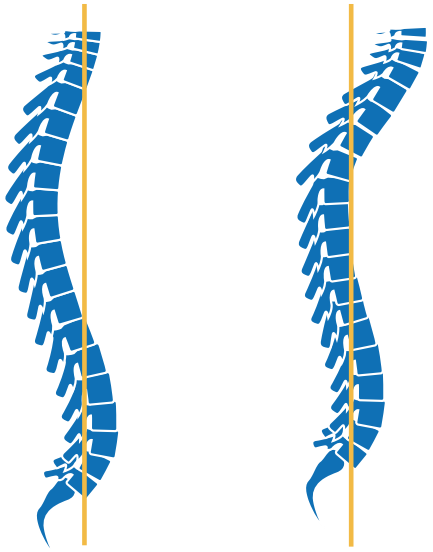
Scoliosis is a condition defined as an abnormal sideways or left-right curvature of the spine. Experienced as an adult, this can be the result of a long progression of adolescent scoliosis (**adult idiopathic scoliosis**) or as a result of adult degenerative changes that cause a sideways slipping of the vertebrae that develop into this curvature (**adult degenerative scoliosis**). Because of these curves, people may experience significant back pain when sitting upright, standing, or performing activities because the spine is not as biomechanically stable compared to a straighter spine. Likewise, the curves themselves can lead to bone spurs or narrowing of the space for the nerves which travel to the legs, and people can experience severe leg pain as well.



Normal *Scoliosis*

Kyphosis

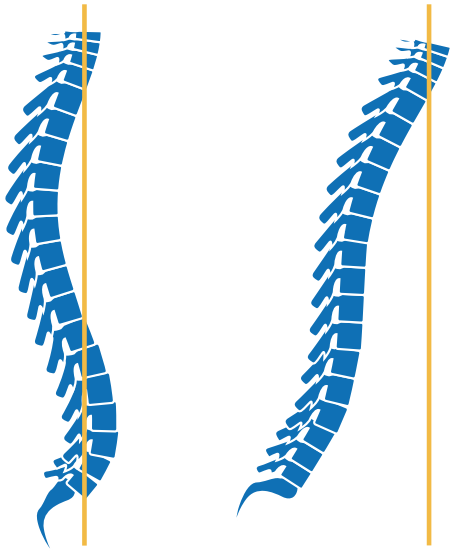
Kyphosis is a condition where the spine is pitched more forward than normal which can lead to a hunched or rounded appearance of the back. There are many reasons that adults can have an abnormal degree of kyphosis, and these can include degenerative changes, osteoporosis, prior fractures, or complications that can occur after spine surgery. If kyphosis occurs in the setting of scoliosis as well, then a diagnosis of **kyphoscoliosis** can also be given if the scoliosis itself is causing a forward posture to the spine.



Normal *Kyphosis*

Sagittal Imbalance

The sagittal plane is viewing the body from the side, as opposed to the front-to-back view. Sagittal imbalance is defined when a patient's head and upper part of the spine are no longer in a favorable biomechanical position when compared to the lower part of the body, including the lumbosacral spine, pelvis, hips, and even knees and ankles. If the spine is out of balance, then this can cause many cascading effects that result in back pain, leg pain, fatigue, and an inability to have an acceptable quality of life. This is sometimes also referred to as **flatback syndrome** and can also occur after prior spine surgery.



Normal *Flatback*

Spinal Regions

All the above spinal alignment issues can occur in the neck (**cervical**), mid-back (**thoracic**), or low back (**lumbosacral**). The exact location of the abnormal curvatures and malalignment – the spinal deformity – will tend to dictate the exact symptoms being experienced and how severely a person's health status is being affected.

Impact on Health Status

Adult spinal deformity can have a profound impact on a person's health and overall well-being. **Physical symptoms** that include chronic back or leg pain, limited mobility, easy fatigability, or a sense of being off-balance can affect all aspects of daily life. An active lifestyle can be hindered or even prohibited, and remaining independent can be difficult if people are unable to walk, lift objects, perform daily household tasks, or drive because of their symptoms. There can be a significant **psychological impact** as well that affects mood, sleep, self-esteem, anxiety, social interactions, a feeling of isolation, and emotional distress.

Altogether, these impacts on health status can greatly affect a person's quality of life.

In conclusion, adult spinal deformity encompasses a spectrum of disorders and diagnoses that affect the overall balance and alignment of the spine. When the spine balance is lost and malalignment occurs, health status can be greatly affected which impacts all aspects of daily life. With proper evaluation by a spine specialist and team knowledgeable about these conditions, there may be options that can treat and improve these conditions tailored to each individual situation which can correct the spinal deformity, alleviate pain, and improve function.

> ***Adult spinal deformity can have a profound impact on a person's health and overall well-being.***

Section 2

NATIONAL SPINE HEALTH FOUNDATION

Helpful Nonoperative Treatments for Adults with Spinal Deformities

By Patrick Sugrue, MD

The surgical success for patients undergoing adult spinal deformity (ASD) correction or reconstruction is well documented in the medical literature and can bring about a significant improvement in quality of life and reduction in pain. However, there are substantial risks associated with this type of reconstructive surgery, and thus most patients should exhaust nonoperative treatments prior to surgery. The good news is that there are many patients who achieve meaningful management of their symptoms with nonoperative means and never go on to surgery.

Symptoms

Adult spinal deformity consists of a variety of spinal pathologies including scoliosis (curvature of the spine from left to right), kyphosis (inappropriate curvature from front to back), or a combination of the two. Often pinched nerves can further complicate the clinical picture, resulting in back pain, leg pain, or weakness that can significantly impact quality of life in a negative way. There are a variety of available treatments to improve these symptoms, including physical therapy, medications, and steroid injections.

Physical Therapy

One of the most effective nonoperative treatments in ASD focuses on activity modification and physical therapy (PT). A directed PT program is not designed exclusively to target symptoms, but also to provide a framework to achieve and maintain an active lifestyle. Typically, a patient will attend a dedicated PT program for approximately 6-8 weeks with 2-3 sessions per week. The key to success in such a program requires the development of a home routine to continue the stretching and strength building exercises long term. This needs to become part of the daily routine to achieve sustainable benefit beyond the duration of the PT program.

An additional key element of a successful physical therapy program is a focus on ***core strengthening.*** The spine loses height and develops more of a bent-forward posture with age, which can lead to worsening back pain or leg symptoms from nerve compression. Scoliosis can further complicate that poor posture and alignment, often leading to additional back and leg pain. Improving core strength can help to support the spine as this degenerative process occurs over time, to maintain a more ideal alignment.

Aquatic PT can be extremely beneficial for those with significant back pain or weight-bearing nerve symptoms who cannot fully participate in a traditional PT program. Aquatic PT takes place in a pool and the buoyancy of the water takes pressure off the spine. This reduced-gravity setting allows for stretching, strengthening, and aerobic fitness to be accomplished with little to no pain or undue stress on the spine.

Medications

Short term medical management may include non-steroidal anti-inflammatory medications (NSAIDs), muscle relaxants, and pain medications. Acetaminophen is a mild, over-the-counter pain reliever that may be intermittently helpful, but dosing must be monitored to avoid liver toxicity. The negative effects and addiction potential for opioid medications preclude long-term use of these medications. NSAIDs can have negative renal and cardiovascular ramifications and should only be used in moderation but can be very helpful for short term exacerbations of pain. Muscle relaxers may be useful in an acute flare up but are not a long-term solution. There are also nerve-specific medications designed to target nerve pain, which can be very effective for long-term use.

Injections

Steroid injections are commonly used to treat nerve-related pain, and can play an important role in the nonoperative treatment for ASD. Targeted injections can be both diagnostic (provide information about the source of pain) and therapeutic (provide pain relief). Although it is difficult to predict how long that relief may last, the information gained from the pain relief achieved may guide the next step of treatment. For example, gaining meaningful but temporary relief after an injection informs the surgeon of a symptomatic nerve that could benefit from surgical decompression. This information can also guide surgical options between a smaller, more targeted procedure or a larger, more comprehensive surgical approach.

Bracing

Bracing is a controversial topic in ASD as it is commonly used successfully in the pediatric spinal deformity population. However, bracing is not only much less effective in the adult spinal deformity population, but it is often detrimental. The core is not engaged while wearing a brace, causing the muscles that make up the core to become weaker. Once the brace is removed, the deformity itself may actually worsen due to a weakening of the core muscles meant to provide spinal support. Therefore, bracing is not a long-term solution.

Conclusion

Many, but not all, patients will benefit from nonoperative treatments alone. Those who typically do attain meaningful long-term benefit without surgery tend to be younger, not obese, with less severe deformity, curve magnitude, and malalignment. Those with weakness, spinal cord compression, signs of spinal cord dysfunction, or severe deformity may require surgical reconstruction without a role for nonoperative intervention.

Ultimately, choosing between operative versus nonoperative interventions comes down to a detailed discussion of risks and benefits of each option between a spinal surgeon and the patient to achieve shared decision-making. The patient must identify the negative impact the spinal deformity has on their quality of life. Then the risks of each treatment option must be weighed against the likelihood and degree with which the quality of life is expected to improve with each treatment. It is also important to recognize that a nonoperative treatment plan may change over time for patients with ASD.

“Ultimately, choosing between operative versus nonoperative interventions comes down to a detailed discussion of risks and benefits of each option between a spinal surgeon and the patient to achieve shared decision-making.

Section 3

NATIONAL SPINE HEALTH FOUNDATION

What to Know Before Considering Surgery for Adult Spinal Deformity

By Dr. Rajiv Sethi and Dr. Rakesh Kumar

Adult spinal deformity (ASD) is a spinal curvature in an adult, which occurs commonly and is often symptomless in many individuals. ASD diagnoses encompass various conditions like degenerative sagittal imbalance, iatrogenic spinal deformity, and adult scoliosis. Better healthcare and longer lifespans have led to healthier older individuals, causing a rise in the occurrence and prevalence of ASD. For those who do not remain asymptomatic, ASD can cause back pain, asymmetrical appearance, and nerve issues leading to numbness, weakness, and leg pain, particularly while standing or walking. Severe cases may require surgical intervention, especially as people age. Surgical treatment is an effective approach for addressing ASD driven by the recognition of the importance of global alignment, advancements in surgical methods, and the need to enhance the well-being of ASD patients who fail nonoperative treatments.

Shared Decision-Making

ASD lacks a fixed management algorithm and treatments must be made using a shared decision-making model. Successfully treating spinal deformities requires precise planning and appropriate patient selection. ASD surgeries often involve extended recovery, some degree of complication, and substantial costs.

Patients play a pivotal role in deciding between nonsurgical and surgical approaches for treating their ASD. Nonsurgical treatments are recommended before surgery due to their potential to alleviate mild disability and pain. The decision to opt for surgery is influenced more by the severity of baseline disability than the specifics of the spinal curve. Pain and disability guide surgical choices for older patients, while greater coronal deformity impacts decisions for younger patients. It is also very important to understand the expectations of the patient and his/her social situation before planning management.

> ***"Choosing the right patient is the roadmap for choosing the right outcome for that patient with adult spinal deformity."***

Surgical Planning

Planning for ASD surgery includes detailed clinical, medical, radiographic, and surgical evaluations. Spinal deformity surgeons utilize clinical and radiological information to develop an individualized management plan for the ASD patient. Radiological evaluation discerns the alignment of the spine in both coronal (front-to-back) and sagittal (side-to-side) planes, as well as the magnitude, apex, and flexibility of the curve. A standard set of preoperative imaging tests includes a series of X-rays, magnetic resonance imaging (MRI), computed tomography (CT) scan, and dual-energy X-ray absorptiometry (DEXA) scan. These various scans provide different details of the spinal anatomy and bone strength, which are ordered based on individual needs.

Given the complexity and magnitude of ASD surgery, a multidisciplinary team approach is taken and assembles preoperatively. This team may include an internist, a physical medicine and rehabilitation physician, a complex spine anesthesiology team, an intensivist, coordinating nurses, and the operating surgeons. Although the team members may vary from center to center, the preoperative medical evaluation is often extensive to complete medical optimization for an ASD surgery.

One way to coordinate all members of the ASD planning team is by a conference approach, which works well at *Virginia Mason Medical Center*. Before the conference, the anesthesiologists and internists thoroughly examine each patient's medical background and health concerns. Subsequently, an overview of the medical history, laboratory results, and screening test results is created. This patient summary is provided to all conference participants. During the conference, discussions revolve around the planned surgical correction and the pertinent preoperative and postoperative medical concerns. Medical problems screened for and that require preoperative and postoperative management include obesity, diabetes, osteoporosis, cardiac and pulmonary problems, and bleeding or blood clotting disorders. If a patient is deemed unfit for the ASD surgery due to medical conditions, nonoperative strategies are discussed.

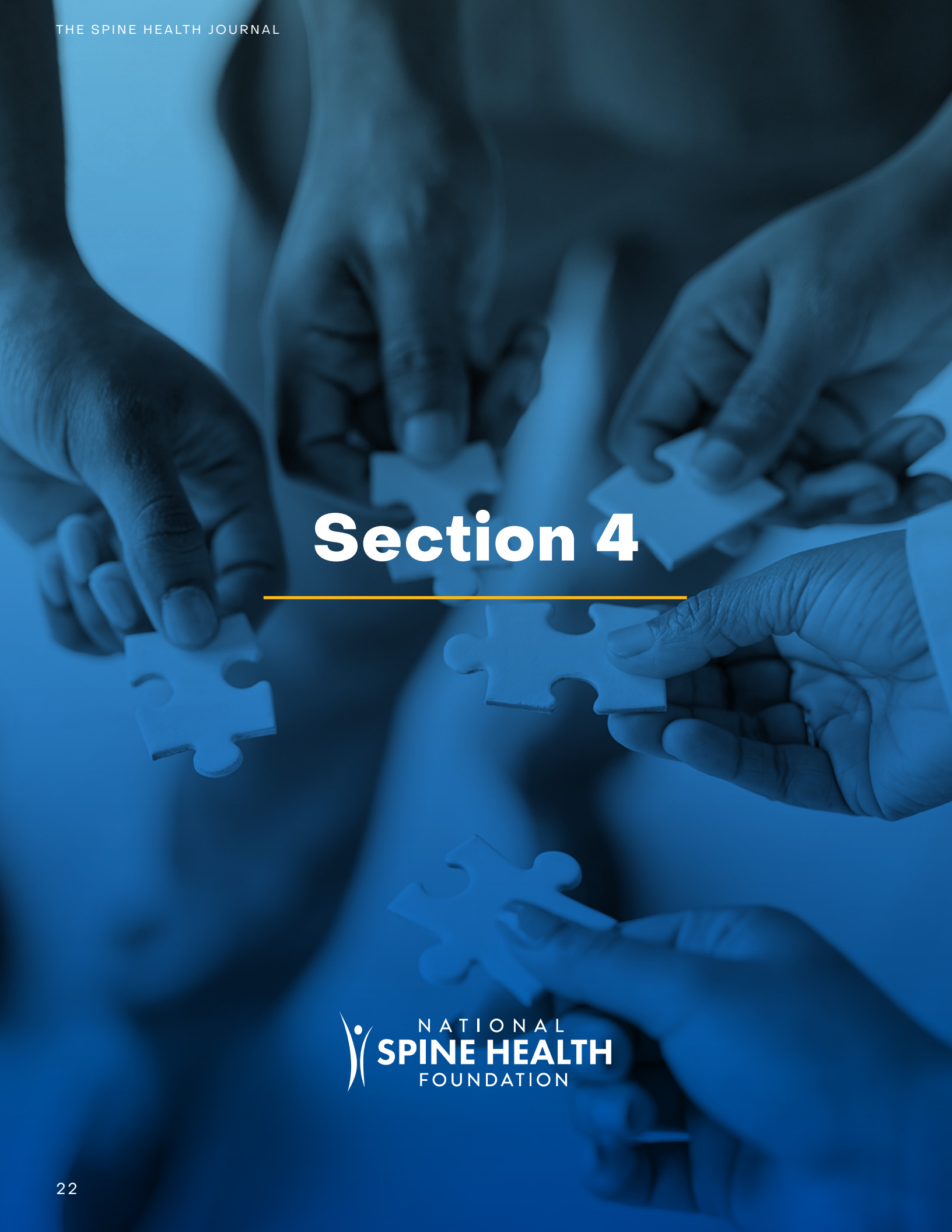
Tracking Outcomes

To track surgical outcomes, ASD patients may complete questionnaires such as Patient Reported Outcomes Measurement Information System (PROMIS), Oswestry Disability Index (ODI), and a European Quality of Life-5 Dimensions (EQ-5D) questionnaire to assess their functional status and overall well-being. By answering these questions before and at various time points after surgery, both patients and surgeons alike can determine overall improvement. This type of information helps to guide the future of ASD treatment recommendations.

Conclusion

Before an ASD patient elects to move forward with surgical correction, understanding these considerations can help prepare them for the road ahead. Patients must be educated on the postoperative recovery phase and must fully understand the consent process that involves discussing potential risks. When choosing a center for surgery, patients should pay attention to the infrastructure for preoperative optimization as this has been shown to reduce complications and enhance outcomes. Finding a spinal surgeon that specializes in ASD surgery is the first step.

> ***"Before an ASD patient elects to move forward with surgical correction, understanding these considerations can help prepare them for the road ahead."***



Section 4

NATIONAL SPINE HEALTH FOUNDATION

Surgical Treatments for Progressive Spinal Deformity

By Ronald A. Lehman Jr., MD and Nathan J. Lee, MD

The adult spinal deformity (ASD) population is incredibly diverse, making it critical that surgical treatment is individualized for each patient. Several factors should be considered when deciding on the optimal surgery. A thorough evaluation of the medical history, symptoms, physical examination, and imaging studies are essential to determine the most appropriate treatment plan. Furthermore, it is absolutely essential to involve the patient in the decision-making process. Realistic discussions about potential benefits, risks, and limitations of surgical interventions should take place preoperatively to set appropriate goals and expectations. Several of these conversations may be necessary over time, given the complexity of the spinal condition, the surgical treatment, the recovery, and life after ASD surgery.

> ***"It is absolutely essential to involve the patient in the decision-making process."***

Types of Surgery

Although surgical treatments for ASD may differ between younger and older patients, these differences depend less on the patient's actual age and more on the variations in bone quality, overall health, radiographic spinal phenotype, symptomatology, and the patient's lifestyle. Depending on these factors, an ASD patient may require either decompression alone, decompression and fusion, and/or a realignment procedure.

Decompression (creating more room for neural structures by removing compressive bone/tissue) may be used alone for patients with a primary complaint of stenosis (narrowing around neural structures) who have a stable and well-balanced spine.

In patients with destabilizing pathology (such as slipping of the vertebrae = spondylolisthesis), **a fusion procedure** (taking away motion of spinal segments) should be included. Decompression without stabilization in patients with instability may further destabilize the spine and lead to deformity progression.

Realignment procedures are appropriate when the primary aim is to correct the deformity, improve global and regional alignment, and prevent progression. However, realignment surgery is more extensive in nature as it includes decompression, fusion, and osteotomies (a surgical technique to loosen parts of the spine to allow for realignment in an otherwise stiff area).

The Importance of Imaging for Realignment

In addition to the well-known evaluation using **magnetic resonance imaging** (MRI), multiple radiographic factors are important to consider in determining the optimal surgical treatment for younger and older patients alike. First, **full-length standing x-rays** are used to assess alignment in the sagittal (side) and coronal (front-back) planes. Patients may appear globally well-aligned on standing x-rays, but special attention should be made to any compensatory changes made in the pelvis and legs, which may mask the true alignment.

There are also natural curves in the spine seen from the side view that balance each other for standing upright: lordosis in the neck, kyphosis in the thoracic region, and lordosis in the low back. These natural curves can change over time and contribute to a spinal deformity condition. The magnitude of mismatch between what the natural curvature in the low back should be and what it has become over time is particularly important in patients who develop a forward-flexed posture. Surgical correction of this mismatch improves posture and is associated with improved patient-reported outcomes.

Flexibility x-rays include laying or bending films to assess the rigidity of the thoracic and lumbar curves. **CT scans** can further characterize the rigidity of curves and illustrate abnormal bone growth, facet joint arthritis, and lumbar degeneration. In some cases, rigid curves may require extensive bone work to loosen up the spine for correction, including:

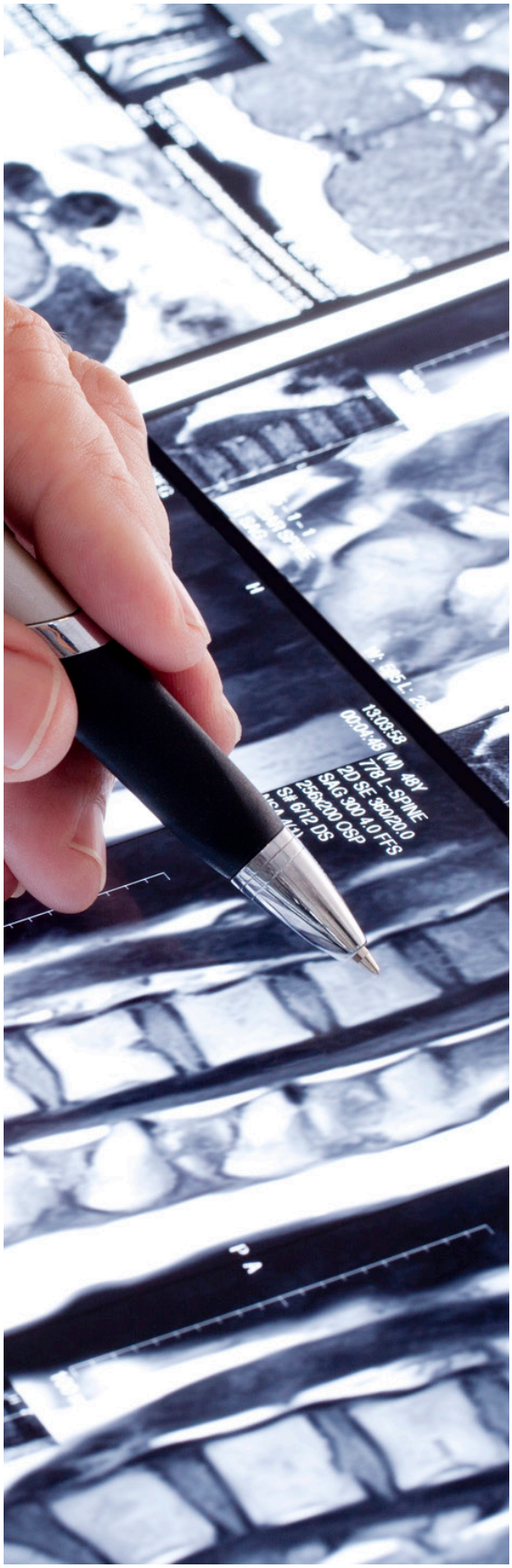
- ***Pedicle subtraction osteotomies (PSO)***
- ***Vertebral body resection (VCR)***

These types of three column osteotomies can achieve greater correction of spinal deformities, but are associated with greater blood loss, prolonged operative time, risk for neurologic deficit, and pseudarthrosis (failure to fuse).

Level Selection for Realignment

The number of spinal levels included in ASD surgery must be carefully considered. The first (or top) level is known as the upper instrumented vertebra **(UIV)** and the last (or bottom) level is known as the lower instrumented vertebra **(LIV)**. The appropriate determination of the UIV and LIV is critical to avoid potential postoperative complications such as new issues developing at the levels above and/or below the surgical levels or a failure to fuse.

The Lenke classification is often utilized for optimizing level selection. Ultimately, level selection should be based on coronal and sagittal alignment, relative magnitude and rigidity of curves, the quality of the muscles that surround the spine, shoulder imbalance, degree of lumbar disc degeneration, and how even the hips/pelvis are. Careful consideration should be made to avoid ending the fusion construct at locations known to be less stable or anatomically problematic.



> ***Significant technological advances have been made in spine surgery over the last decade...***

Surgical Approach to Realignment

An **open,** posterior-based (long incision down the middle of the back) deformity correction is considered the gold standard surgical approach for ASD. The main advantage is the ability to correct large deformities with a single approach. All concomitant procedures including interbody fusions and osteotomies can be made within the same incision. However, this approach is associated with relatively high complication rates.

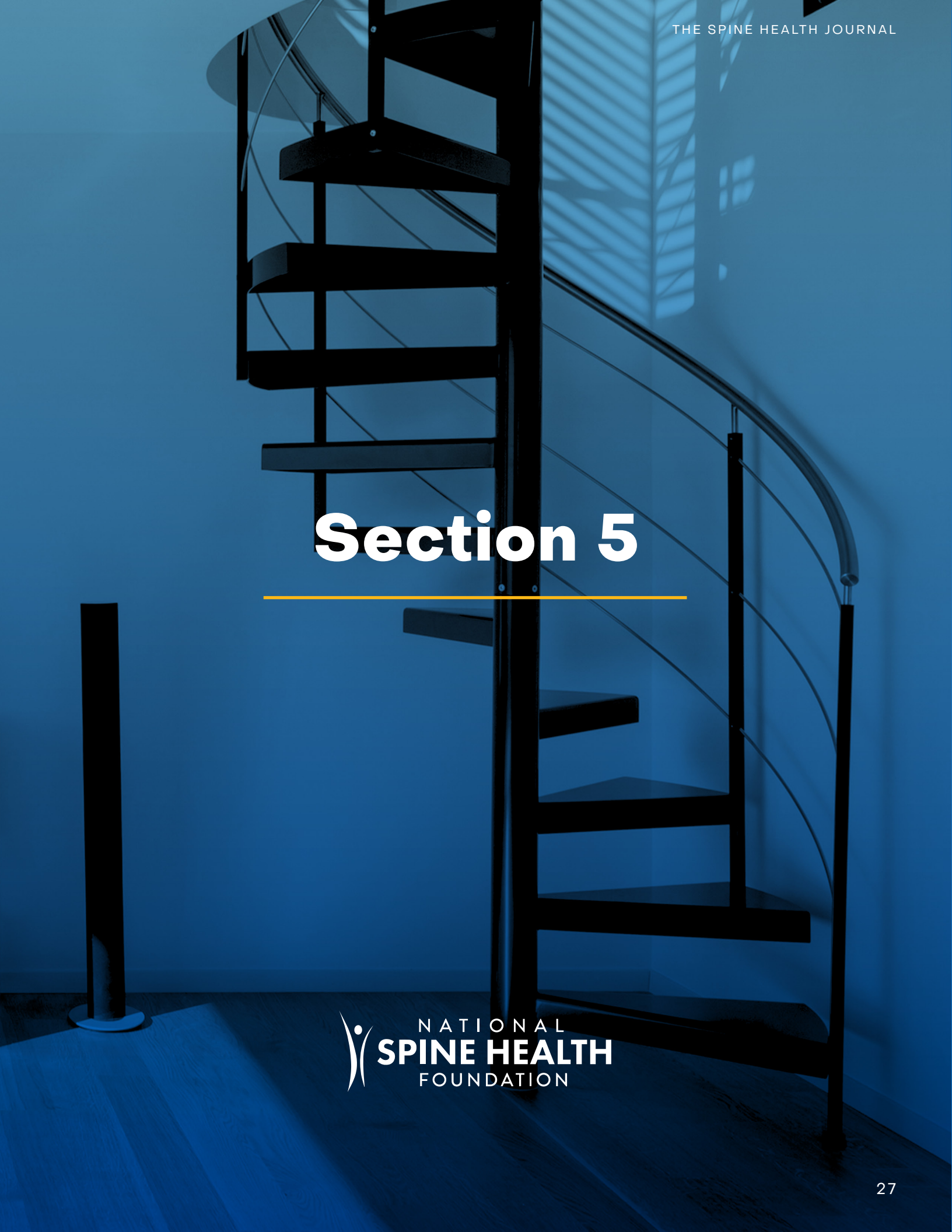
To mitigate these risks, **minimally invasive spine surgery** (MIS) has been introduced with the primary goal of preserving native soft tissue anatomy, which is disrupted during an open approach. Other benefits of MIS include less blood loss and faster recovery. The indications for the techniques continue to evolve. MIS may be best suited for patients with flexible curves of the thoracolumbar spine. MIS is relatively contraindicated in patients with very rigid and large curves or those with significant fixed sagittal imbalance.

Innovative Surgical Technology

Significant technological advances have been made in spine surgery over the last decade, including robot-assisted spine surgery, navigation, and machine learning. Recently, robot-assisted spine surgery has been integrated with navigation technology, which has been shown to reduce radiation exposure and improve instrumentation accuracy. An important advantage of robot-assisted technology is the improved ability to preoperatively plan the surgery, allowing for individualized plans based on each patient's unique needs. Clinical research has demonstrated promising outcomes with the use of this technology. Furthermore, the use of machine learning to further personalize care has continued to expand over the last several years.

Conclusion

Ultimately, the optimal surgical treatment for ASD begins with a transparent preoperative discussion with the patient to foster **shared surgical decision-making.** Surgeons should account for patient factors, including lifestyle choices, comorbidities, and their radiographic phenotype, as well as set realistic short- and long-term goals of surgery. Through this discussion, surgeons should be able to determine which tools to use in their armamentarium to provide individualized care. No two ASD patients are alike!

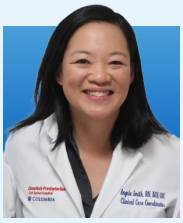


Section 5

NATIONAL SPINE HEALTH FOUNDATION

Sheryl's Scoliosis Story

By Sheryl Miller



Larry Lenke, MD
Angela Smith, RN

When I was Young

In 8th Grade, I fell in gym class and was sent to the nurse's office. When she swept back my waist length hair, she immediately said I had scoliosis and referred me to an orthopedic doctor. The first local doctor recommended watching it for six months, but three months later I returned complaining of pain. Although it was over 50 years ago, I still remember looking at that x-ray as a kid and thinking, "this is horrible!" The x-ray looked like a spiral staircase. It was then suggested I go to a top scoliosis doctor in Manhattan.

Surgery was an option, but it would mean a year out of high school in a full body cast and fusing the whole spine. Instead, I wore a Milwaukee brace throughout high school. Being thin, the brace rubbed my hip bones so badly that they bled. Once the brace was off, I felt so much better even though I had a 56-degree curve as a teenager. **Fast forward into adulthood and two children later, my curve had progressed to 70 degrees.**

Challenges During Adulthood

Throughout my adult life, I sought the advice of many spine specialists on what to do. Then unexpectedly, 11 years ago, my husband came down with stage 4 lung cancer that spread to the brain and spine. He could no longer walk or move. He became overweight, wheelchair bound, and fell often. Trying to move him over the next 10 years really affected my spine and **my curve progressed to just about 100 degrees, and I was in tremendous pain.**

I tried all non-invasive treatments that I could find, like intense traction, Schroth PT, pain injections, and much more. Between my extremely sick husband, intense pain, and concern over what my future would be like post-surgery, I was overwhelmed and apprehensive. I was 64 years old, and my health was changing. On top of that, I was diagnosed with high blood pressure and osteopenia. I knew my spine would not hold up for much longer. At that point, my ribs and pelvis were so close together that they were almost on top of each other. I was told that once they touch, you cannot get through a day without pain. **I knew I was running out of time.**

A Glimmer of Hope

Fortunately, I found Dr. Larry Lenke. Once I read his website, I realized he specialized in complicated cases like mine. **From the moment I met Dr. Lenke, I knew he was the doctor for me!** From his wealth of knowledge, explanations of the surgical procedure, and most importantly to me, he would make a 3D model of my spine that he would study a month before the surgery. Knowing he was going to those lengths to get ready for my surgery instilled confidence that Dr. Lenke would be the most prepared physician I could find.

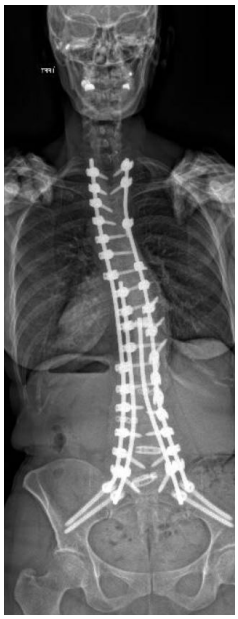
While I had been in denial for years, I finally realized that based on my age and the possibility of a worsening situation over time, I had a small window of opportunity for surgical intervention. I booked surgery with Dr. Lenke. This was monumental for me.

My Miracle

The surgery itself was an arduous undertaking, and Dr. Lenke approached it with incredible skill and precision. It was a 9-hour surgery, accomplishing a posterior spinal fusion with instrumentation from T2 to the sacrum (basically the entire spine except the neck), addressing multiple degenerative changes in both the thoracic and lumbar regions as well as severe lumbar stenosis. There are rods and screws in almost every vertebrae of my spine. Other doctors wanted to do multiple surgeries, but believe me, one was enough!

I am truly amazed at the exceptional results Dr. Lenke achieved, considering the complexity and severity of my condition. **The positive transformation in my body and overall quality of life is beyond what I could have imagined.** Everyone I meet has horror stories about someone they know that had a much smaller spine surgery and is not doing as well as I am doing after such a significant surgery. I have more mobility than I ever expected! I live independently and am thrilled every day at how well I am doing! It is all thanks to Dr. Lenke and his team– you rocked my world!

Before



After

Before

After

Section 6

NATIONAL SPINE HEALTH FOUNDATION

SHORT AND LONG TERM OUTCOMES OF ADULT SPINAL DEFORMITY SURGERY:

How Have Things Improved Over Time?

By Jeffrey Gum, MD

> **"What are the chances this surgery is *successful*?"**

> **"What are the chances something *bad happens* during surgery?"**

These are common questions asked by patients who are about to undergo corrective surgery for adult spinal deformity (ASD). There are several ways to answer these questions, and for the purpose of this commentary we will try to dissect these within the context of short- and long-term outcomes in ASD surgery.

First, these are large, extensive, complicated, and long surgeries that have been consistently shown to be beneficial, but they do carry a high complication rate. Overall, approximately half (50%) of patients undergoing ASD surgery experience some sort of complication if you group all the minor and major complications together. This ranges from wound drainage and a urinary tract infection to heart attack, stroke, or even death. That isn't the best odds! The good news is that complications which affect your outcome in the end are rare.

Outcome assessment after these surgeries has come a long way. Originally, the outcome was determined by the treating surgeon, which meant it was either good or really good (no bias here) and primarily related to what the x-rays looked like in the short term. In effort to develop a more meaningful assessment of how these surgeries or patients did, we transitioned to patient reported outcome measures (PROMs).[1]

PROMs are questionnaires answered by patients before and after surgery (thanks to all of you who have completed these forms), which allow the success of these surgeries to be gauged from a patient perspective. They are not perfect, but definitely a step in the right direction, and they allow us to compare the impact ASD surgery has on health status, pain improvement, and function. In the future, we will likely transition to a more objective, functional assessment that is likely measured with smart implants or wearables that give us activity-related information.

The Short Term

In the short term, these surgeries can be tough to recover from. We now know that it is important to mobilize early, optimize modifiable co-morbidities, follow surgeons' restrictions or limitations, and avoid falls. This seems intuitive but is essential to avoid catastrophic failure with vertebral fractures, loosening of implants and/or failure at the top of the screws and rods (proximal junctional failure/kyphosis). We have improved these surgeries or reduced these short-term complications with several efforts.

First, we have become much more selective about who is a good candidate for these surgeries. It is of the utmost importance that your surgeon does a comprehensive workup to evaluate your bone health, baseline function, nutrition, general health, and to optimize any coexisting comorbidities. Unfortunately, some patients are not good candidates for such extensive surgery and although it is tough to hear this, it is much better to avoid the surgery than have complications and end up with multiple surgeries with no improvement in the end (or even worse). Sometimes surgery may be an option, but we might suggest more time to get patients "tuned up" and optimized prior to scheduling the surgery.

Additionally, we have made a lot of progress on the anesthesia side of these long surgeries. It is important that these extensive surgeries are done by not only experienced surgeons but at centers that have the appropriate anesthesia team. This surgeon-anesthesia collaboration can be critical for minimizing blood loss, appropriate fluid management (helps avoid kidney and heart complications), pain control, and minimizing overly sedating medications that make early mobilization impossible.

Lastly, as for the prevention of proximal junctional problems, we are constantly innovating with our industry partners to develop creative ideas to minimize the risk of this occurrence. **We now have a much larger toolbox to help prevent these types of problems from happening thanks to innovation collaboration.**

The Long Term

Durability is the name of the game with long term outcomes. We strive to minimize the likelihood that patients need additional surgery. The two most common reasons patients return to the operating room are (1) pseudoarthrosis (the bones not healing together) or rod fracture, and (2) adjacent level degeneration (the level above/below surgery wears out). Over the years we have modified our surgical approach to help mitigate these from occurring by adding more construct strength in high stress areas, and although we are doing better, we still have room to improve. The good news is, even if these do occur and result in an additional surgery, typically these long-term complications have minimal impact on patient reported outcomes. Additionally, it's worth noting that most patients are able to improve their function and get back to activities that they enjoy in life. There is a lot of variability among surgeons regarding when and if patients' can return to specific activities, so it is very important to follow your surgeon's instructions.[2]

Overall, reconstructive surgery for ASD is complex with a myriad of potential complications. Studies have consistently shown a benefit with surgery over nonoperative care in the appropriate, well-selected patient. Patients should have an open discussion with the surgeon regarding risks versus benefits and to assure all questions have been addressed.[3] It is recommended to seek care from highly specialized spinal deformity surgeons and centers that have the appropriate workup preoperatively, the appropriate anesthesia team, and the resources to deliver optimal outcomes in both the short- and long-term.

> **Studies have *consistently shown* a benefit with surgery over nonoperative care in the appropriate, well-selected patient.**

[1] *Gum JL, Carreon LY, Glassman SD. State-of-the-art: outcome assessment in adult spinal deformity. Spine Deform. 2021;9(1). doi:10.1007/s43390-020-00220-3*

[2] *Theologis AA, Cummins DD, Kato S, et al. Activity and sports resumption after long segment fusions to the pelvis for adult spinal deformity: survey results of AO Spine members. Spine Deform. Published online 2023. doi:10.1007/s43390-023-00734-6*

[3] *Ogura Y, Gum JL, Soroceanu A, et al. Practical answers to frequently asked questions for shared decision-making in adult spinal deformity surgery. J Neurosurg Spine. 2021;34(2):218-227. doi:10.3171/2020.6. SPINE20363*

About Our Authors

Dr. Thomas Schuler founded the Virginia Spine Institute in 1992 to create a center of exceptional healthcare that is internationally renowned. He is the Chairman of the National Spine Health Foundation's Medical and Scientific Board and is a recognized international leader in the treatment of neck and lower back conditions. Dr. Schuler is a board-certified orthopedic spine surgeon who completed his spine surgery fellowship at Cedars-Sinai Kerlan-Jobe Institute in California. His experience as a spine patient affords him the unique ability to understand the emotional, physical, and recovery needs of his patients.

Dr. Martin Pham is a board-certified neurosurgeon who is part of the prestigious and comprehensive spine care team at UC San Diego Health. He is an assistant professor in the Department of Neurological Surgery, extensively authored and presents his work at the national and international level. Dr. Pham completed a fellowship in robotic, spinal deformity, and motion preservation surgery at Columbia University's New York-Presbyterian Daniel and Jane Och Spine Hospital and a fellowship in minimally invasive and complex spinal surgery at Keck School of Medicine of USC.

Dr. Patrick Sugrue Dr. Patrick Sugrue is a board-certified, fellowship trained spine surgeon who has clinical interests in complex spinal pathologies. He completed his fellowship from Washington University School of Medicine. His practice serves adult and pediatric scoliosis, adult revision surgery, traumatic spinal disorders, spinal oncology, and more. He constantly strives to help patients improve their overall quality of life with his expertise in complex cases and cutting edge technology and techniques.

Dr. Rajiv Sethi is the executive medical director of the Center of Neurosciences and Spine at Virginia Mason Franciscan Health, Director of Spine Research, and Director of Complex Spine Surgery. He is a clinical associate professor at the University of Washington's Program of Health Economics and Outcomes Methodology. He completed a complex spine and scoliosis surgery fellowship at UCSF. Dr. Sethi's involvement in the Scoliosis Research Society's programs, committees, and board is extensive. His leadership has developed the award-winning Virginia Mason Complex Spine Care Pathway and the Seattle Spine Team Approach.

Dr. Ronald Lehman, Jr. is a nationally recognized adult and pediatric spine expert, specializing in complex spinal deformities and minimally invasive deformity surgery. Dr. Lehman completed his fellowship in adult and pediatric spine surgery at Washington University School of Medicine. He served as a Lieutenant Colonel in the Army, receiving three Meritorious Service Medals, the "A" Proficiency Designator and the Order of Military Medical Merit. He was Adult and Pediatric Spine Service Chief and Consultant to the White House. He serves as Program Chairman of three spine societies and has over 120 peer-reviewed publications.

Dr. Jeffrey Gum is a complex spine fellowship trained surgeon at Norton Leatherman Spine Center and an Assistant Clinical Professor at the University of Louisville Department of Orthopaedics. He specializes in adult and pediatric spine deformity surgery and robotic-assisted minimally invasive surgery. He completed a complex spine fellowship at Washington University in St. Louis. He is a published author, holds numerous awards and reviews three spine journals. His research includes adult spinal deformity, robotic-assisted spine surgery and the economics of spine care. Dr. Gum holds committee memberships within the Scoliosis Research Society.

Lenke Classification System

Dr. Lenke, our honored guest editor for this edition, is world renowned for a classification system devoted to Adolescent Idiopathic Scoliosis. While this classification system is not meant to be consumed by patients, we'd like to show you this major contribution to the deformity field. The complexity depicted in this graph demonstrates the highly technical components of looking at spinal curvatures and why it is necessary for providers to have completed specialty training in a spine fellowship following either neurosurgery or orthopedic surgery residency programs. Make sure you look for this advanced training when considering which doctor to choose to manage your spine condition.

The Lenke Classification is scientifically reliable, objective and practical. It is widely accepted now as the standard measuring system for determining a person's type and degree of curve.

The Lenke Classification System for AIS

Curve type	Proximal Thoracic	Main Thoracic	Thoracolumbar/Lumbar	Description
1	Nonstructural	Structural*	Nonstructural	Main Thoracic
2	Structural˟	Structural*	Nonstructural	Double Thoracic
3	Nonstructural	Structural*	Structural˟	Double Major
4	Structural˟	Structural§	Structural§	Triple Major
5	Nonstructural	Nonstructural	Structural*	Thoracolumbar/Lumbar (TL/L)
6	Nonstructural	Structural˟	Structural*	Thoracolumbar/Lumbar–Main Thoracic (TL/L–MT)

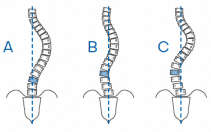
***Major curve:** largest Cobb measurement, always structural; ˟Minor curve: remaining structural curves; §Type4 — MT or TL/L can be the major curve

Structural Criteria (Minor curves)	
Proximal Thoracic	• Side Bending Cobb ≥25° • T2–T5 Kyphosis ≥+20°
Main Thoracic	• Side Bending Cobb ≥25° • T10–L2 Kyphosis ≥+20°
Thoracolumbar/Lumbar	• Side Bending Cobb ≥25° • T10–L2 Kyphosis ≥+20°

Location of Apex (SRS Definition)	
Curve	Apex
Thoracic	T2 to T11–12 Disc
Thoracolumbar	T12–L1
Lumbar	L1–2 Disc to L4

Modifiers

Lumbar Spine Modifier	Center Sacral Vertical Line to Lumbar Apex
A	Between pedicles
B	Touches apical body(ies)
C	Completely medial



Thoracic Sagittal Profile T5–T12	
Modifier	Cobb Angle
– (Hypo)	< 10°
N (Normal)	10° — 40°
+ (Hyper)	>40°

Curve Type (1–6) + Lumbar Spine Modifier (A, B, C) + Thoracic Sagittal Modifier (–, N, +) = Curve Classification (e.g. 1B+):

Kim, H. J., de Kleuver, M., & Luk, K. (2013). Lenke Classification. AO Surgery Reference

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