

The

# Spine Health Journal

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## The Future of Spine Health

*The Promise of Modern Spine Care*



The National Spine Health Foundation is a nonprofit organization dedicated to improving spinal health care through education, research, and patient advocacy. We educate Americans about the treatment and prevention of neck and back disorders, prove what works, drive innovation, and support patients on their journey to spinal health.

### **Purpose**

*We give hope.*

### **Vision**

The National Spine Health Foundation's vision is to improve the lives of those with neck and back pain.

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## President's Letter: The Miracle of Modern Spinal Surgery

Thomas C. Schuler, MD

*Board President, National Spine Health Foundation*

*Spine Surgeon, Founder, & CEO, Virginia Spine Institute*

Fear, sadness, confusion, and anxiety are the most common emotions people exhibit when suffering from severe neck or low back pain. Many people are concerned that, as their pain develops, their lives as they know it are over, too. This is because of historically poor results in treating spinal problems but also due to the fear of the unknown. Spinal health care and spinal surgery have evolved immensely over the past 30 years. Due to this great evolution, today's reality of patients with neck or back problems is extremely promising. Incredible advancements in technology, training, and thus knowledge empower patients to have hope for the future. Contemporary therapy and rehabilitative techniques are the cornerstone of this improvement and, when properly performed, lead to great functional recovery without the need for any significant intervention. There's also hope for those with significant degenerative problems, instability, or pathology that do not respond to non-operative treatment; with improvements in technology come improvements in patient outcomes, as well. Incredible minimally invasive technologies of today, motion-preservation operations such as disc replacements, the 3D printing of anatomical implants, and the use of robotic surgery are all game changers, enabling today's spinal specialists to return patients back to active and fulfilling lives. What we know today is that the diagnosis of a neck or back problem can be only a temporary inconvenience; with proper treatment, people can regain their lives and avoid disabling pain, returning to the people and activities they love.

Spinal surgeries of yesterday often left patients incapacitated for long periods of time and with significant residual problems, but the surgeries of today are truly modern miracles of technology, knowledge, and ability. Because of these medical advancements, patients are able to regain the quality of their life through minimally invasive treatments, yet there is still often a stigma of the success of neck and back treatments. It is interesting to note that few people are questioning the success of hip or knee replacement surgery, like they do with spine surgery. The ability to function for someone with severe hip or knee arthritis is impaired, but after a replacement, these people are amazed that they are able to move, walk around, and enjoy life. What we know from recent research is that people's lives are improved by hip replacement and knee replacement surgery significantly, but the fascinating part is that contemporary spinal surgery improves the quality of life greater than the benefit that is experienced by hip and knee replacement surgery. This means that not only does spinal surgery work by restoring and improving lives, but that it works even better than the massive benefits that hip and knee replacement surgeries offer. The modern miracle of today's spinal treatments enable a motivated patient to regain their life if they are focused on getting better, embracing their responsibility in this process, and working with a spinal specialist team.

Spinal surgery works! Spinal surgery is life-improving! Spinal surgery is an essential resource to keep the millions of Americans who are suffering from debilitating neck and back pain functioning and actively involved in their families and their society.

Thomas C. Schuler, MD, FACS



## A Note From The Editor: The Promise of Modern Spine Care

Ehsan Jazini, MD

*Editor in Chief, National Spine Health Foundation*

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With nearly 100 million Americans suffering from neck or back pain each year, spinal disorders are some of the country's most prominent morbidities with life-altering implications for millions of people. Chronic neck and back pain can have severe consequences on the lives of suffering patients by causing constant pain and preventing them from leading active lifestyles or participating in many of the activities they enjoy. In addition to the detrimental effects spinal disorders can have on an individual's quality of life, neck and back pain have a significant negative impact on the nation's economy as the leading health-related economic expenditure. With serious implications on an economic and individual level, the improvement of spine health care through technology and the development of more cost-effective approaches for the prevention and treatment of spine disorders is a top priority in the field of medicine. The National Spine Health Foundation aims to educate the public about the importance of maintaining their own spinal health as well as providing hope to patients already suffering from neck and back pain through patient-driven education and advocacy initiatives. The Foundation also works to drive innovation in spinal health through research to find minimally invasive alternatives to traditional treatments that contribute to faster recovery times and a better quality of life for patients after surgery.

Prior to modern technologies, many injuries could terminate a patient's activity for life or incapacitate them for several years. For some cases, the introduction of 3D printed implants, robotic systems, and advancements in surgical techniques provide exponential relief, often having patients back to full activity in days. More recently, regenerative medicine practices such as stem cell therapy, have given new light into the future of spinal health treatment options. While extensive surgeries may still be required for severe cases, these costly procedures are not always effective. Studies have now shown that stem cell procedures or novel physical therapy can fill the gap for many cases where previous surgeries were once the best solution, but were not ideal.

These processes, in tandem with newly designed surgery techniques, promise a new wave of spinal health development. Innovations continue to develop; with AI and augmented reality technologies, procedures appear even more effective as doctors can gain more control and specificity in their operations through a more targeted system. New testing is contributing to the excitement surrounding newly developed hardware and software, hospitals are beginning to implement machinery that couples revolutionary robotics with the surgical procedures doctors have learned for many years, reducing surgical and recovery times, all while producing better patient outcomes. These, and other forms of medical technology, have revolutionized the field of spinal health at an incredible rate and will hopefully continue to improve the treatment of neck and back pain.

Ehsan Jazini, MD

## The Burden of Neck & Back Pain



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The burden of neck and back pain in the United States can not only be measured in economic impact but also in individual and national cost, with nearly 100 million Americans reportedly suffer annually. Until now, there has not been a national patient advocacy nonprofit dedicated to educating Americans about prevention for neck and back pain, as well as explaining the many treatment approaches and options, both surgical and non-surgical. As technology and innovations have expanded, especially in the last decade, minimally invasive surgery,

3D printing, augmented reality, stem cell, dry needling, and laser treatments have all come to market as promising treatment strategies. In order for patients to get the answers they need, there needs to be an unbiased, vetted place to get the truth about these treatments, as well as a community of those who have successfully overcome their neck/back disorder. Through its educational, research, and patient advocacy initiatives, the National Spine Health Foundation is the beacon of knowledge in this sometimes confusing and intimidating world

of spinal health, providing hope to the millions of Americans suffering from neck and back pain.

### Defining Neck & Back Pain

Neck and back pain can be classified depending on its anatomical location, cause, and duration. “Low back pain” is the most common type and is associated with the lumbar vertebrae of the spine, while “neck pain” is the second most common and manifests in the cervical vertebrae.<sup>1</sup> For the purposes of this review, all types of spine-related pain will be referred to

**“The effects of back pain on a person’s life can vary tremendously, from minimal disturbance to significant disruption in day-to-day life, including dramatic social, occupational, and financial burden.”**

as back pain. Generalized back pain can be broken down into three main categories based on causative mechanisms: injuries (i.e. fractures, dislocations, strains, sprains), disorders (sciatica, stenosis, disc degeneration) and deformities (scoliosis).<sup>1</sup> Injuries can be traumatic, such as car accidents or sports injuries, or they can be subtle, such as sudden awkward movements or repeated heavy lifting. Most back pain is mechanical in nature, meaning any of the components associated with the spine (i.e. vertebrae, ligaments, muscles, nerves) may fall out of their normal alignment.<sup>2</sup> The majority of cases are acute and will resolve within six weeks with little to no treatment, however some persist and can recur within one year.<sup>3</sup> 1 in 5 acute cases will progress

into chronic pain lasting longer than 12 weeks, which tends to be more challenging to treat and may persist throughout life.<sup>4,5</sup>

### **Personal Impacts**

The effects of back pain on a person’s life can vary tremendously, from minimal disturbance to significant disruption in day-to-day life, including dramatic social, occupational, and financial burden. Just as the spine is the most integral part of the human skeleton, spinal disorders can quickly become integrated into the everyday lives of those affected. The true weight of back pain on an individual’s quality of life is a difficult parameter to measure, although the NIH recently defined the “impact” of back pain as a combination of

pain intensity, pain interference with normal activities, and functional status.<sup>6</sup> Patients suffering from chronic back pain report substantial limitations in daily activities such as eating, bathing, and getting dressed, leading to reduced quality of life. 1 in 3 patients age 65 years and older report they have limitations in activities of daily living, with 1 in 5 (19.2%) reporting limitations specifically due to chronic back or neck pain.<sup>1</sup>

Back pain can affect people of all ages, but there are certain risk factors that make it more likely. Among factors such as increased age, weight, smoking, and poor fitness status, back pain has been found to disproportionately affect workers. A recent CDC survey found that 1 in 4 U.S. workers experience back pain, and up to 10% of workers had to stop working, change jobs, or change activities at work due to their pain. Workers aged 45-64 years old report more pain than younger workers, and back pain is the leading chronic health problem forcing older workers to retire prematurely.<sup>7</sup> Older people who retire early because of low back pain have substantially less total wealth and income producing assets; about 87% less than those who remain in

full-time employment.<sup>8</sup> Existing literature on occupational risk factors debate which occupations are most at risk, but commonly supports that lifting heavy objects, prolonged standing, and poor ergonomics all play a role in causing preventable back pain. Factors such as these should be considered by employers, policy makers, and clinicians when advocating for spine health.

Significant associations have also been drawn between back pain and psychosocial factors.<sup>9</sup> Depression is the most common emotional feeling associated with neck and back pain, and major depression is four times more likely in patients suffering from chronic back pain.<sup>10</sup> On average, 62% of patients with back pain also show signs of depression, and the severity of depression increases linearly with severity of pain.<sup>11,12</sup> Therefore, assessment and management of psychosocial distress may be beneficial in holistic recovery.<sup>13</sup>

Despite what is known about the potentially life-altering effects associated with neck and back pain, many patients choose not to seek medical advice. In a systematic review of ten studies involving a total of 13,486 people with low back pain, care seeking was reported in only 58%.<sup>8</sup> A 2017 survey found that 55% of people

with back pain chose to treat their pain on their own, yet 45% of respondents also reported pain lasting longer than five years.<sup>14</sup> Although self-management can be beneficial in some circumstances, misconceptions about back pain are common and can ultimately impact outcomes, making community outreach and patient education extremely important.

### Health Care Impacts

Overcoming back pain is a journey, and understanding the process of spine care is the first step. Considering neck and back pain is the most common reason a person will visit their doctor for physical pain, the journey to spine health often begins with an evaluation of their symptoms and development of a plan of care.<sup>1</sup> A comprehensive history and physical exam is usually sufficient to determine the source of pain in most cases, while sometimes imaging studies (xrays, MRIs) may be ordered to rule out specific causes.<sup>2</sup> The goal for therapy in most patients with acute back pain is to manage pain and preserve function while symptoms resolve on their own. Clinicians should inform patients that the spontaneous recovery rate for acute back pain is more than 50%–75% at four weeks and more than 90% at six weeks.<sup>1</sup> However, in patients with chronic back pain, treatment can involve a multi-

step process with the main goal of maintaining function, even if complete resolution of pain cannot be achieved.<sup>13</sup>

Contrary to many misconceptions, “treatment” does not always mean surgery. In fact, conservative non-pharmacological treatment is the recommendation for most, such as physical therapy, gentle stretching, and manual manipulation. Medications such as Tylenol, NSAIDs, and muscle relaxants are also common and can be helpful in controlling pain and inflammation. Surgery is often reserved for management of emergent injuries, correction of spinal deformity or instability, relief of nerve root compression, and other chronic cases where conservative treatment has failed. Treatment plans should be specific to the cause of pain and tailored to the individual needs of each patient.

Opioids can be appropriate in some cases but are often overprescribed. Back pain is the major form of chronic pain among adults worldwide and the most common, non-cancer reason for opioid prescription in the U.S.<sup>15</sup> In a study analyzing long-term trends in treatment options for spine conditions, prescription medications showed a dramatic increase of 123% between 1996 and 2014.<sup>1</sup> This is especially



relevant given the increasing threat opioids have had on our communities in recent years.<sup>16</sup> As such, the NIH recently issued a public request to encourage researchers to better illustrate the problem of opioids in spinal care and to identify appropriate alternatives.<sup>15</sup>

## Economic Impacts

In addition to its profound impacts on personal life, the weight of neck and back pain in the United States can be measured by its enormous economic burden. Back pain is a leading cause of health-related economic drain, accounting for an estimated total cost of \$250 billion annually.<sup>1,16</sup> While actual costs are difficult to measure, estimates include indirect costs (i.e. disability and reduced productivity) which are believed to be several times more costly than direct costs (immediate medical costs). Like many other diseases, a small portion of those affected by spinal disorders make up the majority of the costs. Alarming, the top 5% of patients seeking advanced medical treatment for their back pain make up more than 75% of the annual costs associated with back pain in the United States.<sup>4</sup> Back pain has ranked #1 amongst diseases in “years lived with disability” worldwide for nearly three decades and shows no signs of slowing down, posing

a serious challenge to health systems and economies around the globe.<sup>17</sup> This is especially true in the United States, where low back pain is the most expensive occupational disorder and the fifth most common diagnosis from doctor’s visits each year.<sup>18</sup> Back pain is the leading cause of job-related disability in the U.S., with more than 264 million lost work days per year. This accounts for almost half (47%) of total lost work days among the total workforce, and amounts to two days off per employee in the U.S. annually.<sup>1</sup> Back pain is also the second most common source of overall disability and lost productive time for adults; nearly eight million American adults cited back or spine problems as the source of their disability.<sup>19</sup> Disability leads to early retirement and can cause profound financial burden in the individual. In fact, more people are forced to retire because of back pain than heart disease, diabetes, hypertension, neoplasm, respiratory disease, and asthma combined.<sup>8</sup>

Despite its already-extreme prevalence, neck and back pain in the U.S. has maintained an increasing trend over recent decades. The number of physician visits has increased steadily over the years. In 2013, more than 57.1 million patients visited a physician with a complaint of

back pain, compared to 50.6 million in 2010.<sup>1</sup> This may be explained by the aging population, however, back pain is also rising in younger workers, who often spend an increasing number of hours hunched over tablets and smartphones.<sup>16</sup> These increasing trends reflect a lack of progression in addressing this condition, highlighting the need to combat neck and back pain on a national level – an initiative which can benefit nearly all Americans. The current upward trajectory of incidence is of particular concern considering medical costs are also on the rise. Total direct per person healthcare costs for persons with a spine condition were \$9,035 in 2014, an increase of 80% from \$5,023 since 1996.<sup>1</sup> Although the mean length of hospital stay for spinal fusion procedures has decreased from 4.7 days in 1998 to 3.9 days in 2013, the mean hospital charge for these patients has increased significantly. The mean hospital charge in 1998 was \$26,000, while in 2013 the mean charge was \$112,000. Increased use of instrumentation and biologics (mainly bone substitutions) contribute to the higher cost. The total increase in hospital charges rose from \$5.4 billion to \$48.7 billion over this 16-year period, an increase of more than 542%.<sup>1</sup>

Attention is needed to develop

a more cost-effective approach to spine care and prevention in the United States in order to reverse the increasing trends of back pain incidence and reduce the economic burden of spinal disorders. In a recent article, the World Health Organization acknowledged the impacts of unnecessary spine care and the need to reform health policy surrounding back pain, emphasizing the need for sustained and coordinated support from the legislative, labor, health, and government sectors.<sup>20</sup>

## Education

Education plays a key role in successful patient outcomes. Studies have shown that patient education directly correlates to post-interventional outcomes by diminishing fears and setting realistic expectations for recovery. The Foundation offers Spine-Talks®, a unique educational platform designed to improve lives through knowledge and hope, featuring hundreds of hours on the latest diagnostics, therapeutics, and technological advancements.

Community outreach is also key in spreading awareness about spine health and overcoming common misconceptions. Join our community of Spinal Champions®, those who have achieved an improved quality of life through

treatment for their neck or back pain, and hear their stories of hope and recovery through the Get Back To It Podcast®!

## Research

Recent advancements in technology and treatment present an exciting future in spine health. The spine research community has evolved at an impressive rate over the past ten years and continues to gain momentum. Innovations such as minimally invasive robotic surgery, augmented reality, 3D printing, new prosthetic metals, lasers, and stem cell therapy have shown promise in delivering safer and more effective, personalized care. However, further research is needed to record the usefulness of these advancements in common practice. A combination of refined treatment and reformed approach to care can offer hope in the ever-burdening world of spinal disorders. The National Spine Health Foundation's mission is to improve the lives of those with neck and back pain; one way we do this through data-driven research, focused on educating patients on treatments that work, reducing the need for invasive treatments, and improving surgical outcomes. We aim to prove that more efficient and less invasive alternatives to traditional treatments exist, often resulting in faster recovery times and improved quality of life.

## Patient Advocacy

We know that the journey to spinal health is not one that can be made alone. Working to educate Americans about the treatments for neck and back pain, we are committed to proving what works, driving innovation, and improving lives through knowledge and hope. The Foundation's 'Your Patient Journey Program' supplements our educational Spine-Talks® programs with professionally curated information including awareness, diagnosis, treatment, and recovery. We advocate for policy efforts that provide access to this critical spine health information for all patients. In addition, we advocate for funding research that leads to new treatment protocols, clinical studies that evaluate methods to get patients better faster, and minimally disruptive approaches to pain relief for individuals with spinal issues and injuries. We invite patients, providers, policy makers, industry, and the health care community to access the educational resources of the National Spine Health Foundation website and share it with others who may benefit from its content.

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## THE IMPACT OF NECK & BACK PAIN

### PERSONAL



**100 million**

Americans, approximately one third of the United States' population, suffer from neck or back pain each year

**4x** more likely to become **clinically depressed**

### HEALTH CARE



reason for doctor visits for physical pain and **most common** non-cancer related opioid prescriptions in the United States

**2<sup>nd</sup>** highest doctor visits after the common cold

### ECONOMIC



**\$250 BILLION**

annual cost to U.S. economy, with **264 million** lost work days per year

**#1** cause of job-related **disability** in the United States

## WE ARE DEDICATED TO IMPROVING LIVES OF THOSE WITH NECK AND BACK PAIN THROUGH:



### EDUCATION

- **Spine-Talks®** features current insights from the nation's leading spine experts
- **"Get Back to It Podcast"** shares real stories of healing and recovery from **Spinal Champions®** and top spinal specialists
- **The Spine Health Journal**, our patient-centered, research-driven publication
- **Spinal Spotlight Newsletters** offer monthly topic-focused information on spinal issues



### RESEARCH

- **SpineOnline®** is a robust, cloud-based research tool that enables nationwide, multi-centered studies which help prove the effectiveness of spinal treatment options
- **The Research Institute** provides hands-on experience to student interns from high school through graduate level students
- **Scientific Publications:** Spine Health makes important contributions to clinical research publications as well as supports FDA clinical trial research



### PATIENT ADVOCACY

- The **Spinal Champion®** program connects those who have pursued treatment and improved their quality of life, providing hope to others
- **We've Got Your Back Events:** Our annual race celebrates prevention and wellness; our Gala celebrates spinal innovators, patients, and industry partners
- We **support policies and initiatives** that offer much needed support to patients as they embark on their journey to spinal health

### NECK & BACK DISORDERS DEFINED

per ICD-9-CM

#### Back & Neck Disorders

- osteoporosis
- arthritis
- spondylosis
- scoliosis
- deformity
- stenosis
- spondylolisthesis
- sciatica

#### Disc Disorders

- herniation
- degeneration

#### Injuries

- fractures
- dislocations
- sprains

sources: (1) [www.boneandjointburden.org](http://www.boneandjointburden.org) (2) [www.ninds.nih.gov](http://www.ninds.nih.gov) (3) [www.ncbi.nlm.nih.gov](http://www.ncbi.nlm.nih.gov) (4) [www.mayoclinic.org](http://www.mayoclinic.org) (5) [www.sciencedirect.com](http://www.sciencedirect.com)



## Ask the Expert

Todd J. Albert, MD

*Surgeon in Chief Emeritus, Professor of Orthopaedic Surgery, Hospital for Special Surgery*



### What is your speciality and what drew you to the field?

My specialty is spine surgery, with a focus on the cervical spine and other deformities.



### What are the top 3 innovations that you are excited about within the spinal health industry?

Minimally invasive spine surgery: While outcomes may in the end be similar, infection rates are lower, the hospital LOS is less and the patients do want it if we can accomplish similar goals with less destruction of native tissues.

Augmented reality and robotics: Because these adjuncts allow us to perform surgery with less error in instrumentation placement, as a augmentation to less invasive surgery and a augmentation to better workflows and preoperative planning.

Regenerative therapies for the disc: While aspirational at present, when operationalized and developed, these therapeutic interventions have the potential to avoid surgery altogether by inhibiting or reversing disc degeneration and its byproducts.



### What is the most major technological trend you expect to see in the next year?

I foresee the use of augmented reality being regularly used in spinal surgery.



### Looking back to when you first entered the field and comparing to where we are now, what surprises or intrigues you the most?

I never thought we would get to a place where robots actually functioned and were of use in surgery, yet here we are!



### Should patients wait for surgery/technology to improve before receiving care?

Patients should not wait for technology to improve before pursuing surgery if they have an indication (valid reason for treatment) and have tried alternatives. The results are wonderful with the right indications and the advances in the last 10 years are making incremental, positive changes in treatment options for patients.



### Should/do patients have a role in contributing to further advancing spinal health care? If so, how?

Patients can help advance spinal health care by being open to new technologies offered by responsible and innovative surgeons. Participating in appropriately designed and ethical studies of those technologies is another way for patients to be actively involved in contributing to the future of spine.

## The Future of Spine Surgery: Augmented Reality



Christopher R. Good, MD  
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President & Spine Surgeon, Virginia Spine Institute*



Samuel Eaddy, MS  
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### Introduction

As the field of spinal health continues to evolve, advancements in modern spinal surgery are equipping surgeons with state-of-the-art technology to enable improved patient outcomes. One such advancement is the introduction of Augmented Reality (AR) in the operating room. Through the use of interactive AR headsets with specialized holographic lenses, surgeons now have the ability to project computer-generated 3D images of a patient's underlying anatomy directly onto the patient's skin during an operation, providing surgeons with a more intuitive understanding of the patient's anatomy in relation to their surgical instruments, all without taking their eyes and hands off of the patient. This new AR technology makes surgeries more precise and efficient, and has been shown to increase patient safety through decreased tissue damage, radiation exposure, and operation time resulting in faster

and healthier recoveries.

### Defining AR

Augmented Reality is often associated with Virtual Reality (VR), which has generated much attention in recent media for its uses in modern entertainment. Although the two technologies are similar, there is one key difference: VR completely shuts out the "real world" view and creates an entirely separate simulation, while AR enables the user to view overlapping digital content while continuing to see in the real world. Common everyday examples of AR include the colored lines in a car's backup camera and the yellow first-down markers on televised football games. While this technology has already been incorporated into our everyday lives, its applications in surgery are only just emerging and have significant breakthrough potential.

### AR Headsets

Augmented Reality headsets, such as Augmedics' Xvision Spine

(XVS) system, which was the first of its kind to be approved for use in spinal surgery by the FDA in December 2019, are designed to offer surgeons enhanced control and visualization during surgery.<sup>1</sup>

In addition to the surgeon's normal field of view, the headset projects navigational data onto the surgeon's retina, allowing the surgeon to simultaneously superimpose clinical and radiographic data (such as a pre-operative CT or MRI images) onto the patient's body in real time. Integrating these images together creates a transparent 3D model, which can provide considerable visual and spatial advantages when implementing a surgical plan.

### Computerized Surgical Planning

Preceding this new AR technology, advancements in computerized navigation capabilities over the past decade have provided unique 3D views of patient anatomy. This software has

gradually become commonplace in enabling surgeons to combine multiple pre-operative images into a single program to fully understand a patient's unique condition and anatomical landscape. By integrating this data into a comprehensive yet intuitive model, the software guides the surgeon in developing an optimal pre-operative surgical plan to correct the patient's pathology and optimize their spinal alignment. This precise plan is then referenced throughout the procedure inside the operating room, in conjunction with intra-operative imaging to achieve optimal results.

### Visualizing Data through AR Heads-Up Display

AR offers the unparalleled convenience of continuously viewing 3D navigational data and operative plans, while maintaining an operative field of view. Typically, for complex spinal procedures, surgeons are required to repeatedly divert their attention from the surgical site to monitors in the operating room to ensure their instruments are accurately oriented in relation to the patient's anatomy. In addition, surgeons must interpret 3D surgical plans from their 2D appearance on these monitors, and then translate the planned trajectory to the patient from memory. This is a mentally

strenuous process that can require repeated attempts, which can contribute to a disruptive workflow in the operating room, ultimately leading to fatigue and potential for error. With AR, however, the software merges images from each of these screens within the heads-up display while automatically orienting the data into a 3D hologram, which is then overlaid onto the surface of the patient, allowing surgeons to rapidly reference the operative plan and relevant patient data without taking their eyes off of the surgical site. By providing this all-in-one interface, AR may eventually diminish the need for dedicated monitors for the display each component of a patient's data, ultimately reducing costs while providing greater operative comfort for the surgical team.<sup>2</sup>

### Exposing Hidden Anatomy

Minimally invasive surgery has evolved in recent years to allow for treatment of some of the most difficult spinal deformities while minimizing soft tissue disruption, thus enhancing the patient's speed of recovery. However, as incision sites get smaller, surgeons have significantly reduced visualization of the patient's underlying anatomy. By using AR navigation, a surgeon can essentially enable "X-ray vision" to visualize a patient's spine through the skin and identify the location of

important anatomical structures (i.e. nerves, blood vessels, and the distances between them), as well as visualize information about the procedure (e.g. screw direction and angulation). This is a powerful application which can allow for a more intuitive operative experience and help surgeons to further minimize risks of complication and ensure the best possible outcomes for patients.<sup>3</sup> In addition, this guidance can augment the surgeon's ability to accurately and safely place surgical implants, especially in patients with complex or abnormal anatomy.

### Augmented Reality Research

Studies have shown that AR enables surgeons to perform operations more safely and with improved accuracy. Although the usefulness of computer-assisted navigation during surgery has long been accepted by the orthopedic community, the true clinical value of AR-specific navigation in spinal procedures has not been well documented. One of the promising applications for AR 3D-guided navigation in spinal surgery is the placement of pedicle screws in surgical fixation of the vertebrae. Given this can be a challenging procedure, especially with regard to thoracic vertebrae which are inherently smaller than the lumbar vertebrae,

there is significant opportunity for surgical improvement. Until recently, much of the supporting data for AR has come from research conducted on cadaveric spines, which aims to mimic operative experience. In a study assessing the placement accuracy of 94 pedicle screws in 4 cadaveric spines, AR delivered increased overall accuracy, reduced rates of screw misplacement, and eliminated the need for intra-operative fluoroscopy or x-ray imaging compared to the traditional free-hand (FH) method.<sup>4</sup>

A 2016 prospective cohort study on live patients at the Mayo Clinic assessed the safety and feasibility of using an early AR headset prototype in pedicle screw placement in 10 patients. Surgical data from two surgeons demonstrated a total of 40 pedicle screws were accurately placed with decreased operation time per screw placement (4.13 min per screw with vs. 4.86 min per screw without the heads-up display). According to a post-operative questionnaire, the

surgeons reported an overall positive experience with the heads-up display despite a slight learning curve in getting used to the technology. It is worth noting that the surgeons also emphasized an increased ability to focus on the patient throughout operations.<sup>5</sup>

In another recent prospective study comparing pedicle screw placement accuracy in 20 patients using Augmented Reality Surgical Navigation (ARSN) versus 20 matched control patients who received traditional FH technique, researchers demonstrated that ARSN provided significantly higher accuracy (93.9%) compared to the FH method (89.6%). In addition, the proportion of screws that were not misplaced was over twice as high in the ARSN group compared to the FH group (63.4% vs 30.6%).<sup>6</sup> Although compelling data from studies such as these support the safety, feasibility, and overall accuracy of pedicle screw placement, more large-scale clinical outcome studies are needed to establish the full clinical and economic benefits of

this state-of-the-art technology. Despite the current paucity of comprehensive clinical data, the existing literature suggests an increasing interest of surgeons regarding the incorporation of AR in the operating room to enhance the safety and efficacy of modern surgery.<sup>7</sup>

## Conclusion

As the evidence supporting Augmented Reality in spinal surgery continues to develop, we foresee it being a breakthrough addition to the modern operating room. The unique ability of AR to enable surgeons to visualize their patient's underlying anatomy while simultaneously superimposing navigational and instrumentation data within the same field of view is a remarkable innovation with undeniable potential. The emergence of this technology is yet another landmark in the evolution of spinal surgery which has potential to bring significant improvements to patient outcomes.

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## 3D Printing Spinal Implants: A Fad or the Future?



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3D printing technology has taken off in the last number of years. This exciting technology has been used to create small toys to machinery to even an apartment building! 3D printing has been used for the creation of spinal implants as well. Is this simply a passing trend or the direction of the future?

In general, spinal implants may be utilized for establishing fusions, or getting one bone to heal to another in an ideal, stable position. This allows the spine to be properly aligned, reducing any pressure on the nerves. Unfortunately, fusions do not always occur and are a major cause of pain and disability after failed spine surgeries. Therefore, a major goal of implant design is to both help reestablish the spine's proper anatomy and to help it fuse in that position.

3D printing can help achieve both of these goals. By creating a wide variety of heights, angles, and depths, the number of different shapes and sizes for implants is endless. This allows surgeons to use more patient-specific implants

to achieve clinical success through ideal anatomic restoration. In most circumstances, the huge number of implant options is all that is needed for a patient. However, there are situations where having a true patient-specific implant is needed. Complex spinal deformity, tumors, or infection frequently result in significant bony distortion and thus the usual implants are not sufficient. 3D printing technology allows a truly ideal implant to be created to the individual's circumstance.

Implants can also be 3D printed in ways to assist fusion. Certain metals, such as titanium, are ideal to achieve bony union. In general, an implant needs to roughly mimic the properties of bone in order to heal ideally. If the implant is too stiff and rigid, it can indent and settle into bone, thereby losing the spacing and postural correction that was needed to achieve clinical success. If it is too soft, it simply doesn't support the weight and can break. 3D printing can be utilized to create the property match, ideally through different architectural

models with different metals. Further, 3D printing can allow for implants to have framework to allow for the placement of high amounts of bone graft, which assists in "turning on" the entire fusion process. Lastly, 3D printing allows for the creation of surface porosity to the micrometer. The smaller the surface pores of an implant, the more nooks and crannies that bone can form onto. 3D printing allows for these microscopic roughened surfaces to be created and therefore helps increase fusion rates.

Despite the benefits, 3D printing currently isn't needed in every aspect of spine surgery. In most circumstances, having true patient-specific implants is both costly and not necessary. The standard set of implants has a wide array of sizes and shapes which is a fit for almost everybody. Furthermore, the prerequisite CT scan to create the implant requires a radiation dose to the patient. Despite its downfalls, however, 3D printing has huge applications to the current and future goals of spine surgery.



## How Artificial Intelligence & Machine Learning Will Improve the Quality, Value, & Innovation of Spine Care

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The world of spine surgery has seen incredible changes during the past several years. In a short period of time, we have witnessed the introduction and routine use of sophisticated navigated robotic systems that help surgeons place spinal instrumentation, the evolution of dynamic stabilization and disc replacement technologies, and more recently, the rise of artificial intelligence (AI) and machine learning (ML) algorithms in the spine service line. AI and ML have the unique fortune of being able to potentially revolutionize and enhance the quality and delivery of spine care to healthcare systems, providers, and patients. In a review article recently published by our multi-center spine research team at the Cleveland Clinic, Mount Sinai Hospital, and Mayo Clinic; we found that AI/ML could improve spine care through (1) pre-operative patient work-up, patient selection, and outcome prediction, (2) quality and reproducibility of spine research, (3) perioperative surgical assistance and data tracking optimization, and (4) intraoperative surgical performance.<sup>1</sup>

From the surgeon's perspective,

we now have a powerful tool that will help us improve surgical indications, reduce complications, enhance the power and quality of our research, and minimize heterogeneity in outcomes. From the patient's perspective, AI/ML maximizes value of state-of-the-art spine care by improving quality and minimizing costs. Furthermore, the patient's experience is enriched with the knowledge that their surgeon is well-versed in cutting-edge technologies and spine innovation.

AI/ML are being developed to meet a growing need to improve the quality of spine care while simultaneously decreasing costs. This is because spine care is expensive: annual expenditures in the United States currently average approximately \$110 billion in direct costs.<sup>2</sup> Healthcare costs are spiraling out of control and Medicare reimbursements are facing billions of dollars in planned cuts over the next several years.<sup>3</sup> Physicians are facing an increasingly difficult environment of decreasing reimbursements, increasing payer denials, and public reporting of the utilization and quality of care.<sup>4</sup> Without a change in our current financial



“The world of spine surgery has seen incredible changes in the past several years.”

trajectory, we will soon be forced to make major cutbacks in the quality and delivery of spine surgical care.<sup>2</sup>

For example, imagine you are patient with low back pain and sciatica due to a “slipped” disc (spondylolisthesis) in your lumbar spine. You tried six weeks of physical therapy, pain medications, and maybe even an epidural steroid injection. Nothing provided long-lasting relief of your pain. You are referred to a spine surgeon who believes you are a good candidate for surgical intervention. This is the problem: there are many different ways to treat a spondylolisthesis, including (and not limited to), laminectomy, laminoforaminotomy, laminectomy with in-situ posterolateral fusion, laminectomy with instrumented posterolateral fusion, transforaminal interbody

fusion (TLIF), anterior lumbar interbody fusion (ALIF), lateral interbody fusion (LLIF), or some combination of all of the above. While there is evidence to support certain treatments over others, a surgeon's choice in treatment is often dictated by training, experience, and personal performance.<sup>5</sup> It is difficult, if not impossible, for surgeons to reconcile and weigh all of this data and his or her personal performance when indicating such a patient for surgery. AI/ML can assist surgeons with this clinical decision-making.<sup>6</sup> In this setting, AI could assist surgeons in identifying good surgical candidates, advise the surgeon on operative approaches, and predict the likelihood of success, cost, and/or payments of various treatments.<sup>7</sup> These innovative approaches could allow for a stronger guarantee of optimized patient outcomes in certified surgical candidates through ensuring proper procedure selection. Simply stated, AI/ML algorithms are useful as an objective, data-driven tool that allow surgeons to confidently say that a patient is getting the best quality of care for his or her specific spine problem.

As AI/ML becomes increasingly sophisticated, there will likely be drastic changes in the operating room, as well. While intraoperative AI platforms are being developed

and mostly experimental at the time of this writing, the two most prominent technological advances in the modern era of spine surgery, namely, neuronavigation and surgical robotics, are especially well suited to AI.<sup>8</sup> Augmented reality and robotic-assisted spine surgery are generally utilized in minimally-invasive or complex spinal deformity operations. Since image processing is a strength of AI programs, neuronavigation stands to benefit from evolving AI platforms. By integrating patient-specific anatomy, AI-enhanced image processing allows for precise reconstruction of relevant spinal anatomy during surgical planning. This will allow surgical robotics to further increase precision, thereby lowering potential complications from human error.<sup>9</sup>

Advanced navigation technologies allow surgeons to reconstruct patient-specific, 3D-renderings of the spine that provide real-time positional feedback during the operation. For surgeons, it provides us with a "digital roadmap" to the patient's spine. The operating team can also use AI-powered image guidance to direct precise spinal hardware placement. Multiple studies have established that these robotic-navigation systems not only improve accuracy in hardware placement, but also improve

the efficiency and speed of operations, thereby reducing the duration of generalized anesthesia.<sup>8,10</sup> Furthermore, robotic-assisted spinal surgery can also reduce the need for x-ray during procedures and thereby decrease exposure to harmful radiation to the patient, surgeon, and surgical staff.<sup>8</sup> Another challenge in spinal surgery is maintaining surgeon ergonomics during lengthy operations. Even the best trained spine surgeon will eventually develop fatigue during a long operation. Robotic-assisted devices address this by improving surgeon comfort and reducing the need to handle heavy equipment, thus improving a surgeon's stamina.

It is important to note that while these advanced robotic systems are useful and have an important place in spine surgery, they are not replacements for expert surgical skill and decision-making. Even in the most challenging cases, which would benefit from robotic assistance, the surgeon is the key leader who makes the crucial intraoperative decisions and guides the robots in their function. Like any instrument, surgical robots are tools in the spine surgeon's armamentarium. There is also a large price tag associated with the purchase and continued use of surgical robotic devices, which may prove to be a barrier to

their widespread implementation. There has always been a critical balance between cost and innovation in spine surgery, which needs to be realized. While AI-driven technologies for intraoperative surgical assistance are still in their infancy, the potential for AI/ML to guide robotic-guided spinal fusions are certainly on the horizon.

At the Center for Spine Health at the Cleveland Clinic, we are in the process of launching a multi-disciplinary translational research initiative to examine the integration of AI/ML into our spine service line.<sup>1</sup> Our goal is to validate our AI with a comprehensive and robust adult spinal deformity patient database, built on thousands of patients treated at the Cleveland Clinic. One of our preliminary goals is to develop a predictive tool of the

probability of success and risk of complication for any given patient who is about to undergo surgery for adult spinal deformity. The AI will be designed to automatically extract patient-specific information from the electronic medical record to be used as input variables to generate a probability of success and complication for a given surgery. Ideally, this information could be used by a surgeon to develop a surgical plan with the highest evidence-based probability of success, whether that may be a laminectomy or a multi-level spinal fusion. The outputs of the AI/ML models in this study will also examine readmission rates, reoperation rates, and provide “hard” objective data on patient reported outcomes. This project was designed to be transparent and comprehensible, while achieving desired results in a reasonable

timeframe. Once the AI/ML is built based on historical data collected at the Cleveland Clinic, we will prospectively evaluate it during routine practice at the Center for Spine Health. We are very excited about the launch of this initiative and its potential transformative implications in the world of spine surgery!

In conclusion, AI/ML has emerged as disruptive technologies that will revolutionize spine care by reducing expenditures and improving its delivery. AI can help clinicians and hospital centers define the quality and cost of care, improve outcomes, and mitigate downrange financial exposures. AI can also collect, process, and analyze volumes of patient information to extract valuable clinical information for studies. Therefore, incorporating AI/ML algorithms in spine surgery are becoming ever-more important.

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## Enhanced Recovery After Surgery (ERAS)



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The Enhanced Recovery After Surgery (ERAS) protocol is helping evolve spinal postoperative recovery, including better pain control, eliminating the need for IV pain medications, reducing opioids. These advancements allow your medical team to use the best data-driven practices to help patients mobilize after surgery, recover faster, and go home sooner. We'll take a look at what ERAS means, from the experience of a spinal medical team at Reston Hospital Center, located in Reston, VA.



### A Physician's Perspective

ERAS is an innovative program designed to help educate patients, prepare them for surgery, and allow them to have a speedy recovery from their surgery so that they can resume their life activities expeditiously. We at the Virginia Spine Institute, in collaboration with Reston Hospital Center, have developed a tailored program for patients undergoing

spine surgery.

Preparing for and undergoing spine surgery is analogous to training, completing, and recovering from a marathon. Before training for a marathon, a runner must undergo dedicated fitness training, nutrition program, and mental preparedness prior to a successful completion of a run. ERAS is meant to be a marathon training program

that is used before, during, and after the marathon of surgery. Before undergoing spine surgery, intensive preparation must be done to ensure that preparation of the physical body is done - for example, proper nutrition and avoiding detrimental habits such as smoking or excessive drinking. As part of this preparation, educating patients on their expectations regarding the surgery and their recovery is critical.

In the morning of the surgery, the patient is given a cocktail of medications that help support the nerve and muscle function, minimizing the need of pain medications. In conjunction with our anesthesiologists, we also use local anesthetics to help reduce the need for pain medications during surgery, as well as after surgery.

In the recovery unit, patients are mobilized within two hours of surgery in order to start the function of their muscles and joints, which has been shown to help reduce the need for pain medications post-surgery. The patients are then placed on both long- and short-acting pain medications to help avoid the acute crisis of uncontrolled pain, reducing the risk of delayed recovery. Using this regimen, we have been able to avoid the use of Patient Controlled Analgesic (PCA) pumps, often referred to as “pain pumps”, which were found to be ineffective in controlling post-surgical pain control, even requiring more pain medications to be used when compared to the ERAS protocol.

The Virginia Spine Institute, in collaboration with the National Spine Health Foundation, has made great strides in innovation and research with regards to enhancing our patients’ recovery after spine surgery. We have evaluated how patients were doing before and after the program was instituted for both patients with smaller surgeries and larger, complex deformity surgeries. We were able to demonstrate tremendous decrease in pain medication need and usage in patients after spine surgery. We also found that patients were walking faster,

and also able to return to home sooner. We have presented our findings at both national and international meetings where we have shared our findings with other national leaders in spine surgery. For more information, visit [spinehealth.org](http://spinehealth.org).

### A Nurse’s Perspective

As a Registered Nurse and Spine Navigator, my role is to help patients as they recover after spine surgery. Prior to a procedure, I reach out to patients in helping them prepare for and understand what to expect through their recovery process. Because this is a very anxious time for patients, reaching out and educating them on what can be expected helps reduce anxiety and provides them with a sense of comfort and control as they begin their recovery process.

#### *Pain Relief*

A patient is given a “cocktail”

of medications that consist of a short- and long-acting pain medication, muscle relaxers, and Tylenol. These medications are given on a scheduled basis throughout the stay. Giving the medication prior to surgery allows for a “jumpstart” on the pain management. Because patients may or may not have already been using narcotics, we devised a formula for “narcotic tolerant” patients (those that are used to taking narcotics on a semi- or regular basis) and “narcotic naïve” patients (those that have rarely taken any narcotics). We start with one of these two formulas and adjust based on the individual need of the patient. For example, if someone is too drowsy, we will go down on doses or take a certain medication out of the mix. If the patient is not getting adequate pain relief, then we increase the dosage or make a change in the medications. Patients are seeing the benefit of this multimodal regimen because it



hits multiple receptors, providing greater relief than just using one medication alone. The use of oral medications, as opposed to intravenous allow for an easier transition for weaning down and eventually off of opioids, therefore reducing the instances of opioid addiction.

### *Faster Recovery*

Prior to the multimodal regimen, patients would easily become over sedated since most of the time we were controlling their pain with heavy IV narcotics. There were various and often dangerous side effects from these IV narcotics, such as over sedation, confusion, nausea, and urinary retention, often preventing patients from walking like they needed to. In some cases where the medication was prohibiting a patient from eliminating waste, requiring a prolonged use of a catheter.

Now with this ERAS program and multimodal pain regimen put in place, patients recover in the post-anesthesia care unit (PACU), then are taken up to the floor where the stretcher is parked in front of a recovery room. A physical therapist meets the patient and nurse and then assists the patient to walk into the room to the bed – just hours after surgery! This is considered the first evaluation of the patient’s mobility, which allows for physical therapist to

address any potential issues more immediately. Patients are then encouraged to walk once or twice more that day, increasing the frequency of ambulation the day after and throughout their recovery. In addition to the medication regimen we have other therapies available such as ice, music, and pet therapy. Ice is offered and used on almost every patient. There are two TV channels in each patient’s room that have soothing music and nature sounds, along with comforting pictures that cycle through to help distract and calm patients. Pet therapy has grown in a short period of time; a trained dog is brought around in which patients can interact with if they like, also providing great distraction from the pain. As we first introduced this regimen, you could immediately see the difference in the patients. Many would remark that their pain was better controlled because the oral medications last longer as opposed to a pain pump, which rarely provided steady relief, often leading to spikes in pain, disturbing a patient’s sleep throughout the night – a critical component to recovery. With the oral medications, we see patients getting 4-6 hours of relief at a time, leading to better sleep, more frequent ambulation, and overall faster recovery. It is clear that the more mobile a patient is after

surgery, the quicker they go home, less pain they have, and more satisfied they are with their overall post-operative experience. The frequent ambulation also greatly reduces complications, such as pneumonia and blood clots.

Thanks to ERAS, we are able to get patients better, faster, and see a reduction in hospital lengths of stay, immediate and more frequent ambulation, reduced time with a catheter, better sleep, and overall greater patient satisfaction. Enhanced recovery after surgery will continue to evolve, providing patients with more comfort and control during their recovery.

## Getting the Answers to Your Most Pressing Spine Health Questions



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A healthy spine usually makes for a healthy, pain-free body, which makes taking proper care of it incredibly important. Featured in USA Today's Personal Health, we provided answers to some of the most common spine health questions.

### Why is caring for your spine so important?

Your spine helps you perform basic functions like standing up, moving, balancing, and bending. The stronger your bones, the better they will function. Your spine also protects your spinal cord, which sends signals from the brain to your body, allowing you to control your movements. When your vertebrae are not healthy, they can collapse, crushing the surrounding nerves, and sometimes causing pain or disability. To help prevent injury, avoid or reduce pain, and maintain a healthy spine, choose healthy habits and think about your spine throughout the day – this could lead to big impacts in the quality of your spine health, as well as overall health and wellness.

### What are some tips to maintain a healthy spine?

Sit up straight. Did you know the average human head weighs about 12 pounds but can increase to 60 pounds depending on the angle it is tilted? Avoid “tech-neck” by optimizing your work station: Align your monitor with your eyes, use a chair that provides lumbar support and allows you to keep your feet flat on the ground, and invest in a standing desk and/or a yoga ball. Strengthen your core. Your core helps provide balance, stability, and flexibility. A strong core can reduce, control, and even prevent pain or future injury. Keep moving. Designate a time each day to stretch and exercise, and be sure to do it with proper form. Allow enough time between activities for rest and recovery. Rest. Get

seven to eight hours of sleep each night. Talk to your doctor about whether a medical massage can be incorporated into your treatment plan. Stay hydrated. Without proper hydration, your body cannot provide your discs with enough water, sometimes resulting in pain, lack of mobility, and increased risk of injury.

### How can people suffering from spine injuries or disorders, and their loved ones, advocate for themselves?

Know that you are not alone. Nearly 100 million other Americans suffer from neck or back pain at some point in their lives. Join our community to connect with fellow patients, hearing their stories of healing



and recovery in our “Get Back To It” podcast, and connect with the nation’s leading experts in spinal healthcare through our Spine-Talks® educational series. Do your research. There’s a difference between self-diagnosing and being an informed patient. Write down questions and bring a friend or family member to help take notes during your appointment. Not sure what to ask? Your Patient Journey offers you tips and tricks on how to improve the way you care for your spine, helping you to prevent injuries, strengthen your relationship with your doctor,

and reduce your uncertainty and anxiety. Find the right team. Your medical team should treat you with respect, listen to your concerns, and include you in the decision-making process when discussing your treatment options.

### **What are the most promising innovations in spine health right now?**

There have been tremendous advancements in spinal surgery over the past 40 years, helping to make spinal treatments safer and more reproducible,

leading to better overall outcomes. From technological advancements in minimally invasive procedures, motion preservation, and intraoperative image guidance (robotics and artificial intelligence); to 3D printing, predictive analytics, stem cell technologies, and new biomaterials, the future of spinal healthcare is bright and promising! For more information on how to keep your spine healthy, visit us at [spinetalks.org](https://spinetalks.org).



## Navigate, Don't Complicate: The Role of Patient-Specific Guides in Complex Spine Surgery



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### Finding the Right Fit

Spine surgery inherently carries with it a heightened sense of fear, worry, and anxiety for patients and their families. It is important to select a surgeon whom you trust, and your confidence level in that person should be based on the research you have done regarding their skill set and qualifications. The surgeon should also be collecting data points about you as a surgical candidate so that they can decide whether or not to perform the surgery, and can develop a plan suited for your unique anatomy and individual health care needs. In essence, the surgeon and the patient need to decide that this is a good fit in order to achieve a good outcome from spinal fusion surgery.

First, what does a spinal fusion surgery entail? A spinal fusion helps stabilize a spine where there is either a high degree of curvature or deformity, or

the vertebrae themselves are weakened or broken. These problems can cause pain, difficulty moving, or other neurological deficits. This surgical procedure aims to address those issues and enable a patient to live a normal life while minimizing complications.

In a typical spinal fusion surgery, the patient is placed in a prone (belly down) position on the operating table. After the surgeon has made their incision and exposed the spine, pedicle screws are placed in the vertebra, typically one on the left and one on the right. Depending upon the size (how many levels) of the deformity or correction needed, the surgeon may implant between two and thirty-four screws. A screw follows the canal called the pedicle, connecting the laminar surface (what the surgeon sees) to the vertebral body -- hence the name, pedicle screw.

Since the pedicle is buried under

the patient's anatomy, there are FDA-cleared forms of spinal navigation available to help surgeons assess the exact location and size of the pedicle. These modalities include image-guided navigation, robotics, and patient-specific guides.

One type of guide that can be used is a pedicle screw navigation guide - often a biocompatible, single-use 3D printed device that conforms to the patient's vertebrae at predetermined contact points. Navigation guides enable optimal screw placement by incorporating planned screw diameter, direction, length, and entry point into the design of the guides and can be used without intraoperative fluoroscopy. Due to the presurgical planning involved, using guides can increase operating room efficiency and decrease screw placement time. They are also not affected by spinal movement during surgery.

The ability of surgeons to perform surgery faster and more efficiently with pedicle screw navigation guides has made it a very attractive navigation option for pediatric patients, elderly patients, patients with comorbidities, and patients undergoing complex spinal procedures.

## Presurgical Planning

Navigation guides were a game-changer for a 77-year-old woman from Oregon who is a Jehovah's Witness. To protect her privacy, let's call her Jane. As a Jehovah's Witness, Jane's religion prevented her from receiving a blood transfusion during surgery.

Jane had been experiencing progressively worsening back pain over the past 13 years. At the age of 14, she was diagnosed with scoliosis (Figure 1).

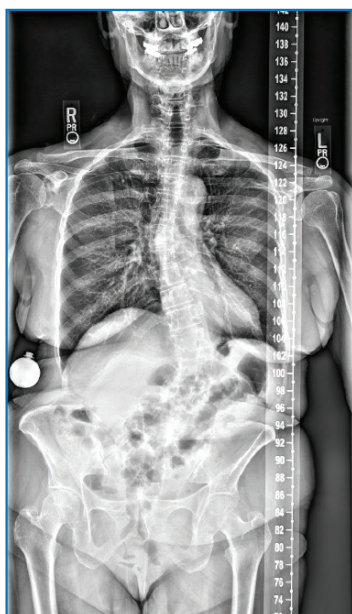


Figure 3

Preoperative posterior x-rays.

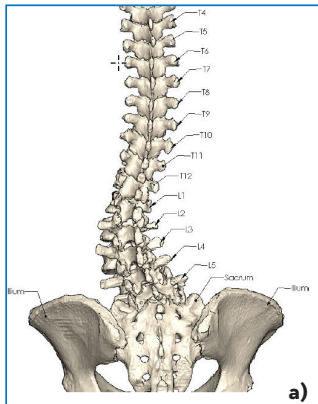
Fifty years later, her pain had progressed to the point where she felt pain after just 5-10 minutes of activity. Her pain was exacerbated with simple tasks such as cooking, dish washing, and meeting with her friends. In the past, she had tried physical therapy, acupuncture, massage, and back injections, all to no avail. Spine surgery, often considered a last resort, was her only available option.

Jane scheduled an appointment with a spine surgeon for a consultation. When she told the surgeon that her religion prevented her from receiving a blood transfusion, the surgeon refused to perform her spinal fusion surgery on the grounds that it would be too risky. This happened on two more occasions, with Jane being turned down as a surgical candidate by multiple surgeons because of the blood transfusion issue. She came to understand that spinal surgeries like hers often last several hours, and significant blood loss is an inevitable side effect. The only way to minimize her risk was to find a spine surgeon who was confident that he could perform the multi-level fusion procedure with maximum efficiency and speed.

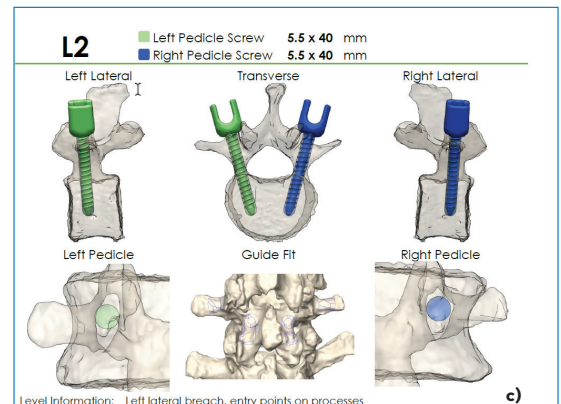
Jane wanted a successful outcome from her surgery and knew that there was no margin for error. Traditional freehand surgery

can be fast, but there can be a tradeoff in terms of the accuracy of the screw placement. Was there a form of navigation that was highly accurate and could also speed up the screw placement process? The fourth spine surgeon she met with at Virginia Mason in Seattle, WA knew of such a technology; he used a patient-specific pedicle screw navigation guide for some of his complex spine cases and had noted that they were highly accurate and sped up his screw placement times due to the mechanical constraint of the guides and the extensive concierge presurgical planning that was done by a skilled team of engineers (Figure 2). The presurgical plan enabled him to be completely familiar with the patient's bony anatomy before entering the operating room, and he knew the screw sizes and trajectories in advance (Figure 3). Making those decisions prior to surgery logically made the surgery itself go faster.

The fourth surgeon agreed to perform Jane's surgery and to use navigation guides to place the pedicle screws. As current evidence shows, potential



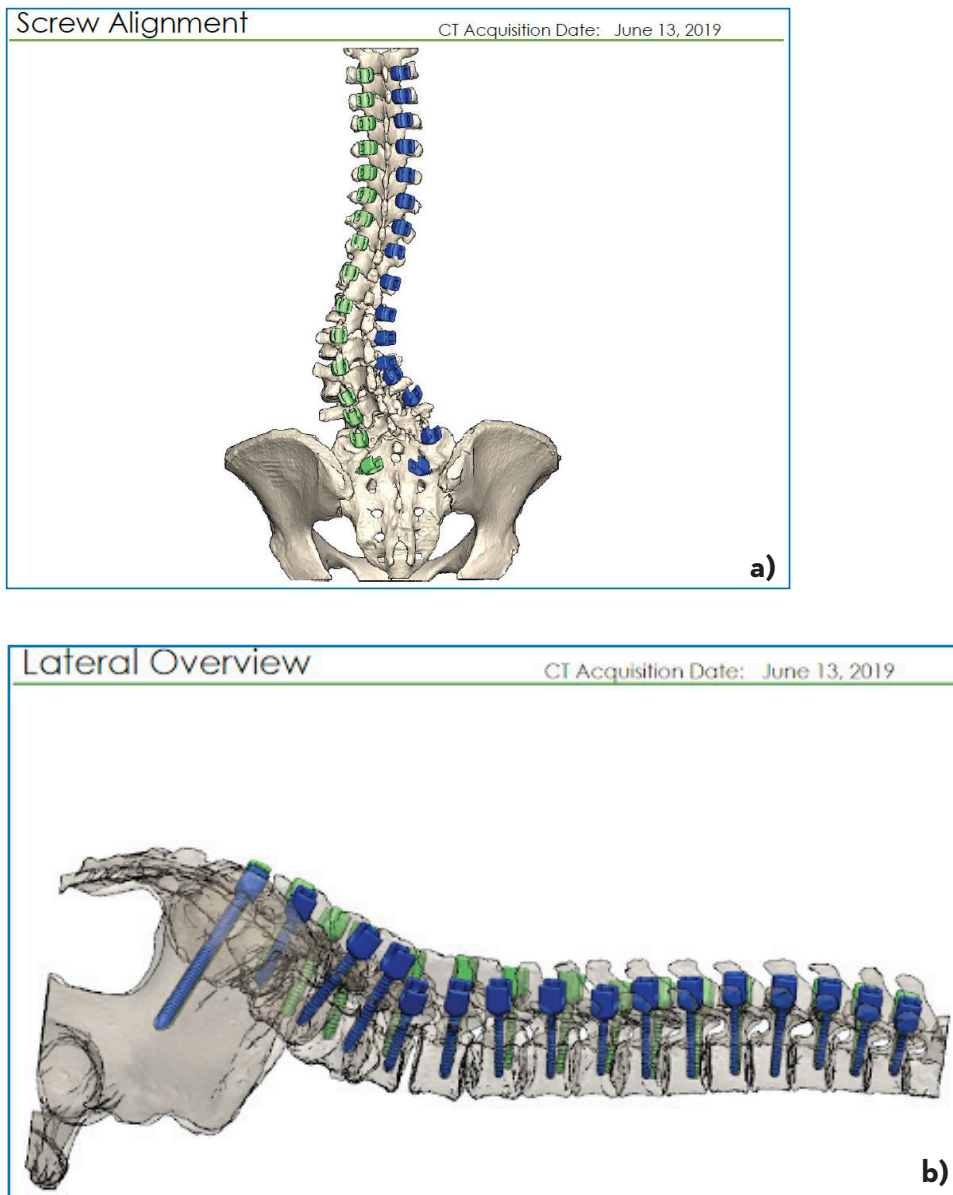
Level(s)	Left (mm)	Right (mm)
T4	4.5 X 25	4.5 X 25
T5	4.5 X 30	4.5 X 30
T6	4.5 X 30	4.5 X 30
T7	4.5 X 35	4.5 X 35
T8	4.5 X 35	4.5 X 35
T9	4.5 X 35	4.5 X 35
T10	4.5 X 35	4.5 X 35
T11	4.5 X 30	4.5 X 30
T12	4.5 X 35	4.5 X 35
L1	4.5 X 35	4.5 X 35
L2	5.5 X 40	5.5 X 40
L3	5.5 X 40	5.5 X 40
L4	6.5 X 45	6.5 X 45
L5	6.5 X 45	6.5 X 45
S1	6.5 X 40	6.5 X 40
S2	7.5 X 100	7.5 X 100



Concierge presurgical planning includes a 3D anatomic model (a), screw sizes (b), and screw trajectory (c).

risk and morbidity as a result of complex spine surgery can be minimized through a three pronged approach.<sup>1, 5-7</sup> First, a multidisciplinary team of experts discusses risk factors and formulates an action plan. This took neurosurgeons, orthopedic surgeons, physiatrists, anesthesiologists, psychologists, physical therapists, specialized physician assistants, and nurses to prepare for the challenge.<sup>5, 7</sup> Second, it was decided that the surgery could not be done without the help of two highly experienced attending surgeons, allowing the procedure to go faster with less complication. Both surgeons would work together and get Jane to recovery as quickly as possible with less blood loss; this had been proven by previous data.<sup>1, 5</sup> Third, there was a strict protocol for the intraoperative management of coagulopathy.<sup>5</sup> Jane was informed of her perioperative surgery protocol and took a mandatory patient education course to review her risks, prepare herself for surgery, and understand

**Figure 3** Posterior (a) and lateral (b) views of the screw head alignment are provided to assist the surgeon with rod placement.



everything that the Seattle Spine Team was doing to make her operation go as smoothly as possible prior to surgery.<sup>6</sup> The surgeon also discussed the use of the navigation guides for her surgery. After all of this was disclosed to her, she agreed to the

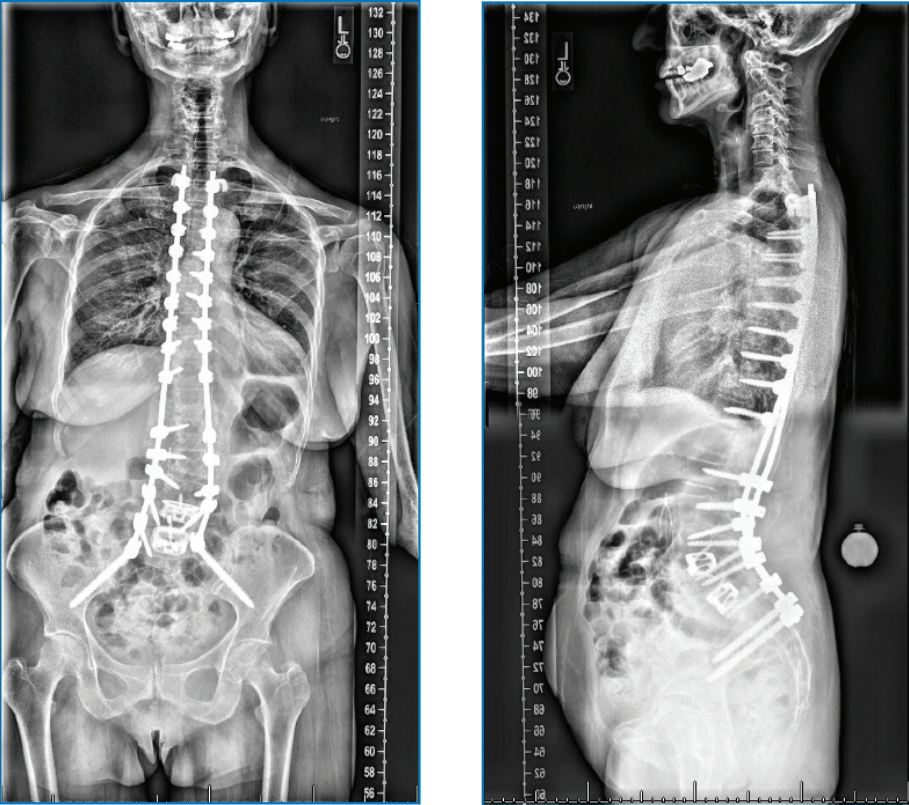
surgery.

With the use of the navigation guide and cell saver technology, Jane experienced no intraoperative complications, and screw placement time for 32 screws was 50 minutes out of a total of 3 hours and 30

minutes for the entire surgery. Her total estimated blood loss was 600 cubic centimeters (cc), while average blood loss ranges from 713-1270 cc.<sup>2-4, 8</sup> Imaging conducted approximately a month after surgery showed no evidence of hardware fracture or failure and continued patient improvement (Figure 4). Upon her six month follow-up, the patient stated that overall she is doing very well and is not having any pain. Patients should ask what form of navigation, if any, their surgeon is planning to use. There are inherent benefits and nuances to each technology, and these factors may come into play for a patient's specific situation and should be discussed with your doctor. You have the right to know, as well as the right to request, that certain technologies are used if you have a preference.

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**Figure 4** Lateral and posterior postoperative xrays.



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## Changing Scenery: Outpatient & Ambulatory Care Settings in Spine Surgery

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Hospitals are no longer the only places patients can have spine surgery! Advances in spine technologies, improved neuromonitoring, continued research initiatives, and new minimally invasive surgical techniques have increased physician comfort, in performing spine procedures in outpatient settings. As the healthcare climate in America continues to evolve with the aging of the baby boomer population and increased attention to cost reduction strategies, ambulatory surgery is on the rise. It is estimated that the number of outpatient spinal fusions will increase by >90% over the next decade, while inpatient procedures are expected to decline significantly.

### *Ambulatory Surgery Center (ASC)*

An ASC is a stand-alone outpatient surgery center where appropriate patients can have same-day, lower risk procedures performed, including spine surgery! The Centers for Medicare & Medicaid Cervix (CMS) has approved multiple spine procedures to be completed outside of the traditional hospital setting,

in ASCs; procedures include Anterior Cervical Decompression and Fusion (ACDF), Kyphoplasty, Discectomy, Laminectomy, Spinal Decompression, and Lumbar Fusion. Success of spine surgery in ASC environments is largely related to appropriate patient and procedure selection by surgeons and offers select patients the option to have surgery at a reduced cost in a safe site of service. According to Medicare and private payor data, the demand for orthopedic and spine procedures will continue to rise and future growth in spine services will be predominantly focused on outpatient surgery strategies. So, why is outpatient spine surgery the future?

### *Reduced Cost*

Having surgery in an outpatient surgery center offers significant cost savings to patients, insurance companies, and the US healthcare system. Reduced overhead, attention to cost saving initiatives, and improved efficiencies allow ASCs to be reimbursed less than a hospital for the same procedure, which ultimately results in lower out of pocket expense for patients. Government and private

payors are realizing the financial benefit of outpatient surgery and are beginning to encourage patients to have their surgeries completed in ASC settings when appropriate.

### *Safety*

Innovation and research helps make outpatient spine surgery safe, and therefore possible! Advanced monitoring capabilities, minimally invasive surgical techniques, improved implants and grafts, and robotics all make surgery faster and safer, the perfect combination for an outpatient setting. Research on patient outcomes surrounding spinal procedures completed in an ASC setting has demonstrated that outpatient cervical and lumbar procedures are equally as safe as when completed in inpatient hospital settings. Future research will help experts continue to learn how to best care for these patients, by understanding which patients, procedures, and techniques are best suited for an outpatient site of service.

Ambulatory surgery centers, like hospitals, are held to a high



standard to maintain safe patient care environments. Appropriate patient and procedure selection by surgeons, as well as attention to high quality care by the multidisciplinary ASC team, are key components in making outpatient surgery successful. ASCs, which are required to monitor and report the safety and quality of the care they provide, are even known for having lower infection rates than some hospitals.

Keep in mind, not all patients and procedures are a good fit for an ASC environment. Each patient

and procedure is unique, and therefore will need to be carefully evaluated by your surgeon to determine who is a candidate for outpatient surgery. Your healthcare team will collaborate to guide you in these decisions, as safety remains a top priority for ASC administrators and surgeons!

Patient Experience

It's all about the experience!

Typically, patient satisfaction scores in ASCs are high! Between the decreased wait times, affordability of care, a smaller and more intimate atmosphere, and ease of accessibility, patients

typically report they would have their surgeries in an ASC again. These satisfied ASC customers will drive the spine market to continue to grow ASC outpatient surgery strategies.

As the demand for surgical spine care continues to increase with the aging US population, ASCs offering comparable patient outcomes and optimal customer experiences at a reduced cost will impact the way the spine industry provides surgical care in the future.

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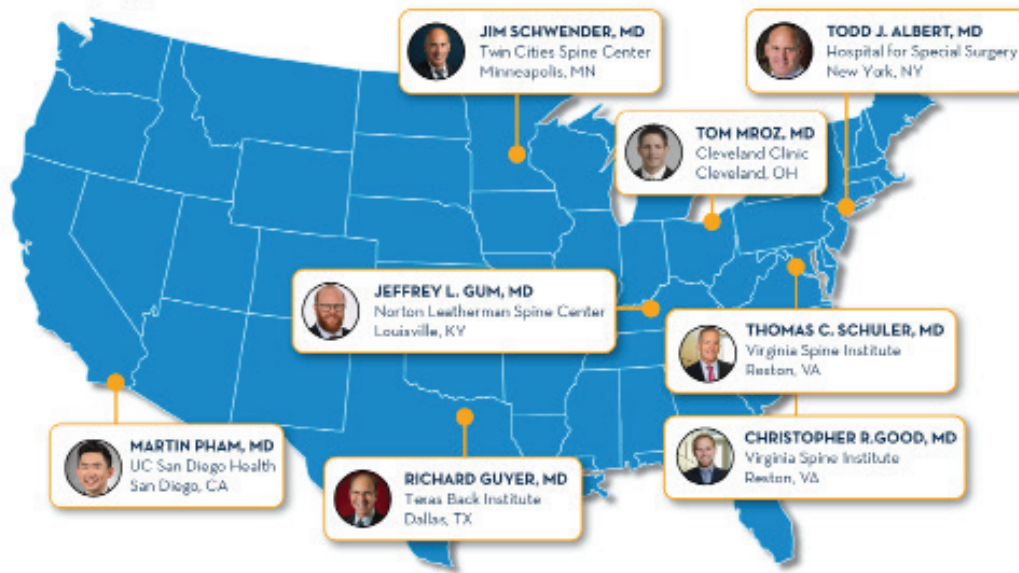
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