



# 9 things you didn't know about medical fabrics

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Mention implantable materials in a discussion and most listeners think of plastics and metals. Woven, knit, and braided fabrics seem to have escaped attention. Yet fabrics can be engineered for special purposes such as filtering emboli from blood streams, providing scaffolds for cellular in-growth, and functioning as a barrier to prevent tissue from growing into or through the material.

Medical fabrics come from manufacturing facilities that seem an odd mix of technology. Some of the equipment seems 19th century, such as textile production machines and looms that one might see in any fabric facility. But look closer and you'll see a 21st-century twist on textiles, such as cleanrooms and controlled environments, process validation capabilities, and ISO 13485:2003 certification. Weaving, knitting, and braiding have all been modernized.

## An intro to weaving

Weaving creates a stable

structure by interlacing yarns or wires, or both, over and under each other and at 90° to one another. It sounds straightforward, but the design flexibility of current weaving techniques allows customizing fabric by adjusting key design characteristics such as:

**Floating.** This fluctuates the interlacing and orientation of yarns from one side of a fabric to the other. It generates dual-fabric surfaces, each with different properties. This might, for example, include an implantable fabric where one side is a wearing surface with the other an in-growth surface.

**Tapering or flaring** takes a flat or tubular structure from one diameter to another over a specified length. Specialized equipment lets fabric produc-

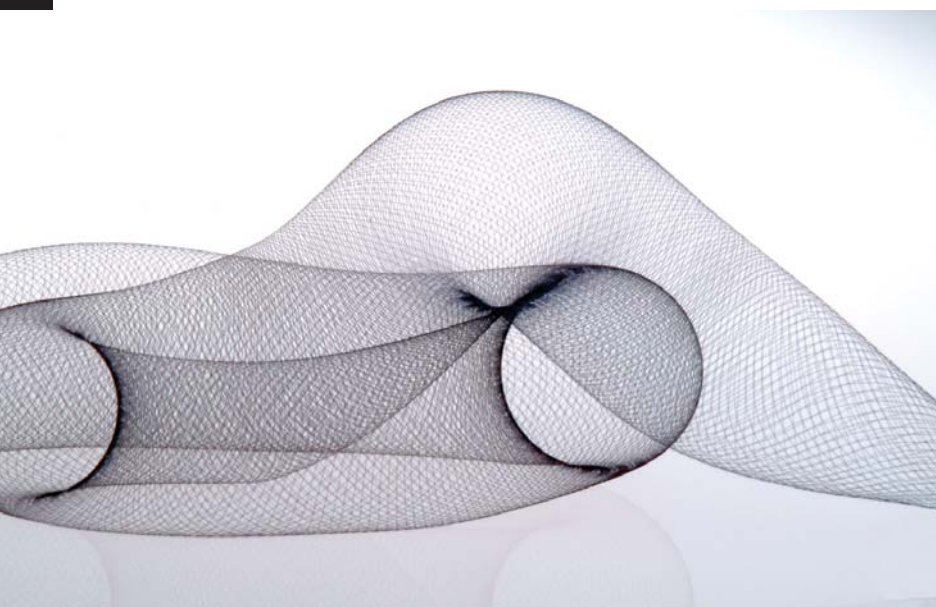


**A technician prepares woven polyester grafts for annealing. This seamless tubular fabric is woven flat, cleaned and then placed over mandrels for heat-shaping to produce a 3D structure.**

ers create seamless tapers, an appealing design characteristic for many device makers. It is now possible to generate sudden tapers which might be used to seal large anatomical defects or provide structural support. Gradual tapers, those found in devices for treating abdominal aortic aneurysms, can mirror the varying diameters of an individual's aortic measurements.

Multi-layer and 3D geometries are gaining ground in novel designs that need a near net shape.

**The Nitinol fabric is braided from a 0.0008-in. diameter wire to filter emboli from a patient's blood stream during angioplasty procedures.**





Preshaped fabrics or those with multiple layers can be used to maintain void space or fill it. This is done with fabrics that contain or direct fluids, or by designing a structure that elicits tissue growth through the thickness of the construct.

### Knitting in a nutshell

Knitting is a kind of controlled entangling that stitches together a series of yarns. Modern knitted fabrics yield several important design characteristics that play key roles in device design, such as:

Controlled porosity and permeability. Fabric manufacturers can design-in specific stretch properties, flexibility properties, and pore size by taking groups of yarns and pulling them in opposite directions. The complex motion of knitting essentially moves yarns from side to side, at the same time as they are wrapped around needles. The side-to-side motion controls pore size. Possibilities include a knitted open-honeycomb structure or solid/flat structure all the way across the fabric. Porosity is useful in treatments that call for either in-growth or through-growth by tissue.

Controlled stiffness, thickness, or elongation. The physical and mechanical properties of a knit can be altered substantially by changing raw materials used to create the fabric. Rigid monofilament fibers can be oriented along either or both axes to make a fabric more compliant. Thickness and elongation of the structure can be similarly controlled through the base fibers.

The idea here is to be able to support aging human tissue with a fiber structure that is just a bit more stiff or elongates by a precise amount. Designers can require, for instance, a structure that elongates no more than 40% at a particular load.

A real life example is a woven urinary device for incontinence

problems. It acts like a sling to support aging urethras yet still allows some flex and maneuvering.

Hybrid material properties. Knitting polymeric and metallic fibers into one structure delivers unusual characteristics. Fiber orientation in the fabric delivers a composite that can yield preferential sidedness, where each face of a two-dimensional fabric can have differing geometric or biologic properties. Also, specific reinforcement zones or properties that change over time with absorption of fibers can be created simply by orienting polymers with dissimilar properties to a specific region in the fabric.

### Basics of braiding

Braiding moves yarns around a central point on a machine. It's often called maypole braiding and has proven useful in catheter reinforcement by incorporating wires into catheters to prevent kinking or torquing during surgical implantation. Characteristics of braided fabrics include:

Density which refers to braiding techniques that use up to 280 different elements (yarns, polymers, or wires in many combinations) in one fabric structure. Sutures by comparison use 8 or 16 yarns. Complex braids can create specific diameters and densities for specialized medical applications. This means fabric manufacturers can "dial-in" an exact number of elements and densities needed by the application.

Radial expansion is, of course, an ability to expand radially. It's based on axial compression forces called foreshortening. Like Chinese finger cuffs, braided fabrics compress or expand radially depending on how it's pulled. In medical devices, braids can be packed to a small diameter in catheter delivery systems, and then undergo a shape transformation when in position in the body.



**The woven tubes are made with polyester and a reinforcing Nitinol wire. The smaller tube has reinforcing wires in opposite winds to prevent kinking.**

Specialized braiding was created in response to new requirements. For example, it's now possible to put platinum and other radiopaque materials in with metals or polymers – letting physicians visualize device locations during deployment and placement. Alternatively, metals and polymers can be combined in the same structure to create substantial hoop strength of a lumen while maintaining a high-density tubular shape.

### Innovation and collaboration

By working with device makers, fabric manufacturers can identify needed characteristics for a design. Then the teams can collaborate on a decision tree that leads to the right materials and a forming technology. Collaboration of this sort keeps edging the capabilities of today's devices forward by leveraging the design flexibility of fabrics made from a wide variety of materials. ■