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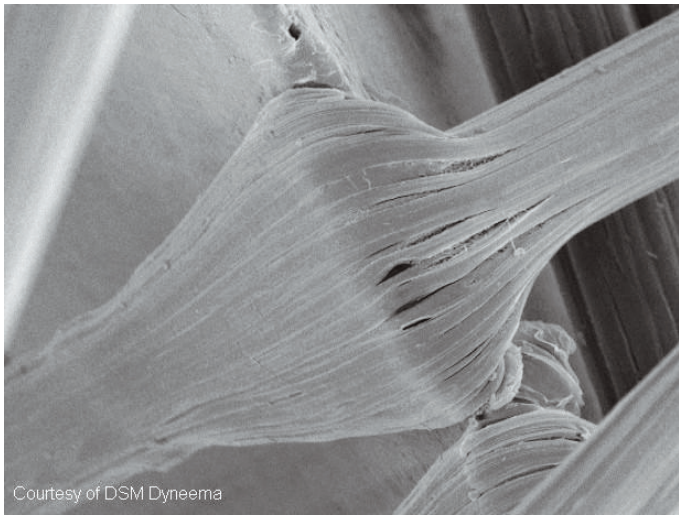
A New Material for the Engineer's Toolbox: Medical Grade UHMWPE Fibers Provide an Opportunity to Improve Device Performance and Patient Outcomes in MIS

After years of medical research and innovation, fiber constructions made of medical-grade Ultra High Molecular Weight Polyethylene (UHMWPE) fiber are quickly emerging as a design alternative to steel. Its properties allow for flexible design of constructions, and its smaller dimensions enable UHMWPE fibers to be used in smaller implants, which integrate with the development and application of new, minimally invasive surgical techniques that can lead to shorter hospitalization, faster recovery times and a lower total cost of care. Fibers also allow for more flexibility and strength than steel. (See Exhibit 1.)

While steel will remain the material of choice for many applications—those, for example, in which fusion is critical and movement is a risk—UHMWPE fiber represents an exciting add-on to steel for those designers and engineers focused on advancing other device and treatment capabilities. The fiber's outstanding strength relative to volume, for example, is supporting advancements in less invasive treatments and techniques, and its superior fatigue resistance has the potential to improve the performance and longevity of dynamic applications.

Yet, for many, medical-grade UHMWPE fiber remains a new frontier that requires a new mindset—and new knowledge—for capitalizing on its innovation potential, especially because of the design freedom it offers: the fibers can be processed into many two and three dimensional constructions such as very thin wires, (flat) cables, tubes, sheets of any shape and size. To help those less familiar with its properties to better understand its potential for fueling a new wave of surgical technique improvements and innovations,

Exhibit 1: SEM image of UHMWPE fiber filament stretched over the sharp edge of a razor blade, demonstrating increased contact surface and high compliance.



this article will outline some of this fiber's mechanical properties and will discuss some of the ways that end-users—surgeons—are using these fibers to improve existing surgical procedures, specifically in regard to spinal minimally invasive surgeries.

Strength Properties Support the MIS Trend

At a similar diameter, the UHMWPE fiber is approximately four times stronger than titanium and polyester. (See Exhibit 2 on the following page.) Its exceptionally high tensile strength of close to 4GPa is enabling medical device manufacturers to design smaller, lower-profile implants for minimally invasive surgical procedures without sacrificing strength and durability. As such, medical-grade UHMWPE fibers offer designers one of the most promising means for realizing the benefits associated with minimally invasive implants and techniques, including shorter recuperation times and less scarring.

Further, cables made with medical-grade UHMWPE fiber generally contain a braided structure, which provides a low bending stiffness and enables easy forming and securing of knots. The nature of medical-grade UHMWPE fiber also facilitates further processing of the cable, resulting in excellent strength properties and bending stiffness characteristics that allow for easy handling and steady control during surgery.

Handling Characteristics Translate into Safety Potential for Patients AND Surgeons

In instances where surgeons are navigating through challenging areas—for example, narrow openings or around nerves—the softness and navigability of constructions made from UHMWPE fiber may reduce damage to the patient that could occur with a tougher or sharper cable, such as those constructed with steel.

The fiber's softness also presents a huge advantage when cutting cables. When steel cables are cut, individual strands stick out as sharp needles. If there is a need to retract the cable during surgery, these needles can cause severe damage to surrounding soft tissue and may even cause nerve damage or paralysis when passing the spinal cord. On the other hand, when a cable made of UHMWPE fiber is cut, this risk of nerve damage is considerably decreased due to the material's softness and non-existing memory properties.

Further, the use of UHMWPE fibers may also help avoid damage to bone. Because steel does not conform to the body,

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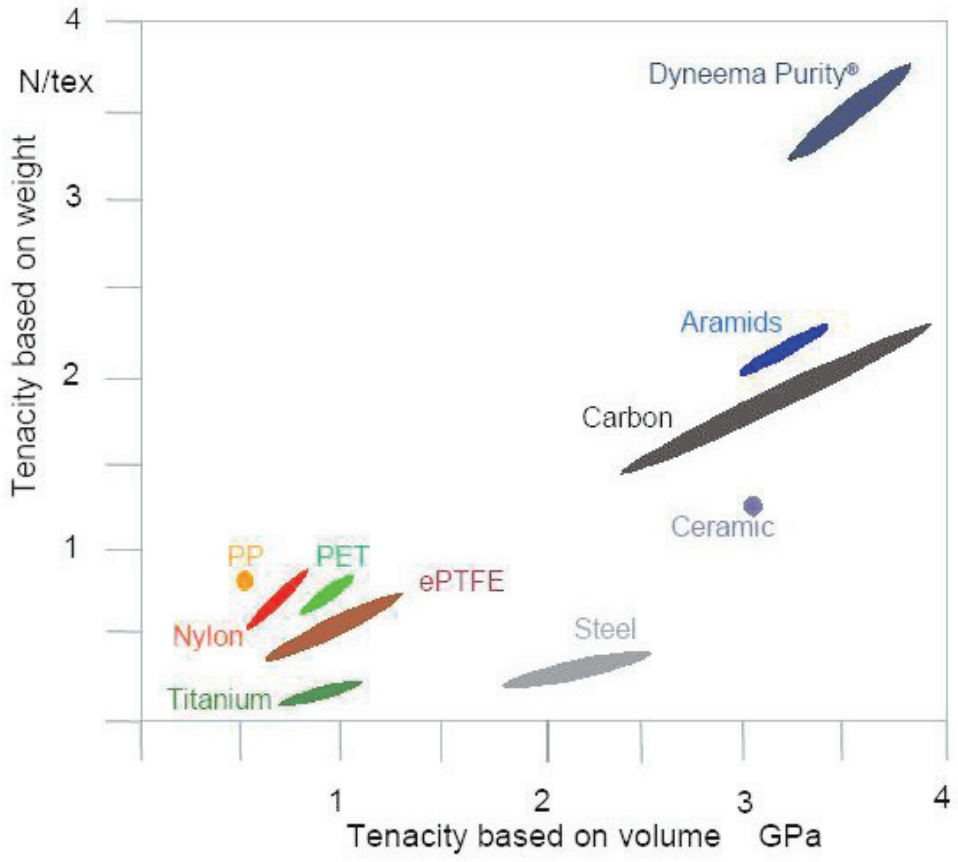
Exhibit 2: A comparison illustrating the ultimate breaking strength of various materials.



there is a small contact surface between bone and the cable. With all force transferred at this contact surface during surgery, a high contact pressure results, potentially leading the steel to cut into the bone. The nature of UHMWPE fibers, however, is that they conform very well to the bone, thereby increasing the contact surface and lowering contact pressure, resulting in less cutting into the bone.

UHMWPE fiber has the potential to be safer for surgeons, as well. Steel wires are sharp, and orthopaedic surgeries in particular can require surgeons to exert significant force during a procedure. Surgeons have been known to cut themselves on sharp edges of steel cables. Steel typically maintains its shape due to its hardness and stiffness, whereas the medical-grade UHMWPE fibers have the softness of textiles, which is appreciated by the end-user. This contributes to a reduced potential for cutting, without compromising any strength in the device. As such, many surgeons find the material far easier and more comfortable to work with.

The dynamic nature of cable constructions made with UHMWPE fiber enable movement or fixation to facilitate the correct longitudinal growth.

Fiber Use Spurs Spinal MIS

Spinal deformities generally result from a congenital impaired development of the vertebral bodies. Emerging numbers of spinal deformities are treated through surgical interventions each year, and UHMWPE fibers are aiding in the development of new techniques.

Most intervention techniques for spinal deformities are characterized by fixation and stabilization of vertebral bodies using rigid rods and screws, which result in vertebral fusion to minimize the adverse effects of the deformity. Although successful in adult patients, these fixation techniques have major disadvantages for younger patients who will continue to grow after surgery and thus, require alternative intervention procedures and devices that preserve the function of the spine—including growth, mobility and proper load distribution.

A cable-based system in a dynamic spine device would guide growing vertebral bodies in the desired therapeutic direction with preservation of mobility.

The dynamic nature of cable constructions made with UHMWPE fiber enable movement or fixation to facilitate the correct longitudinal growth. This dynamic fixation method is expected to require less invasive surgical techniques than currently used methods.

For example, in one current surgical method, a steel cable is wrapped around the portions of bone that require repair (such as those that have been separated due to a trauma or in the course of an operation). Both ends of the cable must be guided through holes in a metal block, with one device and the metal block clamped with a second device. Once this fixation has occurred, no adjustments are possible; a re-adjustment can only be accomplished by cutting the cable and starting the process over again. In contrast, a construction of medical-grade UHMWPE fiber enables the development of a method that allows re-tensioning after primary fixation and provides easy intermediate fixation of the cable, all with just one device.

UHMWPE fiber offers tremendous potential to design the next generation of medical devices for minimally invasive surgical techniques, which not only helps preserve muscles and soft tissues, but also reduces scarring. Its unique combination of strength, flexibility and softness makes this fiber ideal for new approaches to the correction of spinal conditions.

While steel is and will remain an important material for spinal surgeons, the material benefits of medical-grade UHMWPE fibers are just a few of the reasons that growing numbers of surgeons are turning to fiber constructions in increasing numbers. Combined with evolving navigation techniques, fiber's advancements are bringing surgeons closer to achieving their goals of performing less invasive procedures, and ultimately improving the lives of patients.

For more information on UHMWPE fiber, please visit www.dyneemapurity.com.

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