Overview
DePuy Spine, Inc. is one of the fastest growing companies within the medical device and diagnostic sector of Johnson & Johnson. DePuy Spine is known throughout the medical world as a leading designer, manufacturer and supplier of orthopedic spinal implants. Its diverse portfolio of products is used by surgeons to treat patients with spinal conditions resulting from degenerative diseases, deformities, trauma and sports-related injuries.

Simulation Aids Researchers Studying Spinal Disc Implants

ANSYS helps determine optimal placement of artificial disc and provides valuable insight into spine biomechanics.
One of the company’s leading products is the CHARITÉ™ artificial disc. The device was approved by the U.S. Food and Drug Administration (FDA) in October 2004, and is the first device introduced in the United States as an alternative to spinal fusion surgery for treatment of lower back pain caused by degenerative disc disease. Until recently, surgical interventions consisted of limiting the range of motion of afflicted spinal segments.

The CHARITÉ artificial disc is designed to eliminate pain and maintain motion of the operative segment. The device incorporates a mobile core design while most of the competitive artificial discs being developed for total disc replacement (TDR) offer a fixed core design that may not restore the patient’s full range of spinal motion and consequently may transfer additional stress to other areas of the spine where secondary problems may develop. Major drawbacks such as larger stresses and unnatural motion paths are even more pronounced with traditional spinal fusion surgery in which adjacent vertebrae are rigidly joined using bone grafts and metal screws to totally immobilize a portion of the spine.

**Challenge**

Overcoming these limitations, the CHARITÉ artificial disc is a three-piece articulating device consisting of a polyethylene core sliding between two cobalt chromium alloy endplates that attach to the vertebrae with metal teeth above and below the damaged disc space. Over the years, the device has had an extensive clinical history of successful results and durability for total disc replacement with surgeons treating thousands of patients worldwide.

As is generally done with medical breakthroughs of this magnitude, researchers keep striving to understand and improve the behavior of TDR for its safe and effective use in the human body. Of particular interest is understanding the effect of the artificial disc placement within the disc space on the loading of the facets, the protruding portions of the vertebrae clinically known to be generators of pain when supraphysiologically loaded.

Traditionally, such studies are performed with cadaveric testing instrumented with strain gauges and pressure sensors. This method is not without inconvenience. It is expensive, time-consuming and often inconclusive because of the difficulties in achieving similar test conditions and procedures for a sufficient number of samples. Each test is destructive in nature and the specimens’ quality and morphology vary considerably within individuals. Moreover, due to measurement shortcomings, cadaveric testing often fails to provide a background for understanding how precisely the loads placed on the spine relate to structural stresses in each of the spinal segments.

The CHARITÉ artificial disc is the world’s first commercially available artificial disc for treating patients with degenerative disc disease.
Researchers at DePuy Spine used ANSYS Structural software to model and analyze how well the CHARITÉ artificial disc helps restore motion and how it is affected by its placement relative to the center line of the disc nucleus [1-3]. To realize their objective, they obtained the contoured geometry of the vertebrae from computer tomography (CT) scans of actual bone structure.

The resulting model was composed of an assembly of vertebrae, polyethylene core, cobalt chromium endplates and surrounding tissues such as cartilage, ligaments and muscle. All parts were modeled using ANSYS standard pre-processing capabilities and analyzed with ANSYS Structural. Work was done on a standard Intel-based IBM M Pro desktop workstation.

The ability of ANSYS to represent the nonlinear material properties of the various components was critical in this study. Moreover, contact representation was aided with ANSYS surface-to-surface contact elements, which automatically detects and adjusts dissimilar meshes instead of requiring users to perform this task manually.

The use of ANSYS simulation enabled researchers at DePuy Spine to determine what constitutes an optimal placement of the artificial disc. The analysis clearly showed that strain and loads on the facets are significantly less with the CHARITÉ artificial disc when compared to a competitive device with a fixed core used for TDR.

The superior performance of the CHARITÉ can be attributed to its mobile core, which better distributes the loads when compared to conventional fixed-core TDR. In addition, the study contributed valuable insight into spine biomechanics, the details of which until now have not been well understood. Admittedly, the accuracy and detail yielded by the study could not have been attained with physical testing, which would have been costlier and more demanding in terms of time and effort.

Researchers at DePuy Spine believe this information will provide valuable knowledge for the continuing development of artificial disc and related technologies. Working with some of the world’s most respected spine surgeons, researchers at DePuy Spine are already using the results of this study and other simulation-based work to fine-tune procedures and techniques for an optimum positioning of the device.
“ANSYS software is an effective tool in simulating the function of the spine. Contact elements are extremely useful in modeling the complex configuration of components that touch one another. Nonlinear capabilities of the software are critical in accurately representing the material properties and behavior of the artificial disc and surrounding cartilage, ligaments and muscle tissue. Such powerful Finite Element Modeling and Analysis Technologies are essential in studying the impact, stresses and loading in various parts of the spine. Simply put, our work could not have been done as quickly and accurately any other way.”

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References

