Medical-Functional Clothing:

- This category refers to functional clothing for healthcare.
- The medical textiles sector is growing annually, estimated to reach $2.7 billion by 2018
- Characteristics typically include absorbency (wound-dressing), air permeability (surgeons' gowns, staff uniforms) and durability (pressure clothing).
- These types of functional clothing may be categorized into four separate and specialized areas of application, as follows:

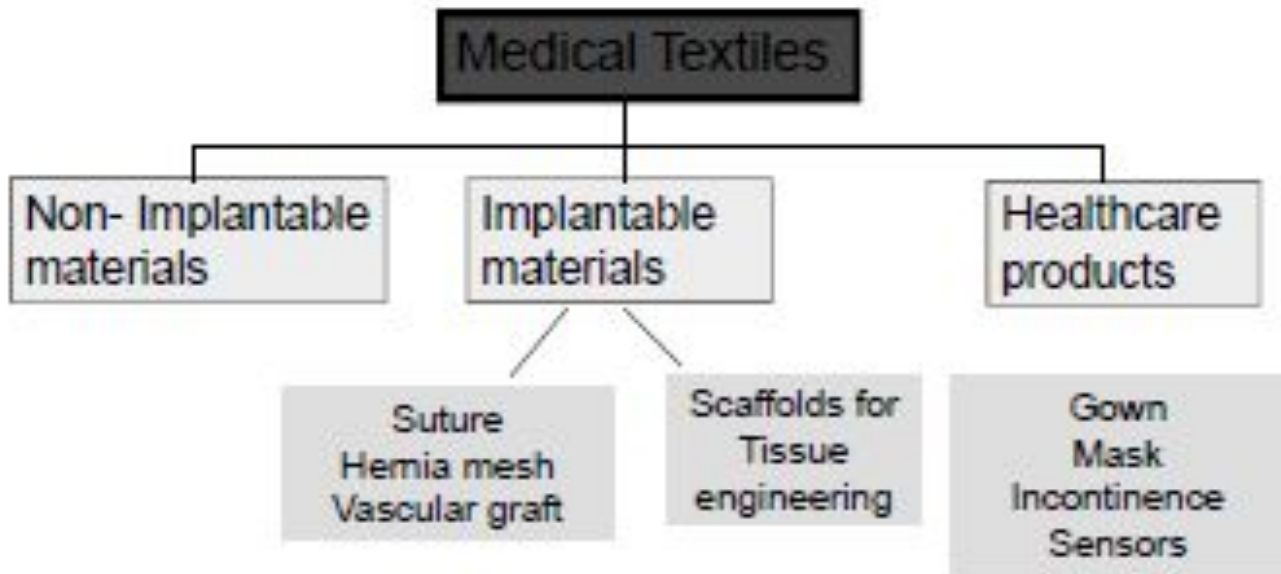
❑ *Healthcare/hygiene clothing,*

❑ *Surgical clothing,*

❑ *Therapeutic clothing,*

❑ *Intelligent functional clothing.*

- Healthcare/hygiene and surgical clothing are important sectors in the fields of medicine and surgery. They may be used in operating theatres and on hospital wards for the care, hygiene, and safety of staff and patients.
- Therapeutic clothing includes pressure clothing and clothing designed specifically to aid in reducing the risk of infection.
- Intelligent functional clothing is a relatively new and specific area in medical-functional clothing.


Medical Textiles
Non- Implantable materials
Implantable materials
Healthcare products
Suture
Hernia mesh
Vascular graft
Scaffolds for Tissue engineering
Gown
Mask
Incontinence
Sensors

Non-implantable materials

Product application	Fibre type	Manufacture system
Woundcare		
absorbent pad	Cotton, viscose	Nonwoven
wound contact layer	Silk, polyamide, viscose, polyethylene	Knitted, woven, nonwoven
base material	Viscose, plastic film	Nonwoven, woven
Bandages		
simple inelastic/elastic	Cotton, viscose, polyamide, elastomeric yarns	Woven, knitted, nonwoven
light support	Cotton, viscose, elastomeric yarns	Woven, knitted, nonwoven
compression	Cotton, polyamide, elastomeric yarns	Woven, knitted
orthopaedic	Cotton, viscose, polyester polypropylene, polyurethane foam	Woven, nonwoven
Plasters	Viscose, plastic film, cotton, polyester, glass, polypropylene	Knitted, woven, nonwoven
Gauzes	Cotton, viscose	Woven, nonwoven
Lint	Cotton	Woven
Wadding	Viscose, cotton linters, wood pulp	Nonwoven
Sutures		
biodegradable	Collagen, polylactide, polyglycolide	Monofilament, braided
non-biodegradable	Polyamide, polyester, PTFE, polypropylene, steel	Monofilament, braided

Implantable materials

Application	Material	Yarn structure	Fabric structure
Arteries	Dacron T56 Teflon	Textured Multifilament	Weft/warp knit Straight/ bifurcations Woven/non-woven
Tendons	Dacron T56 Dacron T55 Kevlar	Low-twist filament Multifilament	Coated woven tape
Hernia repair	Polypropylene	Monofilament	Tricot knit
Esophagus	Regenerated collagen	Monofilament	Plain weave Knit
Patches	Dacron T56	Monofilament Multifilament	Woven Knit/knit velour
Sutures	Polyester Nylon Regenerated collagen Silk	Monofilament Multifilament	Braid Woven tapes
Ligaments	Polyester Teflon Polyethylene	Monofilament Multifilament	Braid
Bones and joints	Carbon in thermoset or thermoplastic Matrix	Monofilament	Woven tapes Knits/braids

Classification of medical-functional clothing:

Healthcare/hygiene

- Healthcare uniform
- Clothing for nursing staff, nurse’s uniform
- Clothing for patients, scrubs, patient wear
- Medical coats, tabards
- Medical protective clothing (in isolation wards and intensive care units)
- Protective gown for dentist
- Protective gown for veterinary

Surgical clothing

- Surgeon’s gowns, caps
- Surgical cover cloths
- Surgical hosiery
- Surgical hosiery with graduated compression characteristics

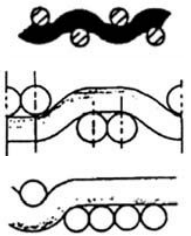
Therapeutic clothing

- Pressure clothing
- Tubular elasticised net garment
- Far infrared therapeutic clothing
- Infrared shapewear
- Anti-microbial underwear
- Anti-irritant’s underwear

Design criteria of Medical textile products

Design criteria

- **Understanding of the tissue into which it will be applied**
- **Fibre Chemistries that regulate selected cell functions**
- **Textile architectures that simulate**
  - desired anatomical features (orientation)
  - desired mechanical properties
  - desired biological properties
- **Cost effectivity**



Woven : plain, twill, satin weaves, 3D weaving

Nonwoven: Air-Laid, wet laid

Knitted : warp knitted, weft knitted

braids, electrospun, Composites

Which polymer ?

- **Chemical**
  - Biodegradability
  - Initially facilitate cell attachment (integrin)
  - Affect cell functions such as mitosis, biosynthesis
- **Mechanical**
  - Strength
  - Modulus of elasticity; stiffness
- **Physical**
  - Porosity

Which method of Textile Eng ?

Woven fabrics typically are stronger
can be fabricated with lower porosities or
lower water/blood permeability, compared to knits

Knits have higher permeability than woven designs
are easier to suture,
but may dilate after implantation.

Braids have high flexibility, but can be unstable except when subject to longitudinal load, as in the case of a suture.

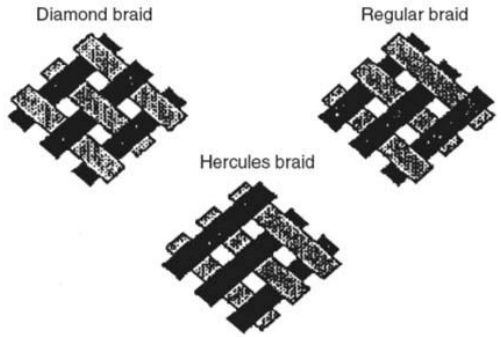
Multilayer braids are more stable, but are also thicker & less flexible than unidimensional braids.

Embroidered structure

Braids

suture materials, vascular graft and ligament prostheses.

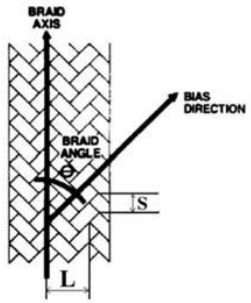
Common braided structures involve the interlacing of an even number of yarns, leading to diamond, regular, and Hercules structures that can be either 2D or 3D.



As the yarns criss-cross each other, braided textiles are highly porous and retain fluids within interstitial spaces between yarns

(optional) coating of biodegradable or nonbiodegradable polymers (Teflon)

Smoothness
Reduce capillarity, porosity



Analysis of Polymeric Braided Tubular Structures Intended for Medical Applications
Mehmet E. Yuksekkaya and Sabi Adanur
Textile Research Journal, Feb 2009; 79: pp. 99 - 109.

Nonwovens

Textile structure produced directly from fibers without the intermediate step of yarn production.

The fibers are either bonded or interlocked together by means of mechanical or thermal action, or by using an adhesive or solvent or a combination these approaches.

Properties are governed by the polymer/fibre characteristics & bonding process

The fibers may be oriented randomly or preferentially in one or more directions, and by combining multiple layers one can engineer the mechanical properties independently in the machine (lengthwise) and cross directions.

Average pore size of a nonwoven web depends on **density of fibers**, & **average fiber diameter**, and falls under a single distribution.

That is why most of the tissue-engineered scaffolds are nonwovens.

High surface area

Very high fluid repellency or absorbency

Extremely low linting

Fast wicking of liquids

Knitted constructions are made by interloping yarns in horizontal rows and vertical columns of stitches.

They are softer, **highly porous**, **more flexible** and easily conformable, and have better handling characteristics than woven graft designs.

Knit fabrics can have **high water permeability values** (5,000 ml cm^{-2} min^{-1}) and still maintain structural stability.

Warp knit is less stretch than weft knits,
Warp knits do not run and unravel when cut at an angle .

highly porous grafts materials are usually coated or impregnated with collagen or gelatin so that the surgeon does not have to perform the time consuming pre-clotting process at the time of surgery.

When knits are produced, the fabric is typically very open and requires special processing to tighten the looped structure and lower its permeability. This compaction process is usually done using a chemical shrinking agent such as **methylene chloride** or by **thermal shrinking**.

Because of their open structure, knits are typically easier to suture and have better handling characteristics

Limitation:
Unlike woven fabrics, high porosity of knitted fabric can not be reduced below a certain value determined by the construction

Woven Fabrics

Yarns (warp, weft) are oriented at 90◦ to each other.
Due to orthogonal relationship between the warp and weft, woven structures show low elongation, high breaking strength in both directions.

Dimensionally highly stable

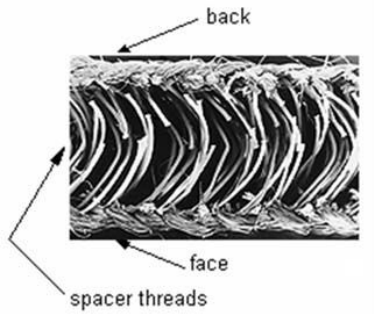
Limitation: tendency to unravel at the edges when cut squarely / obliquely

Leno weave , 3D weave

Spacer fabrics

pressure resistance : fiber material, fiber angle , stitch density

Directed fluid transport :



Spacer fabrics based bandages (lymphedema of the leg)
compression bandage

Specialty bed cover