Basic science lends to the conceptual understanding of complex subject matters in medicine. The field of medicine is dependent on applying knowledge of medical sciences such as anatomy, physiology, biochemistry, microbiology, pharmacology, and pathology to better understand disease at the cellular, tissue, organ, and biological-system level. However, the foundation of this rigorous medical sciences subject matter finds its roots in biology and to a lesser extent, chemistry.

Most scientists and clinicians who are exploring the realms of clinical research are well-versed in the basic science. Basic science involves studying cell biology, biochemistry, microbiology, immunology, neurobiology, pharmacology, and genetics in organisms such as bacteria, mice, pigs, and humans. The application of basic science principles and concepts to address complex clinical research questions drives discovery in clinic. This application of basic science to clinic is called translational research. It is also commonly referred to as bench to bedside, i.e. laboratory to clinic.

The development of novel treatments, procedures, and technologies relies on tapping the wealth of knowledge that resides in the silos of basic sciences. It is the application of principles and concepts from basic science silos to the dynamic field of medicine that holds the key for finding cures for diseases, developing new treatments, and designing innovative medical technologies. Most scientific investigations to understand the underlying disease mechanism can be effectively had by unraveling the basic science behind it.

Application of basic science concepts in the laboratory setting or outside the human body is called in vitro and is part of the translational research spectrum. The translational research spectrum encompasses application of bench or laboratory findings to benefit patients in clinic. Lately, another arch of the spectrum has extended the translational to the community by disseminating the information to the patients through clinicians and public health officials.

One such field that is making a huge impact on translational research is stem cells. Rather than construct grandeur content on stem cell treatments as the panacea, I would like to take the path less taken. I would like to provide the translational research aspect of stem cells that makes them such a great candidate for regenerative medicine.

Fourteen years ago, while working with a prominent stem cell researcher, Dr. Steve Stice, at the University of Georgia, I learned to truly appreciate the meaning of taking stem cells from the bench-side and finding applications for them in clinic. Dr. Stice has been on the forefront of stem cell research.

Among his many accomplishments, he produced the world’s first cloned rabbit in 1989. In 2001, his lab produced the world’s first human embryonic stem cells derived from discarded embryos. In 2005, Dr. Stice further enhanced the field of regenerative medicine by collaborating with Dr. Zhang from the University of Wisconsin to develop human motor neurons from embryonic stem cells.1
In 2012, his lab created revolutionary “fracture putty” that can heal bone fractures in days rather than months. The last two examples demonstrate the translation of basic science to clinic.

Dr. Stice and other researchers like him have a solid understanding of stem cell biology that enables them to eventually apply that knowledge to clinic in collaboration with clinicians. The basic science knowledge of stem cells by itself is an island; once the concepts and mechanisms behind the science find applications in clinic, it opens up avenues for developing treatments. In the words of Dr. Stice:

“There are multiple diseases that could be benefited through the use of stem cell technology. Stem cells could be differentiated into specific cell types and offer a source of replacement cells from damaged tissues. Some of these diseases include Alzheimer’s disease, Parkinson’s disease, ALS, spinal cord injury, retinal disease, stroke, heart disease, diabetes, and fracture repair. Curing these diseases and injuries would be very exciting; however, intensive research still needs to be performed to make sure that the therapies are safe and effective in human patients.”

Dr. Stice’s lab finding on the bone regeneration process through “fracture putty” is basic science research performed on mice. The lab used adult stem cells capable of producing protein involved in bone healing and generation. In collaboration with Dr. Peroni, they inserted the putty using a stabilizing device into fractures in mice. In an effort to translate this treatment into humans, the next step in this research is to conduct this study in large animals. Once a large animal model is established for healing fractures using the stem cell gel mixture, then it can be translated into clinical studies.

In the grand scheme of things in the clinical research world, minus the million-dollar budgets required for clinical trials, basic science is at work behind the scenes. As is the case with basic science research, with a budget of just a few thousand dollars per project, scientists are busy furthering the application of basic science findings to the clinic, including spinal surgery. Clinical studies including clinical trials are an expensive proposition and can cost millions of dollars for testing the safety and efficacy of drugs and devices including stem cell-derived regenerative medicine for use in humans.

A report submitted by the Eastern Research Group, Inc. to the Department of Health and Human Services in 2014 determined that it now costs between $161 million and $2 billion and about 7.5 years to bring a new drug to market. The high financial cost and lengthy timelines puts the pressure back on the basic science to have highly applicable findings that can be translated into clinic. The basic science research costs are a fraction of the clinical trials. A study by Light et al. showed that in 2003 the gross cost for an FDA-approved drug was $7.6 million for animal studies, while the Phase I, II, and III of a clinical trial was $70.7 million, $77.6 million, and $126 million, respectively.

The cost-ratio of conducting clinical research to bench research in animals is lopsided.

Stem cells’ applications in spine have advanced rapidly in the last few decades. According to Orthopedics This Week, around one million patients in the US were treated with stem cell-based therapies in the 15 years preceding the start of 2012. Furthermore, the article reports that in 2012, 100,000 patients were recipients of these stem cell therapies. Spine surgeons, along with ophthalmologists and wound care physicians, were the most frequent users of stem cell therapies. The article attributes the strong adoption of stem cells therapies by spine surgeons to their use of Infuse Bone Graft (commonly called BMP—bone morphogenetic protein—a genetically engineered version of a protein found naturally in everyone’s body that helps regulate bone growth and healing) and allograft. The fact that spine surgeons have had experience using regenerative therapies as alternate treatments in their practices provides the rationale for increased use of stem cells in spine practices across the country.

There is one clear distinction between the biomaterials, allografts, and growth factors that spine surgeons have used in the past and stem cells: all the aforementioned materials used in spine surgery have been well characterized.

There is quality peer-reviewed literature on basic science, animal studies, and the viable translation of these investigations into clinic. However, stem cells have not been studied in depth to elucidate...
the effective translation of animal models to clinical practice.

The specialization of spine and the orthopedic field as a whole has been heavily influenced by biomedical engineering. Spine surgeons, similar to their non-spine orthopaedic counterparts, have used metal and polymer implants, fixation screws, plates, cages, and other instrumentation to address patients’ neck and back problems. They are receptive and inquisitive about growth factors, bone morphogenetic proteins, and other bioengineered materials that assist with bone growth, vertebral disc regeneration, and intervertebral fusion. So it is logical that spinal surgeons would be open to the use of stem cells as regenerative medicine for their patients.

Stem cells used as biologics have been widely embraced by the spinal research community. Spine researchers in their adoptions of stem cells as regenerative therapies have demonstrated their utility for translational research. Spine surgeons are adept at using instrumentation, devices, and biomaterials to assist them in their surgeries to better heal the patient. Incorporating biologics into their practice is a logical next step to further the non-surgical options available to their patients. The minimally invasive nature of these stem cells as biologics that can be injected at the site of a degenerated disc or assist with spinal fusion are a welcome resource for spine surgeons.

There are numerous basic science and animal studies that provide evidence for its success in disc regeneration,6,7 spinal fusion,8,9 and spinal cord injury.10,11 Studies in each of these respective areas of spinal research have found their way to clinical trials. Clinical trials as defined by the National Institutes of Health, a division of Health and Human Services, are research studies that test how well new medical approaches work in people.12 The translation of basic science studies, especially of animal model to clinical trial, represents a major step in bringing discoveries to clinics. To-date there are clinical trials for disc regeneration,13,14 spinal fusion,15,16 and spinal cord injury.17,18

How critical is the link between animal studies in the lab to human studies in the clinic? In the field of spine, translational research holds great promise as is witnessed by the influx of biologics like BMP in most spine practices across the world. Dr. Marshall Urist, a pioneer of biologics in orthopedics discovered BMPs and helped make them a common utility in spine practices. However, his work on animal models facilitated the application of his basic science discoveries of BMPs into clinic.

Dr. Pettine, co-inventor of Medtronic’s Maverick motion preserving disc replacement, extensively uses stem cell therapies to treat patients in his clinic. Nearly 100 patients have been treated with stem cells in Dr. Pettine’s clinic, and he is seeing them benefit from the biologics injection. Similarly, Dr. Richard Steadman, M.D. from the Steadman clinic in Vail, Colorado is starting a stem cell practice for his orthopedic patients after rigorous research studies with animal models. These examples of prominent clinicians assimilating stem cell therapies in their clinical practice demonstrate the growing trend for regenerative medicine.

Biologics are an attractive alternative for spinal surgery. If the data from the last fifteen years is any proof of the demand for stem cells in the spine, then the next fifteen years is going to result in a wider adoption in spine practices as ongoing trials result in FDA approval of them for clinical use. Clinical trials will move the use of stem cells from investigational to clinical adoption through well designed randomized controlled trials which are widely accepted as the highest form of clinical evidence.19,20 The paradigm shift from invasive procedures using scalpels for spinal procedures to the non-invasive method using needles to inject stem cells to the affected site is taking place.

At the forefront of translational research are basic scientists collaborating with inquisitive clinicians wanting to bring regenerative therapy alternatives to their patients. Spine surgeons understand that spinal procedures are limited by the restricted or absent blood flow to the anatomical features that they operate on. Pharmaceutical agents thus have little effect on the repair of degenerating discs or fusing of vertebrae. A strong understanding of stem cell biology and developing animal models that can be effectively translated for application in human spines seems like a viable regenerative treatment alternative to invasive surgical procedures.

*For a full list of references please visit SpineRf.org