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Journal of the Spinal Research Foundation

Innovations in Spinal Health Care

Promising advances | Innovative solutions | Proving what works

SRF

SRF SPINAL RESEARCH FOUNDATION

INNOVATIONS IN SPINAL HEALTH CARE
JOURNAL OF THE SPINAL RESEARCH FOUNDATION
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What's New at SRF?

KARI A. REED, MSED DEVELOPMENT & EVENTS DIRECTOR

Kari is the newest member of the SRF team. She directs all of the philanthropic initiatives for the Foundation and oversees the annual giving and corporate partnership program, communication campaigns, and community outreach events. Kari brings tremendous special event experience to assist with growing the nationwide *We've Got Your Back* race for spinal health and the inaugural *We've Got Your Back* Gala to raise critical funds to advance innovations in spinal health care.

Kari has specialized in advancements for non-profits for over 22 years of her professional career. In her most recent role, she worked as Director of Annual Giving and Director of Donor Relations & Special Events at Shenandoah University. Her primary duties were to plan, develop, and execute diversified fundraising strategies to obtain corporate sponsorships and individual giving and to carry out donor stewardship events. Kari has also coordinated multiple educational conferences, symposiums, fundraisers, galas, and other special events throughout her career. In her spare time, she enjoys attending sporting events and concerts, and being outdoors.

CHRISTOPHER GOOD, MD AND RITA ROY, MD, NEW BOARD MEMBERS

The Foundation welcomed two new members into the Board of Directors this year. We want to thank our newest board members, along with the rest of the Board, for their outstanding service to the Foundation. Continue reading to learn more about how the Board plays an instrumental role in guiding our mission.

EHSAN JAZINI, MD, EDITOR IN CHIEF, JOURNAL OF THE SPINAL RESEARCH FOUNDATION

Hailing from MedStar Georgetown University Hospital, Dr. Jazini joins SRF as the new Editor in Chief. His training in both neurosurgery and orthopedic spinal surgery, paired with his extensive experience in the hospital, university, and private practice settings, has positioned him as a renowned leader in the field. Dr. Jazini has mastered surgical techniques in artificial cervical disc replacement, minimally invasive surgeries, and robot-guided spine surgery. He most notably developed a minimally invasive screw placement that reduces radiation exposure, ultimately leading to safer and more effective results. When he's not presenting research, seeing patients, or contributing to the Journal, he can be found enjoying the outdoors and travelling the world! Dr. Jazini, we wish you the best of luck in your new position and look forward to many years of success with you!

INVITATION TO ATTEND: *WE'VE GOT YOUR BACK* RACE FOR SPINAL HEALTH

Spring 2019 | Reston, VA

The tradition continues as *We've Got Your Back (WGYB)* race for spinal health returns to springtime in Reston! Set your goals now and celebrate healthy spines and Spinal Champions by signing up for the 5K run/walk or the 1 mile fun run/walk! All proceeds from our national race series benefit the Spinal Research Foundation, dedicated to improving spinal health through research, education, and patient advocacy!

The Spinal Research Foundation is a 501(c)(3) non-profit dedicated to improving spinal health through research, education, and patient advocacy.

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LETTER FROM THE EDITOR:
Ehsan Jazini, MD
Virginia Spine Institute

ADVANCEMENTS IN SPINAL SURGERY

There have been tremendous advancements in spinal surgery over the past 40 years. This progress has especially accelerated over the past decade. Improvements in technology, predictive analytics, and non-operative modalities are helping to make treatment of spinal disorders safer and more reproducible, leading to better overall outcomes.

Minimally Invasive

Minimally invasive procedures have allowed patients to recover faster due to less soft tissue disruption, which has been shown to result in lower blood loss, shorter length of stay, and quicker mobilization. Minimally invasive procedures have steadily expanded beyond microdisectomies and one to three level fusions to treating the most difficult adult spinal deformities. This steady progression has been done through thoughtful research as well as strong collaboration between surgeons and industry to help improve patient outcomes.

Navigation/Robotics

Technological advancements in intraoperative image guidance have allowed surgeons to advance from two-dimensional imaging guidance with fluoroscopy to CT-based three-dimensional intraoperative guidance. This improvement provides real-time 3D feedback that allows for better accuracy and reproducibility. Three-dimensional imaging in combination with improved planning software allows for precise surgical planning that can be executed and confirmed intraoperatively. This has led to tremendous improvements in treating revision spinal surgeries as well as spinal deformities with challenging pathologies.

Advancements in robotic spinal surgery have allowed for further assistance in the operating theatre to help improve accuracy and reproducibility as well as preoperative surgical planning. While the robotic arm has primarily been used for pedicle screw placement, this technology is rapidly growing to be utilized in all other aspects of surgery in the future.

Motion Preservation

Motion preservation technology has advanced steadily, allowing surgeons to relieve the pressure off the nerves while preserving the motion between the facet joints. This has been shown to reduce the risk of adjacent segment degeneration and mitigates the need for future surgeries at the discs above or below the initial procedure. This is believed to be due to reduction of stress at the adjacent levels.

3D Printing

The adoption of 3D printing has allowed for real-time three-dimensional models for surgical planning. 3D printing technology has also been utilized for implant design and manufacturing with improved biomechanics as well as surface area for bony fusion.

Predictive Analytics

Data predictive analytics are taking advantage of big data as well as artificial intelligence to be able to better predict how patients will do post-treatment. This allows for better informed patients and surgeons, a better understanding of the risks and benefits of a procedure, and a more tailored procedure for the individual.

While cost is an important barrier to adoption of new technology, many of these technologies will help reduce waste and inefficiencies due to better preoperative planning, intraoperative execution, and confirmation, as well as better outcomes, thereby potentially reducing reoperations. Overall cost is an important consideration that needs to be evaluated during the process of technology development and adoption.

This issue will highlight these technological advancements in detail that serve as testaments to the rapid progress in spinal surgery that holds great promise for the future.

PRESIDENT'S NOTE:
Thomas C. Schuler, MD, FACS
Virginia Spine Institute

HOW DO WE MAINTAIN WHAT IS IMPORTANT DURING PERIODS OF RAPID CHANGE?

The rate of societal change continues to accelerate at an unprecedented rate. Mankind is experiencing epic shifts in many industries due to technological advances, including the healthcare industry. With many of these advances come great improvements; however, an important question is what is being lost and are these losses beneficial? Spinal surgery has only existed for the past 25 years as a unique specialty and has only received national acceptance over the past decade. During this decade, our field has gone through major innovations which have greatly improved patients' lives and outcomes. A significant reason for such drastic improvement was the lack of knowledge and quality of spinal implants prior to the 1990s. Consequently the results of spinal surgery were historically poor. Fortunately for patients, the unique specialty of spinal health care has greatly evolved, but continued improvements are needed in the education of providers and enlightenment of the public. While many clinicians have embraced advancements in the field, others still lag behind.

Identifying the true source of a patient's pain allows the treatment to be centered on the injured structure in the least invasive fashion possible. Properly directed minimally invasive surgery has been the greatest advancement during this period. Novel spinal implants combined with less invasive surgical techniques have resulted in improvements for patients. As with all areas of health care, continued improvements will come with newer technologies and innovations. Stem cell therapies will drastically change medical treatments in all fields, especially spinal surgery. Robotic surgery minimizes the trauma surgical procedures render. Better materials and more ingenious implants will further these advances and continue to improve patient outcomes.

It is interesting to look at medicine historically and see what has changed and what has not.

In the push for digital communication and records, we forget that a critical component of successful medicine is the human relationship.

Also essential is the tactile feedback of the clinician's hands during the physical examination. The clinician using their hands to palpate what is tender on the patient and to identify which joints are not moving properly is necessary as a component of a proper physical examination. Interaction over the phone or a computer eliminates this critical component of what is needed to correctly diagnose and treat most spinal patients. I expect that the need for actual hands-on examination by a qualified and well-trained spinal specialist will not diminish in the near or distant future.

Fracture care is an example where technology has evolved while the fundamentals persist. For example, we still rely predominantly on x-rays to identify and follow fractures. This is because x-rays are effective, readily obtained, easy to follow over time, and one of the least expensive imaging modalities available. In spite of all the technological advancements in imaging, x-rays remain a mainstay. X-ray technology has improved with less radiation and better quality images but the basics persist. Another example of persistent fundamentals is the use of casts to treat fractures. While cast materials have improved, the basic concept of casting a bone has persisted. Not only does casting work, it is also more cost effective than surgical intervention. Most people try to avoid surgery, especially when a non-operative treatment is available. Casting persists in spite of the great advances in knowledge, technology, and surgeries over time.

Patients desire human interaction as part of their care and this relationship aids their healing process. Most patients require human interaction to have trust in their provider and to accept what they must do to contribute to healing.

I recently read an article about a therapist in London who is being paid to "cuddle" with patients. Many individuals do not have someone close to them to provide human interaction and often crave non-sexual physical contact and human warmth. The need for physical and emotional human interaction is prevalent throughout society. People are searching for alternatives because of increasing isolation created by our fast moving societies and the digitization of what used to involve human interaction. It is critical in medicine, especially in spinal health care, that clinicians maintain appropriate interactions with their patients to convey compassion and to build trust. This trust empowers the patient to contribute the energy and effort that is essential for their full and complete recovery. The professional human interaction is in addition to the need of proper physical hands-on examination. The complete real-time physical and emotional human interaction is required to optimally understand the patient's underlying problems that require treatment.

As our government and insurers continue to drive changes in health care that are not conducive for quality time with physicians in the exam room, distrust and dissatisfaction will increase in prevalence amongst patients. Patients' needs will not be met and ultimately outcomes will be compromised. Advances in technology alone will not solve all problems especially when human interaction is an essential component of successful treatment. While it is important to embrace innovations that improve outcomes, we must not lose sight of those timeless remedies that common sense begs us to continue and even enhance. Quality medicine in the future will benefit from great innovations but only if we maintain the human interactions with both physical, intellectual, and emotional input that are essential to treat the entire patient.

ASK THE EXPERT

Kornelis Poelstra, MD, PhD
The Spine Institute on the Emerald Coast

In your opinion, what are the top three innovations that you are excited about within the spinal health industry?
I have the exciting opportunity to witness innovation be born into the field of spinal health; to be able to leverage these advancements and contribute my own research on behalf of my patients is a true honor. The following is an introduction to three cutting-edge advancements in spinal medicine that I'd like to share with you:

Robotics

Having been one of the early adopters of robotic-assisted surgeries, it has been interesting to watch the progression of these technologies, along with my own confidence in them! While I felt the introduction of robotics in spine surgeries was inevitable, I was initially quite skeptical.

> Having witnessed my own transition from skepticism to acceptance over the past 4-5 years, I am now very excited about the benefits of using robotically-guided surgeries.

From improved screw placement accuracy, fewer complications, and less need for revisions, to decreased catastrophic malplacements due to perfectly executed planned trajectories, the benefits of robotics are numerous. Planning not just the individual screw trajectories, for example, but an entire construct including the skin incisions is hugely beneficial. I am no longer looking at one individual pedicle at a time as is done with navigation systems; with the robot I plan the entire line, thus greatly reducing operative times and improving overall accuracy. The key for people to understand is that there is only a certain amount of stress one can handle per case; when using robotics for screw placement, you have no stress from creating an entire construct, so you can reserve that stress for more complicated tasks such as osteotomies and your decompressions.

I foresee significant growth in years to come, perhaps even making robotic-assisted surgeries so automated that robotics will be primarily used in the majority of simple surgeries. In saying that, I do not believe the human factor will ever become obsolete; robotics will be used to enhance what surgical experts are trained to do. Not only have the current robots enhanced the patient's surgical experience by reducing operative, hospitalization, and recovery times as well as radiation exposure, they have prepared us for the future. By embracing robots now, while simple and easy to understand, we are better equipped to understand their capabilities, applicability, and limitations for the future. When more advanced robots are introduced, I'll be ready! The better prepared I am, the better I can serve my patients. The question is not *if* robotics will continue to advance but *how*; perhaps real-time augmented reality headsets for surgeons will become the new norm, projecting the patient's CT scans as a 3D model, allowing a surgeon to locate their tools in real time even if it's below the skin. Whatever the possibilities, I am excited to see what the future holds for robotics in enhancing the patient and physician experience!

New Metals

I believe that new materials will bring the next wave of innovation in spine and I have been involved in introducing Molybdenum-Rhenium (MoRe) to orthopaedics. The benefit of this new material is that, compared to standard materials used in spine (cobalt-chrome, titanium, and stainless steel), it is stronger and more resistant to corrosion. Originally used to make stents in cardiology, MoRe's strength, durability, and flexibility are important characteristics when it comes to inserting hardware that need to maintain a certain amount of load. Another benefit is that the MoRe alloy contains no trace elements as compared to the nickel found in cobalt-chromium, for example.

The hope for the future is that engineers can design far smaller implants with less metal while maintaining their integrity. Industry is also hopeful that the FDA will clear these advanced materials within the next few years for other uses such as joint replacements, fracture fixation, or other uses where improved osteointegration (connection between living bone and the surface of a load-carrying implant) is key to a successful outcome. This will present opportunity for enhanced implants with superior biomechanical properties, a smaller footprint, and more favorable surface characteristics. The more favorable the implant surface is, the more likely bone-forming cells will thrive. However, not all implants are created equal! Implants made with hydrophilic materials attract water, whereas ones made from hydrophobic materials expel water. The plastics that are used in spine are often hydrophobic; bone has a hard time attaching to them. MoRe is even more hydrophilic, or "wettable" than classic titanium, making it more favorable for bone growth. In our studies, bone formation looked better on MoRe than on titanium.[1,2]

To take these advanced materials even further, it is the hope that we can get better at utilizing newer metallic alloys and implement them via 3D printing.

3D Printing Technologies

3D printing technologies offer a tremendous asset to orthopedic and spinal surgery. The acceptance of 3D printing technologies allows us to create tailored implants for patients as well as the possibility for the creation of improved surface characteristics at the bone-implant interface. Let's look at the ability to print implants with different levels of elasticity. Our bones constantly sustain a pressurized load and must have a level of stiffness to be able to resist too much bend; they also must be flexible enough to absorb energy, compress when needed, and lengthen without cracking. The ability to 3D print implants with differing levels of elasticity (stiff yet flexible) allows physicians to meet the needs of a specific patient. A younger and healthier patient may need a stiffer implant, whereas a relatively more "flexible" implant may be more suited for an older patient with osteopenia or osteoporosis. No matter how stiff or flexible, the key is to accommodate the patient's needs and create an environment for the implant to fit better onto and into the bone, making reconstruction surgeries easier and more effective.

In addition to 3D printing technologies, there are new insights into the potential of bioprinting – combining cells, growth factors, and biomaterials to produce biomedical materials that imitate natural tissues. The future of combining 3D-printed technologies with bioprinted materials will be the ability to expand an implant as needed, to change angulations of the end plates where needed, and to eventually reduce the need of 'traditional' bone grafting in these 3D-printed structures!

PEEK is a highly utilized biomaterial and offers great support, but combining new metals with biomaterials and biological materials woven throughout offers even more potential.

While original PEEK implants had the advantage of being transparent on radiographs, they had a hydrophobic surface. New hydrophilic materials can be combined with biomaterials to create a seamless "velcro" attachment against the bone, creating an immediately stable environment. I foresee that hardware removals will become less necessary with the acceptance of these bioactive surfaces, as we will eventually be able to 3D print 'active' implants for specific age and bone density needs. I also see the potential use of (tiny) incorporated Wifi-powered microchips providing us information on our own cellphone about the status of bone incorporation and fusion between the bones and our 'smart' implant. Exciting things are here to come!!

References

1. Poelstra, KA, Isaza J, Kim K, et al. Molybdenum Rhenium (MORE) allows for new generation of Spinal Implants with novel sensor technology for remote real-time monitoring of bone growth across a fixed motion segment. SMISS Annual Forum. Las Vegas, NV September 6-8, 2018

2. Poelstra KA, Isaza J, Kim K. et al. Molybdenum Rehenium (MORE)Alloy provides superior biomechanical and wear properties for a new generation of spine implants. SMISS Annual Forum. Las Vegas, NV September 6-8, 2018

Spine Tales

A Journey to Recovery

Spi·nal Cham·pi·on (n):

/'spīnl·CHampē n/

A person who has achieved an improved quality of life through treatment for neck or back pain. *Our team will work collaboratively to support you in achieving the goal of becoming a "Spinal Champion". Join the We've Got Your Back campaign and celebrate with others by participating in our national race, featuring a 5K and a 1 mile fun run/walk!*

SpineTale (n):

/spīn·tāl/

An inspirational story of a Spinal Champion, from both the patient and the clinical perspective. *We love to hear from our Spinal Champions – your stories will inspire, teach, and provide hope for others who currently suffer from similar conditions. No story is too small; each journey to recovery is equally powerful and helps build awareness and hope. Celebrate your success while inspiring others and share your story!*

Share Your Story: Are you enthusiastic about your journey to recovery? Please contact Sabrina M. Woodlief, Senior Project Specialist (swoodlief@spinerf.org) to learn more!

Tom Frisby

ONE DAY AT A TIME

In 2011, I slipped on ice, but instead of falling, I twisted my back which resulted in a herniated disc.

I suffered through pain and numbness in my lower back and leg for years. I've always been an independent person and didn't want to think of back surgery. In fact, I wanted to avoid it at all costs. While I was hoping to avoid surgery, I knew I had to do something - chiropractic care, physical care, and epidural shots just didn't help.

The pain continued to worsen and soon became unbearable. I found myself barely able to walk and struggled to stand for even 30 seconds without experiencing overwhelming sharp and burning pain that radiated down my leg. I could only alleviate the pain by sitting. I fortunately sit most of the time at work, but I couldn't continue revolving my life around sitting. My primary care physician ended up referring me to Dr. Gum, who explained my options.

Dr. Gum recommended a discectomy and fusion and explained to me that while he would do the surgery, the Mazor X robot would assist in placing the screws.

After waking up from surgery, I felt an immediate difference. It was actually one of the first things I noticed when I woke up; my leg didn't hurt anymore! I was even able to take a few steps without experiencing pain that day. While it may seem minuscule, it was a powerful moment for me. I knew that surgery was only half the battle; there was a long journey to recovery ahead, but I was ready! I went home the next morning and within four days was off pain medication. I took every day one at a time, I started walking around the house, then to the end of my street, and after three weeks, I hit a major milestone!

I enjoyed my first one-mile walk with my wife for the first time in I don't remember how long – I was almost in tears, I was so happy about it!

My world isn't quite as bleak now; my life has truly transformed. Having lost more than 20 pounds since surgery, I am living a much healthier lifestyle.

Being pain-free and more mobile, I'm back to doing activities that I once loved, including kayaking, walking with my wife, playing with our dog, and photography.

How do you thank someone for giving you your life back? It's not something you do on a regular basis. In an effort to express my gratitude, I gave Dr. Gum a photo of a bald eagle that I took, symbolizing the freedom that Dr. Gum gave back to me.

THE CLINICAL PERSPECTIVE

Jeffrey L. Gum, MD
Norton Leatherman Spine Center

Tom came to me after suffering from debilitating back and leg pain for years. We discussed his symptoms, identified realistic expectations, and, while he was originally hesitant, we elected to move forward with robotically guided surgery.

Using robotics during a fusion to assist with the placement of instrumentation (screws) enhances precision and accuracy. This minimally invasive procedure allows for a smaller incision, less blood loss, and less tissue damage. It's all about the angle in which the screws are placed; the robotically enhanced precision reduces the amount of muscle stripping. Another objective and possible benefit of utilizing this technology is reducing hospital stays, post-op pain, and therefore post-op narcotic use. Tom, like many of our patients, is a great example of this. I was actually surprised at how quickly he recovered, partly due to the technique. Even if the surgery is the same, the technique has changed significantly with the help of the robot.

People like Tom are why I came into his field. His perseverance is a testament to how dedicated he was to getting his life back. Seeing him smile, enjoying life, and receiving such a meaningful gift is truly touching – I still have the photo of the eagle hung in my office!

THE REAL IMPACT OF BACK PAIN

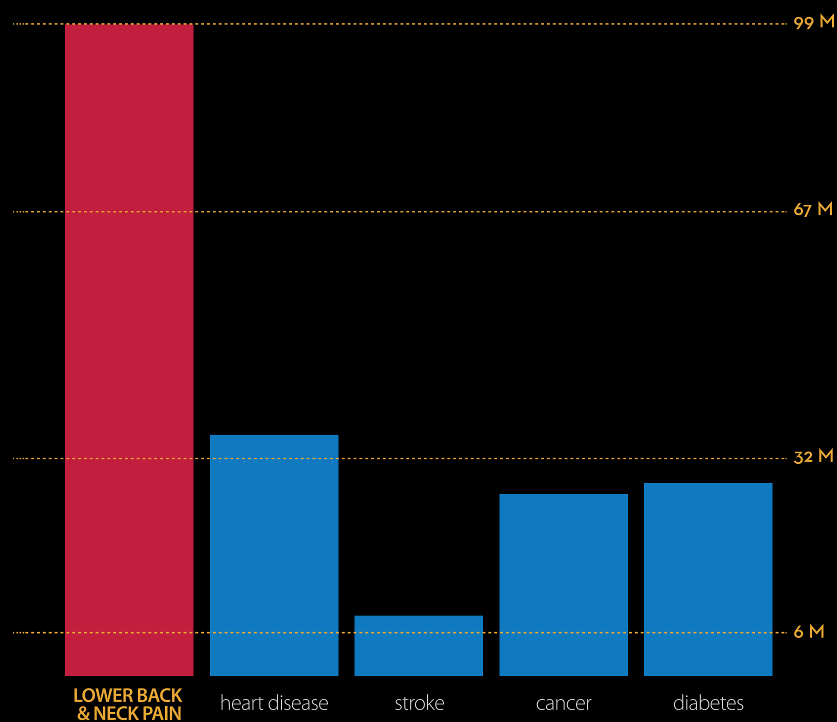
Spinal injuries and disorders are much more common and have a greater impact than many people know. They impact people of all ages, ethnicities, and economic situations. Onset can be sudden or become chronic, growing worse each year. For these patients, each day means battling pain, crippling fatigue, muscle weakness, numbness, and more. The Spinal Research Foundation believes that these people have the right to thrive and live free from pain.

Together we will help patients return to the people and activities they love.

99.3 M

adults in the U.S. suffer from low back and neck pain each year

DIAGNOSED U.S. ADULTS, ANNUALLY

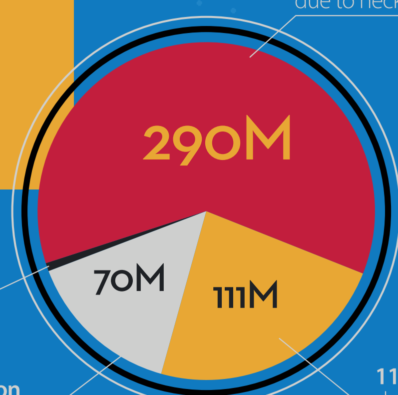


1 in 20

will be unable to work due to back or neck pain

1 in 2.5

adults will experience low back or neck pain this year



Lost Workdays Per Year

SPINAL RESEARCH FOUNDATION

Sources: Center for Disease Control, National Academy on an Aging Society/Asthma & Allergy Foundation of America, American Diabetes Association & American Academy of Orthopedic Surgeons

THE SPINAL RESEARCH FOUNDATION'S

WE'VE GOT *Your Back*

RACE FOR SPINAL HEALTH

Thank you for making the 11th annual ***We've Got Your Back*** race for spinal health a success! The event had over 400 participants that braved the wet conditions to support the Spinal Research Foundation's efforts to educate the public about spinal health. A special thank you to the Corporate Partners, volunteers, and Spinal Champions for their generosity and enthusiasm because without their support, this event would not be possible!

Photo Credit: Audrey McCann

wevegotyourbackrace.org

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Christopher R. Good, MD, FACS
Virginia Spine Institute

Jeffrey L. Gum, MD
Norton Leatherman Spine Center

THE FUTURE OF SPINE SURGERY: COMPUTERIZED SURGICAL PLANNING, ROBOTIC GUIDANCE, & SPINAL NAVIGATION

Abstract

The goals of modern spinal surgery are to maximize patient function and expedite a return to an improved quality of life. As spinal surgery has evolved, more focus has been placed on minimizing trauma to the tissue during surgery, which in turn accelerates recovery through the use of minimally invasive techniques. The era of modern spinal surgery has blossomed over the past 15 to 20 years as a result of research and technology advancements including better understandings of spinal balance, improvements in spinal implants and placement techniques, and the emergence of minimally invasive spine surgery.

These advancements have paved the way for very exciting breakthroughs in the field of computerized surgical planning, robotic-assisted surgery, and real-time spinal navigation; all of which are aimed at improving the lives of patients undergoing spine surgery. Not only will these advancements improve patient outcomes, they also improve a surgeon's ability to understand a patient's condition so that they can precisely plan the ideal surgical procedure and then accurately and efficiently execute that plan in the operating room. Research is showing that by improving accuracy, patients experience better surgical results, decreased risk of complications, and less need for additional surgical procedures, all concerns for patients undergoing spinal surgeries.

Spinal & Total Body Balance

Maintaining the balance of our bodies is critical during daily activities. The human body is a series of bones and joints attached together, all stacked one on top of each other, working in the most efficient and concise manner. These structures relate to each other but are meant to be in balance. Thinking big picture, a person's head is meant to balance directly over their ankles when they are standing upright. Any situation that causes someone to lean forward or to the side increases stress on the body and the muscles that support it and therefore can increase pain and dysfunction of the spine. Recent advancements have put an emphasis on the importance of body and spinal balance,

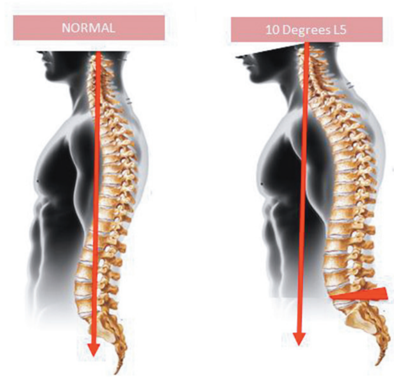

Figure 1. A side view of the spine with normal balance (left) and malalignment (right).

leading to improved surgical outcomes now that surgeons are better able to identify the necessary realignment to produce the best results.

For example, when the spine is viewed from the side, there are multiple regional curvatures in the spine all meant to balance out so that the person's head stays directly above their pelvis when sitting or standing. There is a normal inward curvature of the lumbar spine (lordosis) as well as a normal outward curvature (kyphosis) of the thoracic spine. These curvatures are meant to balance out so that when standing erect, total body alignment (balance) is achieved (Figure 1). Any situation where one of these curvatures changes abnormally will lead to accommodations in other areas, potentially driving people out of balance. When people develop an injury, are affected by age-related degeneration, or experience an imperfect surgical procedure that drives the spine "out of balance", their quality of life can be greatly affected by decreased function and/or increased pain.

Surgeons need to be very cognizant of optimizing a patient's spinal alignment during any surgical procedure but especially a fusion, in which the alignment gets locked. This is where the future of computerized surgical planning becomes most important. New and evolving computer programs can allow surgeons to input multiple types of images (x-ray, CT scan, MRI scan, etc.) all in to one software package in order to gain an understanding of a patient's spinal alignment and anatomy. This software can also evaluate the spine's flexibility as it bends into different positions, assisting the surgeon to predict the best surgical techniques to achieve optimal spinal alignment. The robotic system allows the surgeon to use the images from a preoperative x-ray and CT scan to create a surgical plan ("blueprint) for each surgical procedure. This surgical plan is loaded into a computerized 3D planning system, allowing the surgeon to precisely plan the surgical procedure before ever entering the operating room. (Figure 2)

While assisted by the robotic system, the surgeon does all of the actual work in the operating room. During the surgery, the robot is placed near the patient, with the ability to bend and rotate its arm to be placed on the spine on the intended trajectory. This guidance can improve the surgeon's ability to safely and more accurately place implants, particularly when working through very small incisions (minimally invasive surgery) or when dealing with complex anatomy (spinal deformity or previous spine surgery).

All spinal surgical procedures need to be precise, particularly when implants are utilized. Specific situations can make placing implants safely even

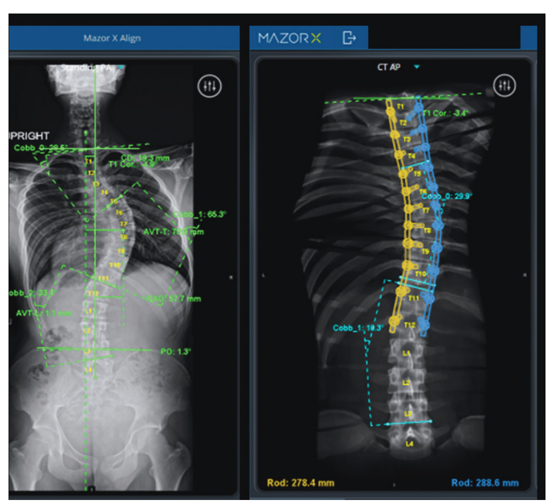

Figure 2. Preoperative computerized surgical plan (left) with proposed correction of spinal curvature and ideal location of implants (right).

more challenging especially when patients have abnormal anatomy such as scoliosis or abnormal spinal curvatures where the bones are rotated. Similarly, when minimally invasive surgical procedures are being performed, the surgeon has minimal visualization of the anatomy that they are working on. Preoperative computerized planning coupled with operative robotic guidance can provide surgeons with a very powerful tool to overcome these challenges and to achieve their preoperative plan with a high degree of accuracy, ultimately improving patient safety.

Navigation in Spine Surgery

Navigation in spine surgery was first reported in 1995 and has grown significantly over time. Navigation options include using a combination of intraoperative and preoperative imaging to display real-time views of surgical tools overlapping imaging studies in the operating room. This allows a surgeon to look at the anatomy while simultaneously visualizing the imaging studies with instruments overlaid using a computerized system. (Figure 3) Combining the patient's own visualization anatomy with simultaneous review of the images can provide tremendous benefit. This technology is similar to using GPS guidance to travel to a desired location.

Minimally Invasive Spine Fusion

The purpose of a spinal fusion is to create a rigid union between two separate segments of the spine to correct malalignment or instability (which is a pain generator). Spine fusion has traditionally been performed using "open surgery" with an incision that is big enough to expose the entire area being treated. Open surgical techniques are

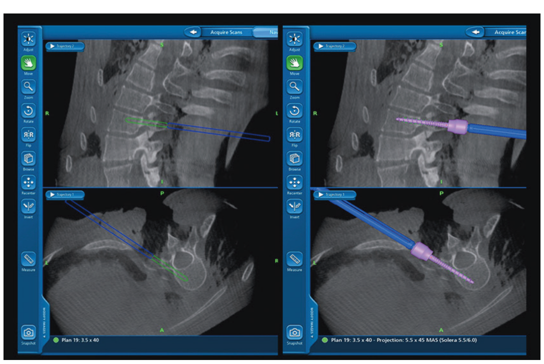

Figure 3. Overlay of surgical tools and implants during surgery.

beneficial and necessary for many conditions, but in some cases minimally invasive surgery (MIS) can be utilized. MIS uses smaller incisions which usually result in less damage to surrounding healthy tissue, less postoperative pain, and a faster recovery. (Figure 4)

MIS often requires an increase in the use of intraoperative x-rays in order to compensate for a surgeon's inability to directly see the spine. In some cases, this lack of visualization decreases the surgeon's accuracy when compared to open surgery. To compensate for the lack of visualization and to maintain accuracy, additional x-rays are required, exposing the patient and medical team to higher amounts of radiation. Increased radiation exposure during surgery is a concern for the patient as well as the health care team as previous studies have shown an increased rate of cancer among spine surgeons than the general population.[1] Robotic-guided technology and navigation allows a surgeon to precisely perform MIS while minimizing the need for radiation during surgery. Robotic technologies guide the surgeon's tools during MIS to ensure accuracy while also decreasing tissue trauma, resulting in less bleeding, smaller scars, less pain, and faster recovery.

Robotics & Navigation Research

Studies have shown that utilizing navigation and robotic-guidance when placing implants demonstrates greater accuracy than traditional open surgery or fluoroscopic- (x-ray) guided techniques. Up until recently, almost no clinical data existed to demonstrate that this improvement in accuracy actually translates improvement in patient outcomes after surgery. The initial assumption was always that increased accuracy would lead to better outcomes through lower complications. In 2007, a meta-analysis (combination of data from multiple studies) of 130 studies with almost 40,000 spinal screws placed showed an overall accuracy rate of 91% within improvement accuracy to 95% using spinal navigation. A more recent meta-analysis showing 26 prospective clinical studies with over 6,000 screws placed supported increased accuracy for screws placed and significant decrease in implant malposition with use of navigation techniques.[2]

Figure 4. Difference of incisions using a minimally invasive technique (left) vs. traditional open surgical technique (right).

Turning to robotics data, a retrospective review of over 14 medical centers with 635 cases surgeries and over 3,200 implants was published.[3] They found that 98% of pedicle screws placed utilizing robotic-assisted technology was deemed to be safe and 89% to be completely contained within the bone. In another study, 112 surgeries were retroactively evaluated and showed improvement in screw accuracy using robotics, a decrease in complication rates, and a decrease in hospital length of stay in patients treated with robotic-assisted surgery.[4]

Another study group was formed to specifically look at patient outcomes after robotic-assisted spinal surgery with particular interest in prospectively evaluating patients undergoing fusions of the lumbar spine via a minimally invasive technique and to compare the results between patients treated with robotic-guidance versus traditional fluoroscopic techniques. The goal was to assess for differences in patient complication rates, rates of additional revision surgeries, and differences in intraoperative radiation exposure. Early results show that patients treated with robotic-guidance had a 3.1 times lower risk for a complication after a surgical procedure and a 14.7 times lower risk of needing an additional surgical procedure. There is also a 79% decrease in the amount of x-ray radiation used in the operating room for patients treated with robotic guidance.[5]

Conclusion

Improvements in understanding total body and spinal balance are leading to improved outcomes in patients requiring spinal surgeries. Computerized preoperative planning offers a tremendous potential benefit for surgeons and patients in order to properly execute the planned spinal procedures. Robotic assistance and real-time navigation can improve the accuracy and safety of spinal surgeries and we believe these technologies will be transformative in the world of spinal surgery.

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ENDOSCOPIC SPINE SURGERY:
MINIMALLY INVASIVE SURGERY PROFILE

What Is 'Endoscopy'?

The field of spine surgery is rapidly advancing. Traditional surgical techniques utilizing large, open incisions are being supplanted by minimally invasive approaches that allow for less surgical pain, faster recovery, and better overall results. Endoscopic surgeries are one such example of minimally invasive approaches. These approaches are now available for use in spinal surgery, in which a small camera (endoscope) is placed through a tiny incision to remove structures that are pressing on nerves and causing sciatic pain.

For years, orthopedists have been doing shoulder, hip, and knee surgery using arthroscopic cameras. Similarly, general surgeons and OBGYN doctors have used cameras to assist with abdominal surgeries. Frankly, spine surgeons have been slow to utilize this technology, but the delayed adoption hasn't been for lack of trying! Based on anatomy, scopes are most commonly used to increase visualization in regions that are large enough or that can be expanded. The spine, on the other hand, has much smaller openings and is very sensitive to pressure due to the surrounding delicate nerves.

Endoscopic Microdiscectomy

The most common use of endoscopic spine surgery is with lumbar disc herniations. The lumbar intervertebral discs are composed of two major parts: the nucleus pulposus and the annulus fibrosus. The inside 'jelly' layer (nucleus pulposus) functions as the shock absorber. The outside layer (annulus fibrosus) is the more structural component that keeps the nucleus contained. When a disc herniation occurs, the nucleus breaks through the annulus, often putting pressure on the nerves and resulting in sciatica. While most disc herniations heal with non-operative treatments, some require surgery. The procedure of choice is often a microdiscectomy in which a small incision is made in the middle of the back, a minimal amount of bone is removed to visualize the disc fragment, and the herniation is removed. (Figure 1)

The procedure often presents positive results and surgical recovery is generally shorter than other, more invasive procedures.

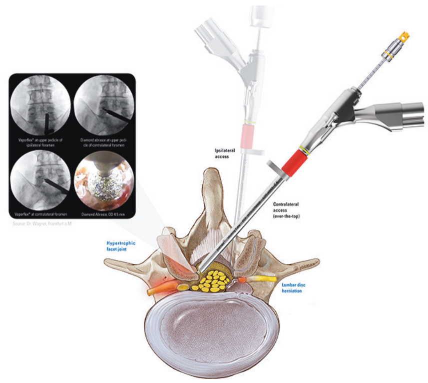

Figure 1. Removal of a herniated disc using the interlaminar access path.

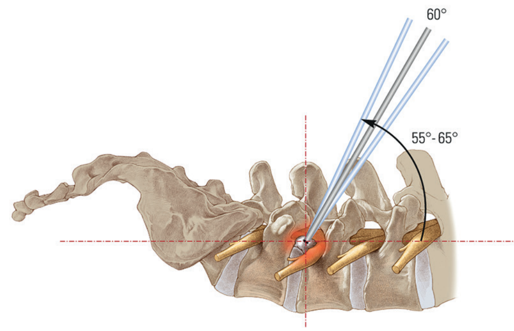

Figure 2. Removal of a herniated disc using the Tessys method, a lateral, transforaminal, endoscopic access path via the intervertebral foramen.

An endoscopic microdiscectomy is technically very different from the conventional microdiscectomy. A smaller incision is made approximately 10cm off to the side of the midline, as opposed to directly over the affected disc. Rather than removing bone to access the herniation, the fragment is removed through an opening called the neuroforamen. The nerves normally exit the spine through the neuroforamen, making it an ideal opening for a small camera (endoscope) to access the discs. Once the disc fragment is visualized, it can then be removed to relieve the pressure of the affected nerve. (Figure 2, 3) Furthermore, because of the small incisions, many of these procedures are often able to be performed without general anesthesia[1], reducing length of stay in hospitals and decreasing overall recovery times.

So why even consider endoscopic surgery when a regular microdiscectomy involves a relatively small incision and works so well? Overall, recovery from both types of microdiscectomy is excellent, with greater than 90% happiness rates reported by patients.[2] However, endoscopy involves an even smaller incision, less muscle disruption, and less bone removal. In essence, it is an enhancement to an already minimally invasive technique. When the two types of microdiscectomy procedures are compared, potential benefits are generally shown in favor of endoscopy, with reports of fewer infections, quicker return to work, and less back pain, as documented in scholarly literature.[3]

Other Indications of Endoscopic Spine Surgeries

In addition to disc herniations, research is being done on the use of endoscopic technologies for fusions. Fusions have traditionally required large incisions in order to properly visualize the bony surfaces, a key step that is necessary to get bony growth across a spinal level. However, the small endoscopic camera allows a surgeon to see a magnified image of regions of the spine that may be otherwise difficult to visualize with the naked eye. This opens up the possibility of endoscopic fusions which would revolutionize spinal fusion recovery standards. Implants are actively being designed for these procedures to occur in the near future.

Endoscopy also has a role in complex revision lumbar spine surgeries.[4,5] Unfortunately, a common cause of revision lumbar surgery is persistent nerve pressure. Because scar tissue is always created after the first surgery, there is an increased risk of spinal fluid leak where the scar tissue becomes adherent to the nerves. An endoscopic surgery uses a different surgical approach through undisrupted tissue planes, reducing the amount of internal scarring that is encountered.

While beneficial in many applications, not every surgery should be done endoscopically. Although disc herniations are the current best indication for endoscopy, there are many circumstances where the nerves are being pinched by both the disc and overgrown bone.

A more conventional microdiscetomy would usually be preferred in such cases because the technique allows for easier bone resection. If there is major instability, a fracture, or scoliosis, endoscopy alone isn't as successful as other surgical techniques either. Lastly, endoscopy is not commonly used in the cervical spine; although patients with pinched nerves in the neck are not currently candidates for this technology, perhaps they will be in the future.

The Future of Endoscopy

While there are limitations, the future of endoscopy within spinal health is bright. Current spinal applications are very successful and the scope of this ultra-minimally invasive technology is rapidly growing.

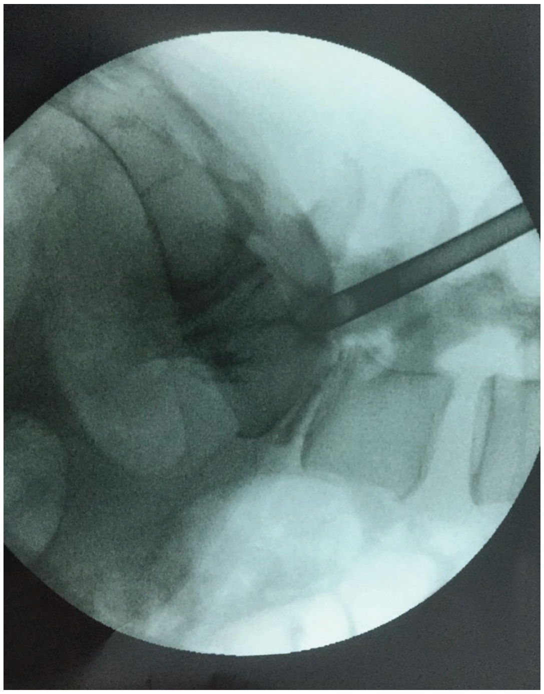

Figure 3. Discogram showing endoscopic removal of herniated disc.

More complicated fusions, scoliosis surgeries, and fractures will likely be treated with endoscopic spine surgery in the coming years.

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PERSONALIZED MEDICINE FOR THE SPINE:
A PATIENT'S GUIDE TO 3D PRINTED SPINAL NAVIGATION

You've probably heard a lot about it, or have seen it in the news; 3D printing is a new frontier in medical technology. From custom implants and surgical tools to bioprinted tissues and organs, it's one of the future technologies of personalized medicine. While there are many applications of 3D printing to various medical procedures, what can 3D printing do to help spinal surgeons?

As it turns out, 3D printing can help spine surgeons develop treatment plans and devices that are specific to each patient. In the case of spinal surgery, the precision is intended for each vertebral level; just like snowflakes, no two vertebrae are the same. By using 3D planning software, the surgeon can evaluate the patient's virtual spine, identify anatomical landmarks, and develop a plan precisely for that patient. This type of preoperative planning is particularly helpful in complex spinal fusion surgeries.

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.

Figure 1. A surgeon places a Guide on the 3D printed patient-specific bone model.

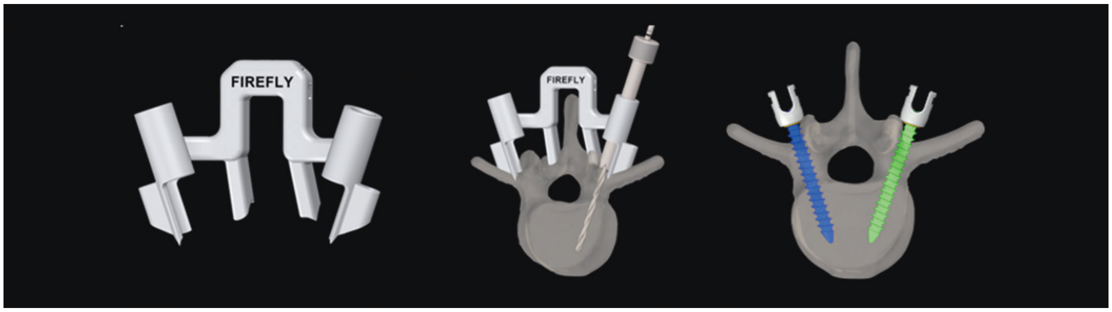

Figure 2. A Guide is placed on the vertebra and pedicle screws are placed.

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 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. The main obstacle that a surgeon may face during surgery is the fact that the pedicle is not visible without the use of CT scans or x-rays. The exact location and size of the pedicle are largely unknown without the help of such advanced imaging. Surgeons try to minimize their use of such imaging because exposure to radiation can be harmful over time.

Surgeons are trained to perform spinal fusions using a "freehand" method, where they carefully observe the anatomical bony landmarks that give them clues as to where the pedicle is, where to place their screws, and what size screw should be used in order to achieve the best bony purchase. However, some anatomy can be so complex in terms of derotation or tiny pedicles that even a highly trained and very experienced spine surgeon will need better visualization or guidance in order to achieve optimal screw placement accuracy. To accomplish this, there are several tools that a surgeon may use during the operation: C-arms for x-rays/fluoroscopy throughout the procedure, image-guided and computer-assisted navigation, and robotic arms for guiding a drill. Technology has now progressed to the point where 3D printing can also be of assistance for navigation.

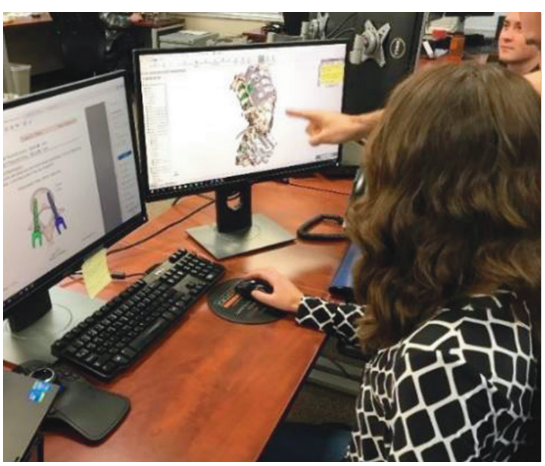

Figure 3. Engineers plan a complex case.

3D-printed Guides are biocompatible, single-use devices that conform to the patient's vertebrae at predetermined contact points. They enable optimal screw placement by incorporating planned screw diameter, direction, length, and entry point into the design of the Guides. When our surgeons order a Guide, he/she sends the patient's CT scan to Mighty Oak Medical, where the Guides are designed. That CT is processed to make a 3D virtual model of the patient's spine, where trained engineers develop a detailed preoperative plan according to the surgeon's preferences and safety practices. (Figure 3) This plan is sent to the surgeon for approval, often weeks prior to the surgery.

After approval, the Guides are designed around the surgeon's approved trajectories and are made to conform exactly to the patient's own anatomy. (Figure 1) This makes each Guide not only patient-specific, but level-specific as well. Just like a puzzle piece, no Guide can be placed on a different patient or even on a different level than the one inscribed on the Guide. In addition, a 3D-printed anatomically exact bone model of the patient's spine is provided for intraoperative use and can be shared with the patient and their family to promote better understanding of the surgery.

Thanks to careful preoperative planning, the surgeon has complete familiarity with the patient's anatomy and has a surgical plan for screw placement at each level, before entering the operating room. (Figure 4) Surgeons who utilize Guides are dedicated to planning their complex surgeries and minimizing surprises in the operating room. They would rather put the time into planning a long-construct fusion than have to "wing it" or rely on complicated navigation equipment in the stressful environment of the operating room.

People recognize the importance of an architect using a blueprint to build a house; it is no different for a surgeon creating a long construct of screws and rods in a spinal fusion surgery. Because of the Guides, the surgeon may also be able to perform screw placement with less intraoperative imaging, which results in less radiation for both the patient and the surgical staff. Of course, the main benefit of the use of a Guide is an increase in screw placement accuracy and safety. (Figure 5)

If you or a family member have an upcoming scoliosis surgery, 3D printing can provide an optimized and personalized surgical experience.

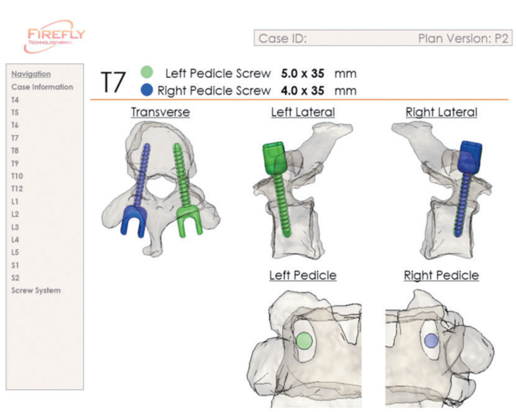

Figure 4. A page from a patient-specific surgical plan.

This article is courtesy of Mighty Oak Medical of Englewood, Colorado. We can be reached at support@mightyoakmedical.com.

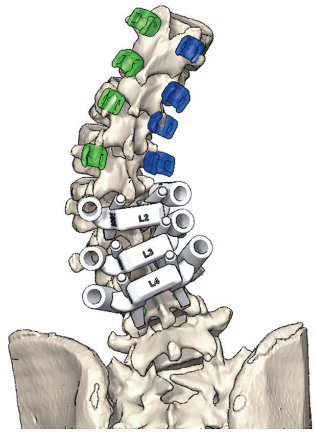

Figure 5. A virtual 3D spine with planned screws and three designed Guides.

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MINIMALLY INVASIVE ROBOTICS & NAVIGATION-BASED CORTICAL SCREWS

Introduction

Pedicle screw instrumentation combined with posterolateral fusion has been the gold standard technique for achieving stabilization of the spine with or without decompression of the neural elements. The growing desire to improve patient outcomes by decreasing disruption of the soft tissue, including the paraspinal muscles, has led to the rapid development of advanced procedures. In fact, the maintenance of the integrity of the multifidus, a major paraspinal muscle, and its tendinous attachments has been proposed as a criterion for minimally invasive spine surgery regardless of incision size.[1,2]

Technique

In 2009, a novel pedicle screw trajectory was described that takes advantage of a denser (cortical vs. cancellous) aspect of the bone.[3] It was initially developed to improve pullout strength in osteoporotic bone. This track is laterally oriented in the transverse plane and superior oriented in the sagittal plane. (Figure 1)

This trajectory, especially when combined with advancements in robotic and navigational tools, allows for a less disruptive technique that has been shown to improve recovery, minimize tissue disruption, and potentially decrease damage to adjacent segment levels.

The surgical technique for medialized posterior interbody fusion utilizes a single midline incision (approximately 1.5 inches) that uses a muscle-splitting corridor in which the posterior musculature is retracted with its muscle insertions preserved. Laterally, the exposure is to the facet joints while preserving the lateral superior articular facet and its accompanying neurovascular complex. This is believed to minimize blood loss as well as to reduce postoperative pain. (Figure 2)

The facet joint that is part of the fusion can then be completely or partially resected in combination with laminectomy to allow for access to the disc space without neural retraction. Due to the starting point of the screw placement at the level above and angulation of the screw trajectory, there is no contact to the facet joint at the level above, minimizing the risk for iatrogenic (medical treatment-related) injury.

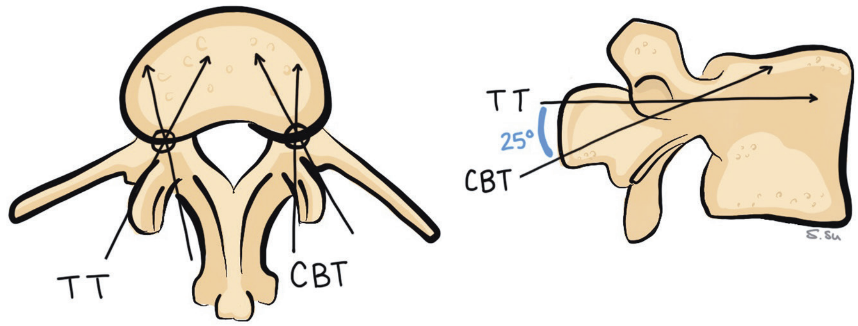

Figure 1. (L) Axial view of the laterally to medially directed traditional trajectory (TT) with the medially to laterally directed cortical bone track (CBT). (R) Sagittal view of the straight-forward screw path of TT compared with the caudal to cranial trajectory of the CBT screws.

Outcomes

Prospective as well as retrospective studies have demonstrated decreased operative time, blood loss, and incision length, and improved short-term function with cortical versus pedicle screw based constructs. In addition, there was no difference in fusion rates between pedicle versus cortical based screw procedures at one year.[4]

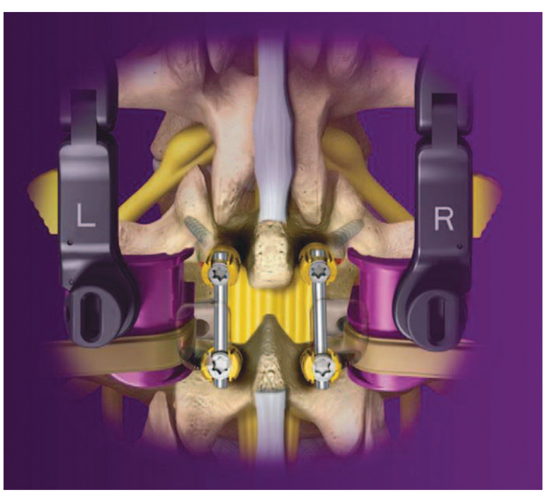

Figure 2. Illustration showing surgical exposure and cortical bone trajectory, medial-to-lateral pedicle screw, and rod fixation in MAS PLIF. [12]

Biomechanics

Biomechanical studies have found that cortical screws significantly improved insertional torque as compared to traditional pedicle screws.[5] Insertional torque is correlated with pullout strength which helps prevent screw loosening especially in setting of osteoporotic bone.[6] There is also evidence of improved resistance to cranio-caudal cyclic loading with cortical screws.[7]

Complications

Due to the starting point of the cortical screw, pars fracture (a break in a small connecting bone, called the pars interarticularis) is a concern. However, this is very rare due to the fact that the pars thickness increases moving medial (middle) to lateral (side). Moreover, cortical screws can always be converted to a standard pedicle screw if necessary. Screw malposition rates are very low with reports of 0% medial breach rates in multiple studies.[8,9,10] One study found a 2.1% rate of cortical screw malposition as compared to 3.7% with traditional pedicle screws.[11]

With advancements in navigational and robotic tools, malposition rates have been decreased to near zero.

Conclusion

In concurrence with robotic and navigational technology, cortical screws have many advantages including better pullout strength, which can be especially helpful in setting treatment of osteoporosis. They also allow for minimally invasive techniques that minimize tissue disruption, resulting in faster recovery, decreased blood loss, and reduced operative times. Due to positioning, cortical screws avoid the adjacent segment facet joint violation with potential for preventing adjacent segment disease.

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RARE DISEASES: PREVALENCE, GENETIC TESTING, & TREATMENTS

Preventative care will always be superior to curative and palliative care. In the recent years, discoveries and practices such as vaccines, proper diet, vitamin and mineral fortification of food and beverages, supplementation, routine checkups, and cancer screenings have significantly advanced preventative care.[1]

Completion of the Human Genome Project in 2003 immensely contributed to advancing genetic testing and gene therapies that have become life-changing tools of preventative medicine.[2]

Genetic testing has played a crucial role in revealing mutations that may cause illness or disease. Genetic spinal disorders are often difficult to diagnose, however, improvements in technology and advances in research are making tests for rare genetic diseases commonplace.

It is important to note that while genetic testing determines the risk of developing certain diseases, it is not all-inclusive; a positive result from genetic testing does not necessarily mean you will develop a disease. Likewise, a negative result does not guarantee that you will not develop a certain disease.

Ankylosing Spondylitis

Ankylosing Spondylitis (AS) is an inflammatory disease that affects 0.1-1.4% of the population. Although it is systemic (found throughout the body), the spine is most severely affected. Due to the inflammatory properties of AS, patients may experience fusion of both the spine as well as sacroiliac joints.

While the exact pathogenesis of AS is not fully understood, mutations in the HLA-B gene have been found in patients with AS. The mutation HLA-B27 is prevalent in 7% of the population, but only 5-6% of these carriers have a chance of developing the disease. It is also worth noting that only 90% of those who suffer from the disease are positive for the HLA-B mutation. Given this, preventative testing is not very common for AS and in most cases, tests for AS are conducted only when a patient presents with symptoms.[3]

For those who suffer from AS, it is important to maintain a healthy lifestyle by staying active, eating a proper diet, avoiding smoking, and practicing good posture. A common treatment for the increased inflammation caused by AS is the use of non-steroidal anti-inflammatory drugs (NSAIDs) such as: ibuprofen, diclofenac, naproxen, and celecoxib. More severe cases of the disease can be treated with the antirheumatic drugs sulfasalazine or methotrexate which were originally developed as chemotherapy agents. Two other treatment options involve tumor necrosis factor (TNF) blockers and interleukin 17 (IL-17) inhibitors that work by interrupting the biological anti-inflammatory cascade system, drastically reducing inflammation. This unfortunately leaves the body prone to infection. Surgery is considered after other treatment options are exhausted.[4-5]

Charcot-Marie-Tooth

Charcot-Marie-Tooth (CMT) disease is one of the most common inherited neurological disorders, occurring in roughly 1 in 2,500 people in the United States. CMT affects the peripheral nervous system and is characterized by a loss of motor and sensory function. Symptoms normally occur in early childhood and can manifest themselves through scoliosis, hammer toe (curling of the toes), or weakness in the hands and arms.

CMT has been mapped to a large group of responsible genes, stemming from the duplication of a portion of chromosome 17. There are five known subtypes of CMT (CMT1, CMT2, CMT3, CMT4, and CMTX) each of which can be dominant or recessive mutations. The way in which these mutations affect the function of respective proteins is not yet fully understood. Research suggests that these mutations either impair the axons that transmit nerve impulses or the Schwann cells that are responsible for producing the myelin required for nerves' myelin sheath.[6]

Many of the symptoms of CMT can be mistaken for radiculopathy (radiating pain caused by compression of a spinal nerve) or myelopathy (spinal cord compression or injury). It is common that patients will be referred to spinal surgeons for evaluation due to the similarities in symptoms. Proper diagnosis of CMT requires an assessment of medical and family history coupled with a neurological exam. If CMT is suspected, an electromyography (EMG) test can also be prescribed. Genome sequencing can be used to detect specific subtypes of CMT and can be a useful tool for family planning.[7-8]

Treatment of CMT consists of physical therapy, assistive orthopedic devices, and/or orthopedic surgery. Although there is no cure, keeping active and maintaining flexibility can help reduce the disabling effects of the disease.

Gene therapy research is being conducted in animal models to gain insight into a potential treatment. One such study is examining the treatment of the CMT subtype (CMT1B) with curcumin, the medicinal component of turmeric.[8]

Klippel-Feil Syndrome

Klippel-Feil syndrome (KFS) is a primarily dominant, inherited, congenital disease that occurs in 1 in 40,000 to 42,000 newborns worldwide (a recessive and spontaneous form of the disease also exists). It is typically recognized by limited neck movement caused by the fusion of two or more cervical vertebrae at birth. KFS may also affect other functions of the body including the heart, lungs, ribs, and kidneys. The diagnosis of KFS will most often occur after an x-ray is taken for cervical spine pathology. Examination of the other aforementioned areas that the syndrome can inflict may be suggested as a precaution once diagnosed, as these areas may require surgical intervention.

Mutations in the GDF6, GDF3, or MEOX1 genes are known to cause KFS. These genes are responsible for assisting in bone, cartilage, and joint formation during early embryonic development. A person carrying these genetic mutations has a 50% chance of passing the gene down to their offspring. Genetic testing is also available for diagnostic purposes.[9-10]

There is currently no cure for KFS, however, the identification of specific genetic markers make gene therapy a likely candidate in the future.

Options for managing KFS include physical therapy, traction, NSAIDs, and pain medications. Depending on the circumstances, spinal surgery can be a viable option in the management of symptoms. The varying severity of KFS creates a range of prognoses, but those who suffer from KFS generally lead normal lives with comfort increasing for those who take advantage of the current recommended treatment regimens.[9-10]

Chiari Malformation

Characterized by four types with increasing severity (Type I, II, II, and IV), Chiari malformations (CMs) occur in roughly 1 in 1,000 people. CMs form during fetal development and result in the lower part of the cerebellum dropping and extending through the hole at the base of the skull (foramen magnum) into the top of the spinal canal. Type I malformations are usually asymptomatic and are often diagnosed during review of images (MRI or CT) taken for other purposes. When a CM Type I is symptomatic, reflex abnormalities such as areflexia (lack of reflexes) of the upper limbs and a positive Babinski sign are common. Type I can also present with sleep apnea, balance abnormalities, light hypersensitivity, drop attacks, severe head or neck pain, and loss of pain or temperature sensation of the upper torso and arms.

As severity increases with CM Type II, III, and IV, more concerning symptoms are present. Type II may result in loss of arm strength, involuntary and rapid eye movements, and irregular breathing patterns. Type III and IV, although extremely rare, will typically be accompanied by other major birth defects such as hydrocephalus and often result in premature death.[11-12]

Treatments of CMs vary greatly and are only considered if the malformation is symptomatic. For symptomatic Type I and II, a decompression (suboccipital craniectomy) is performed, where the back of the foramen magnum is removed and the cervical spine is fused. Depending on the severity of the case, it may be necessary to remove some of the lower cerebellar components as well.

CMs are the leading cause of syringomyelia, a cyst or cavity within the spinal cord. This can typically be treated by draining the syrinx during the suboccipital craniectomy surgery. The genetic factors involved in CMs are currently not understood and no genetic test is available to determine if a fetus will develop a malformation. However, research is being conducted to examine the genetic factors associated with increased risk of developing a CM and related disorders.[11-14] Recent studies suggest that brain overgrowth may be caused by specific gene mutations in the PI3K-AKT signaling pathway, which may contribute to CMs.[15]

Conclusion

Just as vaccines have nearly eradicated many diseases, gene therapy will one day be able to do the same for specific genetic diseases. Recognizing and testing for these diseases as early as possible is crucial in helping those inflicted live a more normal life. More research is necessary to determine the underlying causes (and eventual phenotypic manifestation) of these genetic mutations.

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SPINAL CORD STIMULATION FOR CHRONIC BACK PAIN

Background

Chronic spinal pain is a debilitating problem that affects more than 80% of the population and is the leading cause for physical and emotional suffering, disability, and missed work days.[1,2] Treatment for relief of neck or back pain often relies on surgery, physical therapy, or a combination of both. These traditional treatments may prove ineffective or, in some cases, increase pain and prevent individuals from enjoying their lives.

One treatment option for alleviation of chronic spinal pain is spinal cord stimulation (SCS). SCS is a technique that allows for continuous delivery of a low-voltage, electrical current to the spinal cord in order to block pain signals. If a patient is unresponsive to conventional treatments for chronic spinal pain, SCS may be a viable alternative.

History & Function

SCS first surfaced as a new approach for pain management in 1967 and was approved in 1989 by the Food and Drug Administration (FDA) to relieve chronic pain due to nerve damage (neuropathic pain). Technology has since advanced to more closely tailor patients' needs.

To understand the basics of SCS, it is helpful to first understand how your brain perceives "pain". The spinal cord is comprised of bundles of nerves that are responsible for sending both sensory and motor signals to and from your brain, respectively. Sensory nerves run throughout your body and traverse the spinal cord before reaching the brain. Think of the spinal cord as a transportation hub; the signals generated from your peripheral nerves in your wounded finger, for example, are then transferred (via the spinal cord) to another nerve that runs to your brain. Once this signal is received by your brain, it is then interpreted as a painful sensation. This all happens in a matter of milliseconds. In the case of individuals with chronic pain, their sensory nerves are constantly sending electrical signals to the brain's pain center. Similarly, when a nerve in your spine is damaged due to an accident, trauma, or disease, the damaged nerve elicits an electrical signal via sensory nerves, sending a "pain" signal to your brain. This pain can radiate across your limbs making it extremely difficult to live a normal, productive life.

SCS was designed to inhibit the electrical signals generated by damaged nerves in the spinal cord. This is accomplished by sending weak electrical impulses through the epidural space, the space between the vertebrae and the spinal cord. The elicited impulses induce a numbing/tingling sensation (paresthesia) which has been reported to have a positive impact on reducing the pain levels of patients.[1]

Although pain is generally considered to be a protective response, chronic pain can present despite no visible indications that something is wrong.

SCS is typically used for neuropathic pain which normally does not serve a protective purpose and does not support healing.[3]

The actual mechanism by which SCS relieves pain is still under debate, although it is thought to function via a 'gate' theory. The gate theory explains how the central (brain and spine) and peripheral (nerves outside the brain and spine) nervous systems work in conjunction to communicate to the brain that one is experiencing pain. Once the pain signal is generated via periphery (cut finger, damaged nerve, etc.), it encounters a type of 'gate' in the spinal cord. The gate is responsible for determining the extent to which the signal travels through the spinal cord up to the brain. By sending an outside electrical signal through the nerves responsible for the pain generation, one is able to 'close' the pain gate and minimize the pain signals that reach the brain.[1,4] The main goal of SCS is to inhibit painful sensory signals at the spine and cut off the relay to the brain.

Sixty years after the first use of a stimulator, the exact mechanism of SCS-derived pain relief is still discussed. However, it is now clinically proven that, with minimal side effects, SCS is effective in relieving chronic pain by changing how our bodies interpret and react to pain signals.

Traditional Spinal Cord Stimulation

The standard SCS technology used today has four main components: electrode leads, an extension wire, a pulse generator, and a wireless handheld remote. The pulse generator (roughly the size of a pocket lighter) generates the electrical impulses responsible for intercepting the pain signals. Upon generation, the pulses flow through the extension wire to the leads implanted around the nerves of the spine. (Figure 1) The physician and patient may control the output of impulses via remote and may adjust a variety of parameters including amplitude, frequency, and pulse width.[1]

Spinal cord stimulators use one of two types of electrode leads: paddle or cylindrical. Each has their unique set of advantages and disadvantages. Both deliver impulses through uniformly spaced electrodes, allowing for a relatively large area to be covered. However, there are different implantation procedures depending on which lead is chosen. Cylindrical leads can be placed percutaneously (through the skin) and only require local anesthesia. While cylindrical leads are mobile within the body and are easier to adjust, they also move more freely and could stray from their intended target nerve, failing to effectively relieve pain. Paddle leads are implanted through more invasive surgeries requiring direct access to the spinal cord. Because paddle leads are anchored to the tissue, it is rare for the leads to move. However, fixing the leads within the epidural space makes them more difficult to manipulate after placement if any adjustments are needed. The location of the leads is one of the main determinants of pain relief. Despite variances between lead fixation methods, studies indicate little difference in pain-relief between the two SCS systems.[5]

Use of spinal cord stimulators always starts with a trial period of 3-15 days. This is meant to test the efficacy of SCS on the patient before executing a more permanent implantation. Leads are first placed percutaneously with the pulse generator externally taped to the patient. While the patient is awake, the leads are adjusted to determine the ideal location for maximum pain relief. This is often accomplished using a series of real-time x-rays. The physician then adjusts the electrical pulse for optimal pain relief. At the end of the trial period, the physician decides whether to permanently implant the spinal cord stimulator based on the patient's self-reported outcome. Most practices proceed with SCS if the patient experiences at least a 50% reduction in pain.[6]

If the patient decides to move forward, leads are placed (depending on type of leads chosen) around the nerves of the spine, in the area of interest, and the pulse generator is surgically implanted in the lower back/buttocks for security. With the hardware permanently in place, patients are able to participate in a variety of activities without worrying about dislodging equipment.[7] The battery life of the pulse generators continue to improve, with some lasting over a decade.[1] Moreover, with the adaptation of new technology, patients are able to securely adjust their pulse generation parameters using Bluetooth, often from their Smartphone. This allows the patient to increase or decrease the power (within range) of the electrical signal depending on their pain without having to return to the physician's office.

SCS has had promising success in relieving pain, increasing quality of life, and decreasing opioid usage for chronic pain patients. A 20-year survey reported that using SCS for Complex Regional Pain Syndrome had an 84% success rate of alleviating 50% or more of pain. The success rate of SCS for back/limb pain and failed back surgery syndrome showed a 67% and 62% success rate, respectively.[6]

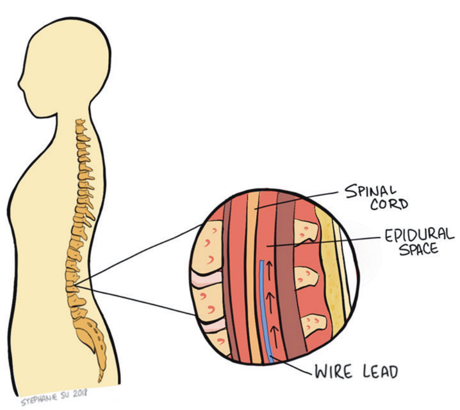

Figure 1. Placement of wire lead within the epidural space.

Additionally, research conducted on opioid usage before and after SCS concluded that the morphine equivalent dose of pain medications used by patients decreased after the SCS systems were implanted, giving a promising look at an alternative to opioids.[8]

Complications

The majority of complications associated with SCS can be prevented or reversed. The most common complications are hardware problems such as lead migration, where the leads move within the patient's epidural space. One study found that 17% of patients experienced lead migration, however, with proper physician expertise, this is becoming less common. The next most widespread complication, lead breaking, occurs in only 7% of patients and requires a repeat procedure to repair.[6] With the advancement of materials and technology, lead malfunction will become less common.

Spinal cord stimulation is not a risk-free procedure, but with the current research and success rates, over 50,000 people worldwide opt for SCS each year, with the vast majority experiencing life-changing relief.[9]

The Future of Spinal Cord Stimulation

New SCS technologies are continually being approved by the FDA and utilized in practices across the United States. The top four medical device companies in the SCS industry (Abbott, Boston Scientific, Medtronic, and Nevro) have been competing for decades to create the most affordable, effective, and innovative devices.

Industry is working on manufacturing SCS devices that aim to avoid paresthesia, which some find uncomfortable. Higher frequency and burst pulse generation are two options currently being explored. High-frequency (HF) devices use impulses with a frequency of 10,000 Hz instead of the traditional 50 Hz. A new study using these HF SCS devices show a 25% higher efficacy rate in reducing chronic back pain compared to traditional SCS systems. Burst SCS avoids paresthesia in a different way. These systems send five rapid pulses through the leads that mimic the body's natural way of firing electrical signals, preventing the patient from feeling a numbness or tingling.[7]

Conclusion

With new research and technology continuing to surface, SCS will only become more effective at relieving chronic pain. In the coming years, perfecting SCS technology and monitoring prescription drug usage will continue to minimize the prevalence of chronic neck or back pain and decrease dependence on opioids.

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WHAT IS LASER THERAPY?

One of the most recent advancements in physical therapy treatments was the introduction of Class IV Laser therapy or Low Level Laser Therapy (LLLT). LLLT is a proven, non-invasive technique that applies a therapeutic dose of light to injured or dysfunctional tissue. The energy from the laser creates a cellular response that leads to reduced pain and inflammation and to faster healing for musculoskeletal conditions. This lasting pain relief treatment has been cleared by the FDA since 2003 and offers a safe alternative to medications and surgery.[1]

LLLT has been available for nearly three decades, but earlier lasers were only able to provide less than 0.5 watts (W) of power, which was not effective and resulted in poor outcome studies. In comparison, Class IV Lasers are capable of delivering light therapy of up to 25W of power. The use of high power lasers are integral to effective laser therapy because most low power lasers are not able to provide a sufficient number of photons to reach deep into the tissue in order to promote healing. Due to their lower power output, previous lasers were limited to treating single spots the size of the tip of a pen. The laser must be held in a single area for 30-90 seconds before moving to the next, making quick analgesia (pain relief) difficult to achieve. Large areas of tissue cannot be addressed in the same sweeping motion as the Class IV Lasers, which severely limits positive outcomes associated with low power lasers.

What Are The Benefits Of Laser Therapy?

Benefits of laser therapy include:

- Pain relief
- Decreased inflammation
- Acceleration of tissue repair and wound healing
- Improved nerve conduction
- Waste removal from damaged tissue
- Delivery of important healing agents

Physical therapists use LLLT to reduce inflammation as quickly as possible so that the body's natural healing process can begin. This allows us to restore range of motion and normal function of the body.

How Does It Work?

Laser therapy triggers a series of mechanisms in the body that activate the production of adenosine triphosphate (ATP) in a process known as photobiomodulation. (ATP is the fuel compound of the cell and facilitates energy transfer within the cell.) According to the FDA, there is consensus that the application of a therapeutic dose of light to impaired or dysfunctional tissue leads to a cellular response mediated by mitochondrial mechanisms that reduce pain and inflammation and speeds up the healing process.[1] This cellular response is driven by the activation of ATP, which in turn provides energy to cells, making them more reactive.

The primary target (chromophore) for the process is the cytochrome c complex, found in the inner membrane of the cell mitochondria (energy powerhouse of the cell). Cytochrome c is a vital component of the electron transport chain that drives cellular metabolism. As light is absorbed, cytochrome c is stimulated, leading to increased production of ATP. In addition to ATP, laser stimulation also produces free nitric oxide and reactive oxygen species. Nitric oxide is a powerful vasodilator (enlarges blood vessels, decreasing blood pressure) and an important cellular signaling molecule involved in nervous, immune, and cardiovascular system processes. Reactive oxygen species have been shown to affect many important physiological signaling pathways including the inflammatory response. In concert, the production of these signaling molecules has been shown to induce growth factor production, increase cell proliferation and motility, and promote extracellular matrix deposition and pro-survival pathways. Outside of the cell, nitric oxide signaling drives vasodilation (which improves microcirculation in the damaged tissue) and delivers oxygen, vital sugars, proteins, and salts while removing wastes.[1]

What Conditions Does It Treat?

Due to its non-invasive nature, laser therapy is often used as a powerful complement to existing physical therapy treatments. It can be used before, during, or after surgical procedures and in conjunction with rehabilitation programs. Laser therapy has a broad spectrum of effects and is a versatile tool that can be used to treat many common conditions including, but not limited to:

- Acute and Chronic Pain
- Sprains, Strains, and Fractures
- Radicular Pain
- Rotator Cuff Injuries
- Post-Surgical Pain Relief
- Orthopedic Disorders
- Carpal Tunnel Syndrome
- Plantar Fasciitis
- Arthritis

Recent advancements in laser technology have benefitted patients by allowing healthcare providers to deliver therapeutic light therapy via a Class IV Laser to treat a variety of conditions without medication or surgery.[2-6] These include:

- Lateral Epicondylitis
- Achilles Tendonitis
- Spinal Nerve Radicular Pain
- Sport Injuries
- Chronic Pain Syndromes

Laser therapy is not recommended during pregnancy, for children (due to growth plate exposure), or for those going through radiation treatments. Laser therapy should also not be used to treat epilepsy, thyroid disease, coagulation disorders, cancer, or brain damage.

What Can I Expect During Treatment?

Laser therapy treatments last between five and ten minutes, depending on the condition being treated, and are administered directly to the skin, as the laser light cannot penetrate through clothing. The application is painless and patients will often only experience a warm sensation caused by the activation of the body's cells. Patients experience this warmth as their body absorbs the light from the laser and their cells become more active in accelerating the healing process; the laser itself is not hot.

Pain relief is often immediate and can allow patients to better perform during their physical therapy exercises. Some patients even report pain relief lasting for several hours after a therapy session.

Moreover, athletes often find that laser therapy helps them recover faster between sporting events. For best results, five to six treatments are recommended in conjunction with your physical therapy regimen.

Conclusion

Lower Light Laser Therapy provides patients with a diverse portfolio of options when determining the best way to approach an injury challenge. LLLT can be used as an adjunct to prescription drugs as well as a substitute for surgery.

Due to recent findings on the harmful effects of opioids, patients are searching for alternative ways to manage their pain. Physical therapists use a variety of techniques and skills to help their patients control their pain, Class IV laser therapy now being an option.

Studies are continually being released showing LLLT as a viable alternative to surgery. While continued research is required, studies show the use of LLLT with stem cell treatment increases cell proliferation within the damaged tissue. Cells such as endogenous opioid neuropeptides, fibroblasts, keratinocytes, lymphocytes, and osteoblasts have shown an increase in proliferation when exposed to light therapy from Class IV Lasers. This explains the accelerated healing response to tendon and bone injuries as well as the analgesic effects patients experience when treated by LLLT. More research needs to be done regarding dosage and protocols when using laser therapy with stem cell treatment but preliminary studies seem to be positive.[7]

Due to high success rates and recent positive outcomes measures, LLLT has been adopted as an essential pain management tool in physical therapy clinics nationwide, even those of NFL, MLB, NBA, HL, FIFA, and Olympic teams.

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MEET THE BOARD

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The Spinal Research Foundation leadership is committed to improving spinal health through research, education, and patient advocacy. We thank the following members for their service to our Board of Directors and are grateful for their combined hours of dedication, guidance, and support.

Michael H. Howland
Chairman

Mr. Howland is a retired career diplomat and businessman. He commenced a public service career with an eight-year stint in the US Military, including a tour in Vietnam. Mr. Howland followed his public service career by founding and operating a groundbreaking technology firm. He recently retired and is now an author, presently writing a major book on the Iranian Revolution.

Mr. Howland holds a graduate degree from Georgetown University in International Law & Politics. He was also on the staff of Georgetown University for two years prior to joining the US Foreign Service, where he served throughout the Middle East, South Asia, Europe, and the former Soviet Union. In 1979, Mr. Howland was one of 52 American diplomats taken hostage by Iranian terrorists and held prisoner for nearly two years.

Mr. Howland resides in Middleburg, VA with his wife Kathy and their two English Setters, where they are active in the community and focus on helping children. He is past President of the Board of Directors of Creative Youth and A Place to Be Foundations. Both organizations help disadvantaged and challenged children find a voice through the performing arts. He is also a member of the Board of Directors for the Cherry Blossom Foundation, a breast cancer organization, as well as the current Vice President of the Board of Trustees of The Hill School, Middleburg, VA. He is an avid fly fisherman and chases trout, with moderate success, anyplace he can find them.

Thomas C. Schuler, MD, FACS
President

Dr. Schuler is CEO and founder of the Virginia Spine Institute. He has previously been the spine consultant to the Washington Redskins and frequently treats professional and amateur athletes. Dr. Schuler is a pioneer in the advancement of disc arthroplasty, minimally invasive spine surgery, and regenerative therapies. He has revolutionized spinal health care across the Washington, DC metropolitan area and the nation.

Dr. Schuler is the Physician Assistant Fellowship Program Director at the Virginia Spine Institute. Dr. Schuler is a distinguished fellow in both the American College of Spine Surgery and the

American College of Surgeons. He is a member of the North American Spine Society, and the U.S. Capital Chapter of the World Presidents' Organization.

Kevin M. Burke
Secretary

Mr. Burke is the President and CEO of Centuria. Since founding the company in 2002, Mr. Burke has guided Centuria through five consecutive years on the Inc. 500 index of America's fastest growing companies and four consecutive years on the Washington Technology Fast 50. Prior to founding Centuria, he founded Synapse Incorporated, which grew to over 40 employees in less than twenty-four months. Before building these companies, he served as a technical resource for MCI, a GS employee within the Department of Health & Human Services, and a United States Marine. Mr. Burke has been featured in Inc. Magazine and is an executive committee member of the Washington Baltimore Chapter of Young Presidents' Organization.

Brian D. Nault
Treasurer

Mr. Nault is the Chairman, CEO, and Co-founder of AOC Applied Technologies Corporation (ATCorp) and BlueWater Federal Solutions, Inc. He is a proven executive with experience in the fields of financial services, technology, and Federal Government contracting. With his passion for our "Nation's future," Mr. Nault and his companies support several important charities, including St. Jude Children's Hospital, Special Olympics, and the Redskins Foundation.

Brian R. Subach, MD, FACS
Chief Scientific Officer

Named one of America's Top Doctors (as featured in American Airlines Magazine), Dr. Subach is a neuro and spine surgeon at the Virginia Spine Institute. He is a nationally recognized expert in the treatment of spinal disorders and an active member of the American Association of Neurological Surgery, the Congress of Neurological Surgeons, and the North American Spine Society. He is an invited member of the international Lumbar Spine Study Group and a fellow in the American College of Surgeons. He lectures extensively regarding the management of complex spinal disorders in both national and international forums, has written 15 book chapters, and has published more than 50 articles regarding treatment of the spine.

John Beatty
Member of the Board

Christopher R. Good, MD, FACS
Member of the Board

Dr. Good is a spine surgeon and the President and Director of Scoliosis & Spinal Deformity at the Virginia Spine Institute. He is a nationally recognized expert in the treatment of spinal deformities, an active member of the American Academy of Orthopaedic Surgeons, North American Spine Society, and the Scoliosis Research Society, and is a fellow in the American College of Surgeons. He has pioneered the use of robotics and navigation in spine surgery as well as the use of regenerative stem cell therapy for lumbar disc disease.

Dr. Good participates in multiple scientific advisory boards working to improve patient safety and spinal balance; he routinely presents his findings, both nationally and internationally.

William H. Evers, Jr., PhD
Member of the Board

Dr. Evers is President and CEO of Systems, Technology & Science, LLC, which he founded in 1998. He is responsible for both setting the strategic direction of the firm and insuring its day-to-day execution. Dr. Evers currently serves as a member of the independent Scientific & Engineering Review Group (iSERG) of the Missile Defense Agency. He previously served as a member of the Defense Science Board Task Force on Tactical Battlefield Communications, Vice Chair of the Army Science Board, a member of the Executive Committee of the National Academy of

Sciences Board on Army Science & Technology, and was a consultant to the Defense Science Board 1993 Summer Study on Global Surveillance. Dr. Evers also served as the Chairman of the Laser Device Panel of the Office of the Under Secretary of Defense Research & Engineering's High Energy Laser Review Group (HELRG).

Raymond F. Pugsley
National Race Liaison

Mr. Pugsley earned his undergraduate degree from Dartmouth College and his Master's degree from Johns Hopkins. He is co-owner of Potomac River Running, Inc., a running/ walking specialty store with eight locations in the Washington, DC metropolitan area. Mr. Pugsley raced competitively at Dartmouth College and as a cross country lover, he's been going strong for 30 years — he was the US Junior National Cross Country Champion in 1988 and finished second in the US Masters Cross Country race in 2009 and 2013. Mr. Pugsley takes advantage of his extensive experience with both training and injuries by coaching adults through the PR Running Club, which was created in 2001. As a life-long athlete, Mr. Pugsley strives to help people in the local community stay active and healthy through his stores, coaching, and event support.

Mr. Pugsley knows the importance of spinal health all too well; he underwent a laminectomy (1996) and a spinal fusion (2003) and, after recovery, was once again able to enjoy the athletic life that he loved, most recently winning the RRCA Master's 10-mile championship at the 2010 Cherry Blossom 10-Miler!

Rita Roy, MS, MD
Gala Liaison

Dr. Roy is a physician and entrepreneur in the use of emerging technology for healthcare communication and education. She is a co-founder of Convergent AV, a Reston-based firm specializing in e-learning solutions and virtual conferences support for medical and healthcare associations and institutions. During her career, Dr. Roy has used her technology expertise to build complex web applications, transform ideas into successful internet-based business models, and advise and develop e-learning web applications using database driven marketing strategies for nonprofits, associations, and universities.

Paul J. Slosar, Jr., MD
Member of the Board

Dr. Slosar is an orthopedic spine surgeon and president of SpineCare Medical Group in San Francisco, CA. Dr. Slosar is also the Medical Director of the SpineCare Institute of San Francisco, Co-Director of the San Francisco Spine Institute, and Director of Surgical Research. Dr. Slosar is board certified by and an oral board examiner for both the American Board of Orthopaedic Surgery and American Board of Spine Surgery. He has authored many articles in peer-reviewed journals, written book chapters, and given podium presentations at national and international meetings. Dr. Slosar is an editorial board member of several peer-reviewed journals including *Spine* and *The Spine Journal*.

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TRIPHASIC TRAINING

In our last article we discussed healthy movement patterns for the individual tied to a desk or office job and unable to get to the gym. Mastering the skill of movement is not easy and takes practice. This time around, we're going to jump to the other end of the spectrum and discuss a certain type of training for athletes: Triphasic Training (TT).

This type of training works on the three elements of a muscle movement. Training these elements can make you quicker, more reactive, and have the ability to develop more force at a higher rate.

- Eccentric Phase: Lowering and lengthening
- Isometric Phase: Static
- Concentric Phase: Lifting and shortening

Triphasic Training takes your normal gym workout and gives it purpose. Instead of simply pumping out meaningless rep after meaningless rep, it teaches your brain (nervous system) and muscles to produce power. Production of power (force X velocity) is what separates the elite athletes from everyone else. You learn to absorb force (store energy) during the eccentric phase of muscle contraction and convert it into power on the concentric phase. This means that you can punch or kick harder, jump higher, and run faster.

Let's take two examples from our previous article (squat and push-up) and demonstrate how you can incorporate a portion of TT into your current workout. We recommend completing nine squats or push-ups with zero breaks in between movements to maximize these exercise's benefits.

If you are unsure of your squat or push-up competency, start with a trainer before implementing Triphasic Training.

Triphasic Training Squat

Perform a normal squat motion while implementing these techniques:

- Instead of rushing into the position, take at least five seconds to descend.
- Hold the squat position for five seconds.
- To release, push your hips up and away from the ground as fast as possible, returning to your standing position.

Have trouble getting deep into that squat? It's ok to start slow. Some regressions include performing a mini squat action instead of trying

Figure 1. Triphasic Training Squat

Figure 2. Triphasic Training Push-Up

to go deep into the position. You can also use a heavy elastic band anchored from a secure, overhead location; face the band and grasp it with both hands. Be sure to keep your chest from rounding and use the elasticity of the band to help you lower deeper into the squat. (Figure 1)

Need something more challenging? Add load or go for a single leg squat. Try an eight second descent or hold for eight seconds at the bottom.

Triphasic Training Push-Up

- From a plank, take five seconds to descend into the push-up position.
- Hold the position for five seconds.
- To release, evenly push your hips and torso up and away from the ground as fast as possible, returning to your plank position.
- If you feel your shoulders shrug or your hips sway or peak, regress back to plank holds in various positions to increase strength and endurance.

Are you having trouble getting your chest to the ground? Try using the wall, chair (Figure 2), or elastic tubing to help lower yourself into or return up from the push-up position.

Is this push-up too easy? Add load, like a weight vest, or put your feet onto a chair. Try an eight second descent or hold for eight seconds at the bottom.

Why Triphasic Training?

If performing the more advanced levels, we recommend that you cap these more challenging exercising at five reps. The key here is to remember that you are training your nervous system and that strength training principles don't really apply to triphasic training. Avoid the monotonous and less productive "three sets of ten" mentality. You shouldn't feel exhausted after doing triphasic training; you should feel encouraged and ready to go!

The information contained in this article is based on the book Triphasic Training by Ben Peterson and Cal Dietz.[1]

References

1. Dietz, Cal. Peterson, Ben. Triphasic Training: A Systematic Approach to Elite Speed and Explosive Strength Performance. Bye Dietz Sports Enterprise, 2012.

Spinal Research Foundation's

SPINAL HERO

Steven D. Wray, MD

Practice:
Atlanta Brain and Spine, P.C.

Why did you choose your specialty and how has it changed since you started?
I narrowed down my studies to spine care because by in large, spinal patients are healthy patients. They tend to be highly motivated to get their family, work, and lives back. On top of patients' commitment to recovery, the fact that technology, specifically the implementation of image guidance, has enhanced so much has made my job that much easier! Image guidance has reduced radiation, increased precision and accuracy, and enhanced the overall safety and efficacy of surgical procedures. Knowing that I, with the help of new technologies, have a significant impact on enhancing someone's life is what brings me into work each day.

You focus on educating your patients on their conditions while nurturing the doctor-patient relationship. How do you balance that?
The medical field necessitates doctors who are inherently compassionate; when you have a patient seeking your help with an emotionally charged issue – *an issue that affects their day to day health, happiness, and quality of life* - having the opportunity to help is extremely gratifying. At the same time, part of my job is to educate a patient so that they have a clear understanding of their options (showing films, demonstrating with models, etc.). I have a deep appreciation to those physicians who did not have the tools and technologies that are afforded to us today (MRIs or magnetic resonance imaging, for example); trying to explain to a patient their diagnosis without imagery is certainly a challenge and I am thankful to have this technology today!

How valuable do you see the new trend of big data and patient registries for advancing care and treatments?
Big data is vitally important in proving the efficacy of treatments and necessary to persuade third-party payers to pay for these effective treatments. The onus is on us to prove the efficacy of treatments and procedures especially when considering the financial burden our patients face while trying to achieve a pain-free life. Tracking outcomes data is an empowering way to significantly change policy, enhance patients' lives, and affirm our profession.

What changes might you expect to see in your area of medicine in five and 10 years time – and how are you preparing for the future?
In general, I can't emphasize the importance and value of continuing medical education (state, regional, national, international...) enough. Some areas in which I believe offer great potential are:

1. **Minimally Invasive Surgeries** will continue to see a decrease in operative and recovery times, as well as in less radiation exposure.

2. **The expanded acceptance and use of osteoinductive biologics**, such as bone

morphogenetic protein (BMP), which aid in the formation of bone. *(Once third-party payers start realizing the efficacy and benefits to the use of biologics, these treatments will hopefully become less expensive and more readily available to the public.)*

3. **Nanotechnology in orthopedics**, specifically intervertebral implants. When using nanomaterials, a more favorable interaction between implants and native bone occurs. *For example, fibrosis (thickening and scarring of connective tissue) generally occurs less frequently with PEEK, as compared to metal implants*.

4. **Stabilization techniques** have also improved over the years and I'm excited to contribute to these findings. This is especially important for those undergoing fusions but suffer from poor bone quality. Thanks to a relatively new technique, the cortical bone screw trajectory demonstrates a good option to obtain fixation, even for those with low quality bone.

Research seems to be very important to you. Can you tell us more about your findings on cortical bone screw trajectory?

Yes, clinical research is very important to me, specifically research on screw trajectories. Low bone mineral density in patients undergoing spinal surgeries with screws can be challenging; poor bone quality can compromise the maximum achievable purchase of the screws. We looked at the advantage of using a cortical (vs. pedicle) screw trajectory in cadaveric spines and found equivalent purchase and strength in these shorter cortical screws. The data demonstrated that the cortical trajectory provided denser bone which allowed for utilization of smaller screws to obtain purchase that is equivalent to long pedicle screws placed in the traditional pedicle screw trajectory. This is important and poses a real advantage when it comes to obtaining fixation for the lumbar spine with low quality bone.

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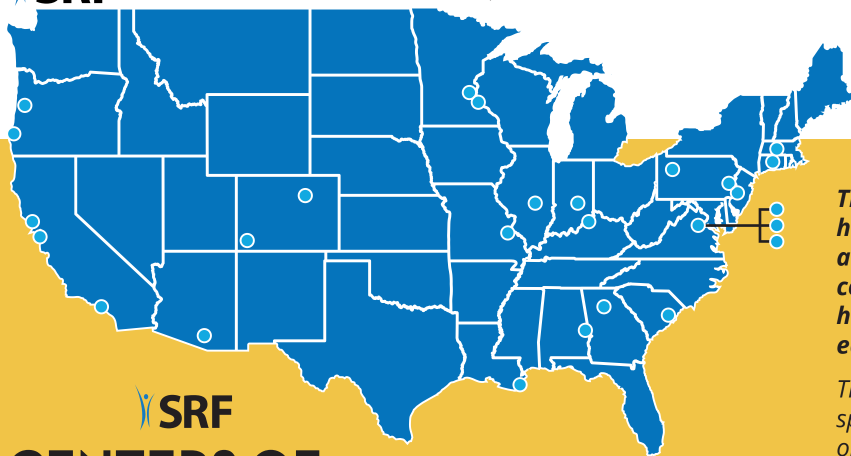

SRF

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The Spinal Research Foundation has named 26 Research Partners across the country that share one core mission: improving spinal health care through research, education, and patient advocacy.

These centers offer the best quality spinal health care while focusing on research programs designed to advance spinal treatments and techniques.

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WITH YOUR GENEROSITY AND OUR RESEARCH, **WE ARE CHANGING LIVES!**

The Spinal Research Foundation was founded in 2002 and exists to prove what works, to drive innovation, and to provide hope for all those who are affected by neck and back pain. We have been hard at work finding answers that help people return to the activities and people they love.

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Your investment will assist in the effectiveness of spinal health treatments, drive innovation through clinical research, and empower all of those that suffer with neck or back pain with knowledge and hope.

For more information about the Corporate Partnership Program or other ways to support SRF, contact Kari Reed, Director of Development & Events (kreed@spinerf.org).

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