Smart mesh, biological mesh and novel materials in hernia repair

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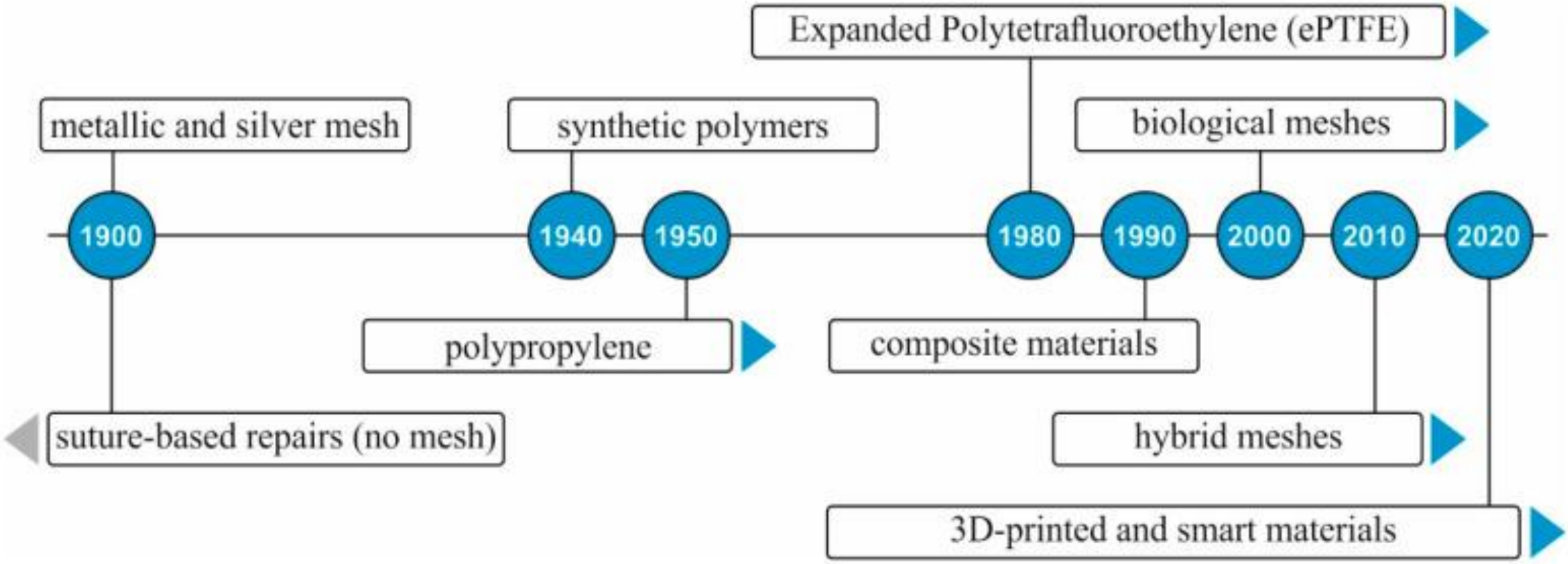
Timeline of mesh evolution



Dream mesh

- ✓ Biocompatibility: Non-carcinogenic and non-allergic.
- ✓ Infection Resistance: Does not act as a vehicle for infection transmission.
- ✓ Physical Properties: Sufficient mechanical strength and mimics the physiological function of the abdominal wall.
- ✓ Handling: Easy to handle and implant.

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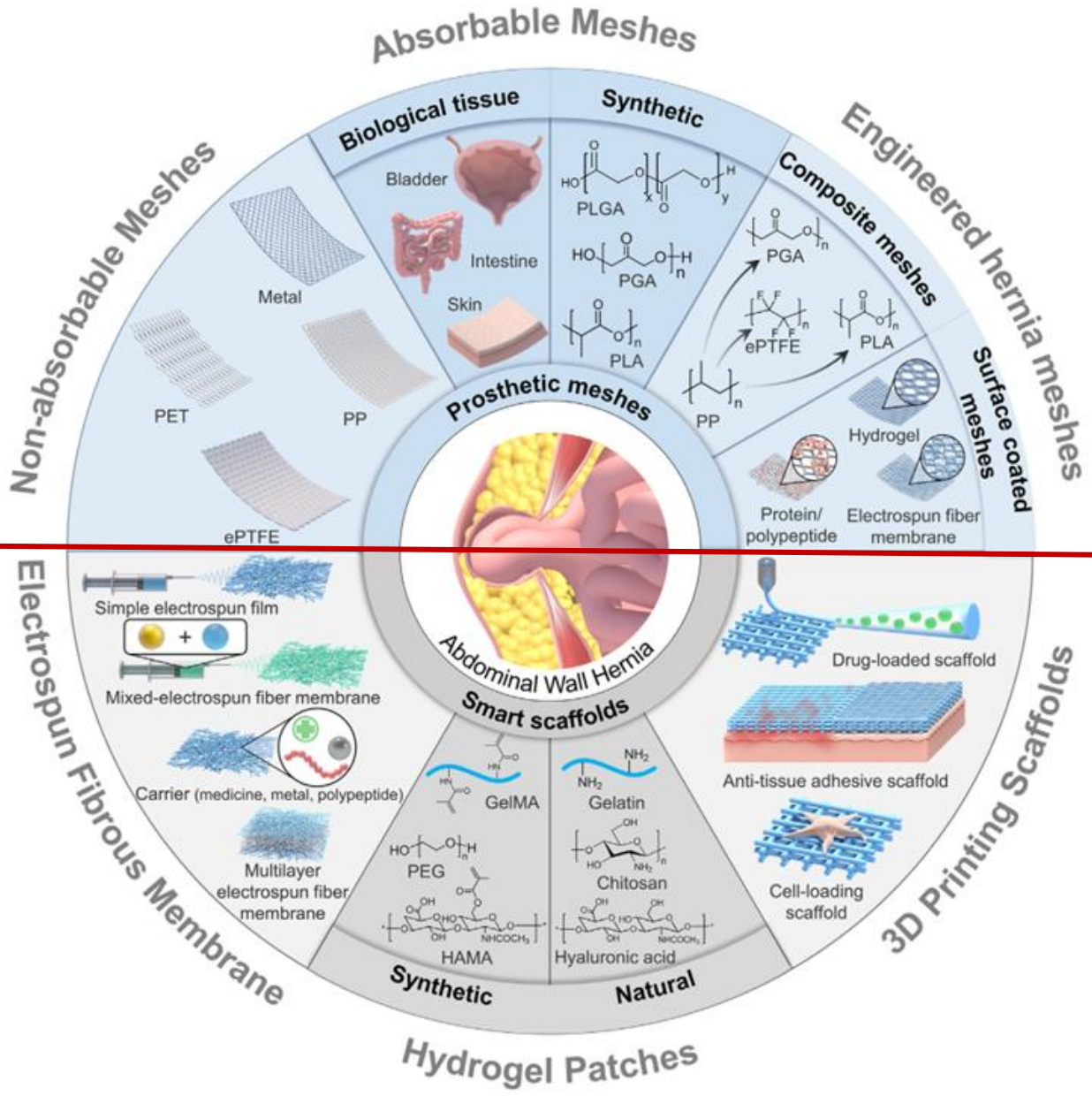
No single product feet now

Mesh materials: now and future

Current

Future



Mesh materials: now and future

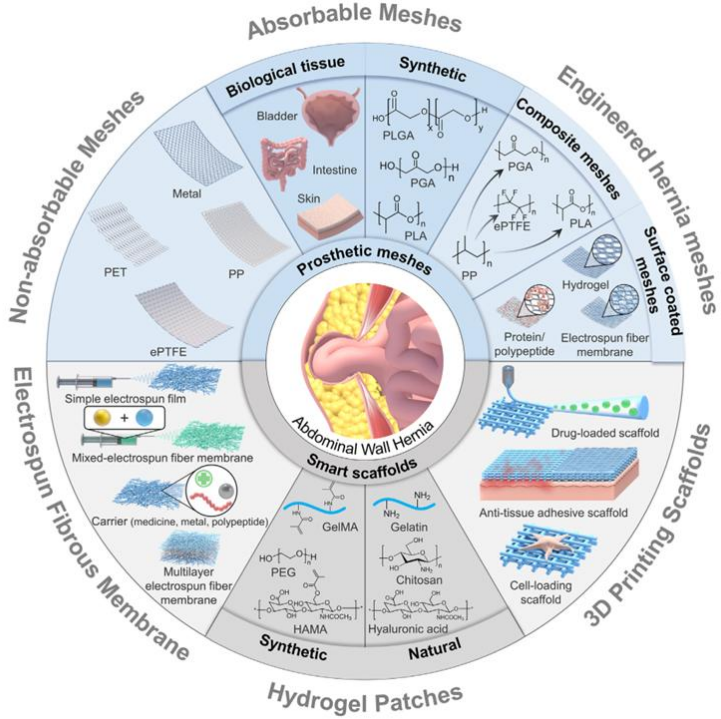
Synthetic mesh

Hydrophobic (疏水)

- ✓ Ex: PP
- ✓ 發炎反應強
- ✓ 容易沾黏
- ✓ 長期牢靠
- ✓ 絕不能面向腸子
- ✓ 較有韌性好掌握
- ✓ 感染後有機會保留

Hydrophilic (親水)

- ✓ Ex: PET, ePTFE
- ✓ 短期合一
- ✓ 防沾黏
- ✓ 較軟不好控制
- ✓ 感染後多需要移除
- ✓ 移除網膜非常困難



Heavy-weight Polypropylene (PP)

Heavy-weight Polypropylene (PP)

Characteristics:

- ✓ High density
- ✓ Small pore
- ✓ High weight (80-100g/m2)
- ✓ Strong reinforcement
- ✓ Hydrophobic

Drawback:

- ✓ Strong foreign body reaction
- ✓ Scar plate
- ✓ Chronic pain
- ✓ Prevent immune cell entry

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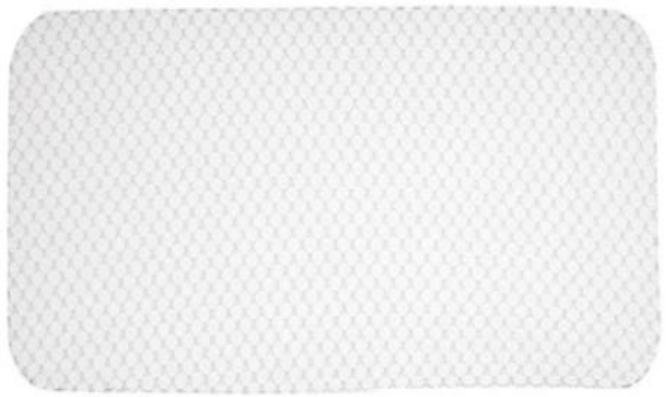
Lighter? Bigger pore?

Light-weight Polypropylene (PP)

SKU: 0117008 GTIN: 00801741030857

Bard™ Soft Mesh, Rectangle, 2 in x 4 in (5 cm x 10 cm)



Light-weight Polypropylene (PP)

Characteristics:

- ✓ Large pore (>1mm)
- ✓ Light weight
- ✓ Allow immune cell entry
- ✓ Reduce chronic postoperative inguinal pain (CPIP)

Heavy vs. Light-weight Polypropylene (PP)

JOURNAL ARTICLE

Systematic review and meta-analysis of the use of lightweight *versus* heavyweight mesh in open inguinal hernia repair Get access

Volume 99, Issue 1
January 2012

- ✓ **Data Source:** 9 RCTs; 2310 patients
- ✓ **Key Findings**
- ✓ **No Significant Difference:**
  1. Hernia recurrence rate
  2. Operative time & Time to return to work
  3. Acute postoperative pain
  4. Perioperative complications & Testicular atrophy
- ✓ **Significant Advantages of LWM:**
  1. Reduced Chronic Groin Pain
  2. Reduced Stiffness / Foreign Body Sensation

Heavy vs. Light-weight Polypropylene (PP)

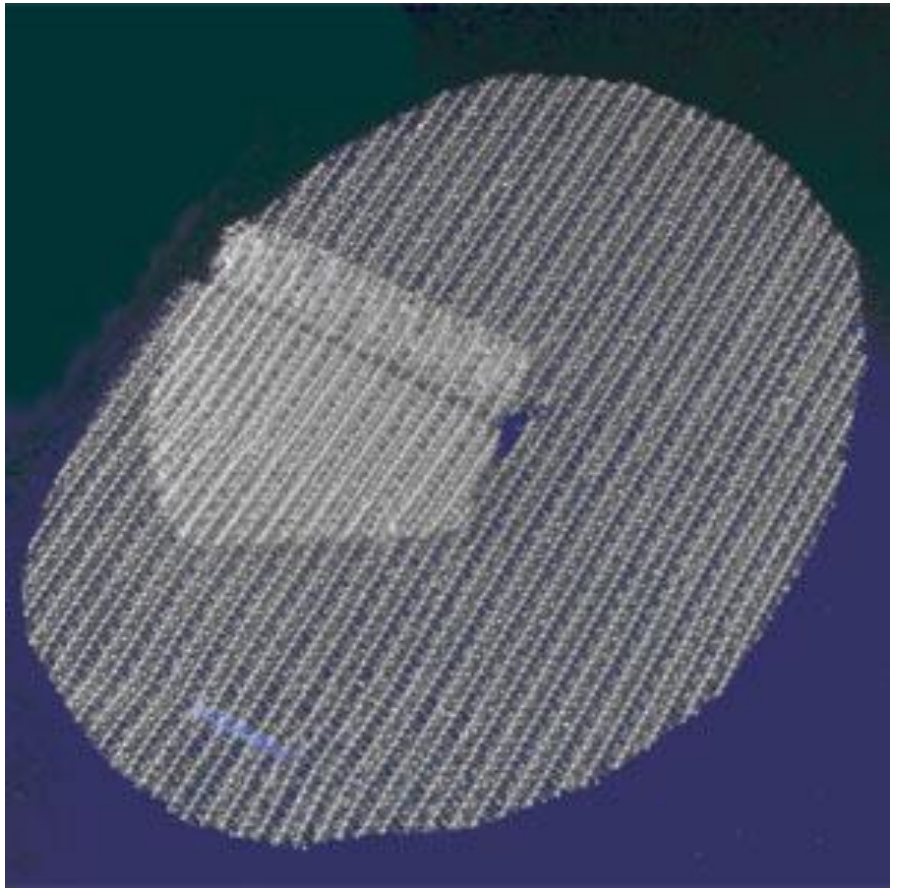
META ANALYSES

Heavyweight Mesh Is Superior to Lightweight Mesh in Laparo-endoscopic Inguinal Hernia Repair

A Meta-analysis and Trial Sequential Analysis of Randomized Controlled Trials

- ✓ **Data Source: 12 RCTs, 2909 patients**
- ✓ **Key Findings**
- ✓ **Pain & Sensation (Slight Benefit from LWM):**
  - ✓ **No significant difference in chronic pain (RR 0.79).**
  - ✓ **No significant difference in foreign-body sensation (RR 0.94).**
- ✓ **Recurrence (Higher Risk with LWM):**
  - ✓ **Overall Recurrence: Significantly higher in LWM group (RR 2.21; 95% CI 1.14–4.31).**
  - ✓ **High-Risk Subgroup: Direct hernias without fixation (RR 7.27).**

Polyester (PET)



Polyester (PET)

Characteristics:

- ✓ Hydrophilic
- ✓ Multi-filament → 容易藏細菌
- ✓ 組織快速長入
- ✓ 非常難移除

Expanded Polytetrafluoroethylene (ePTFE)

Characteristics:

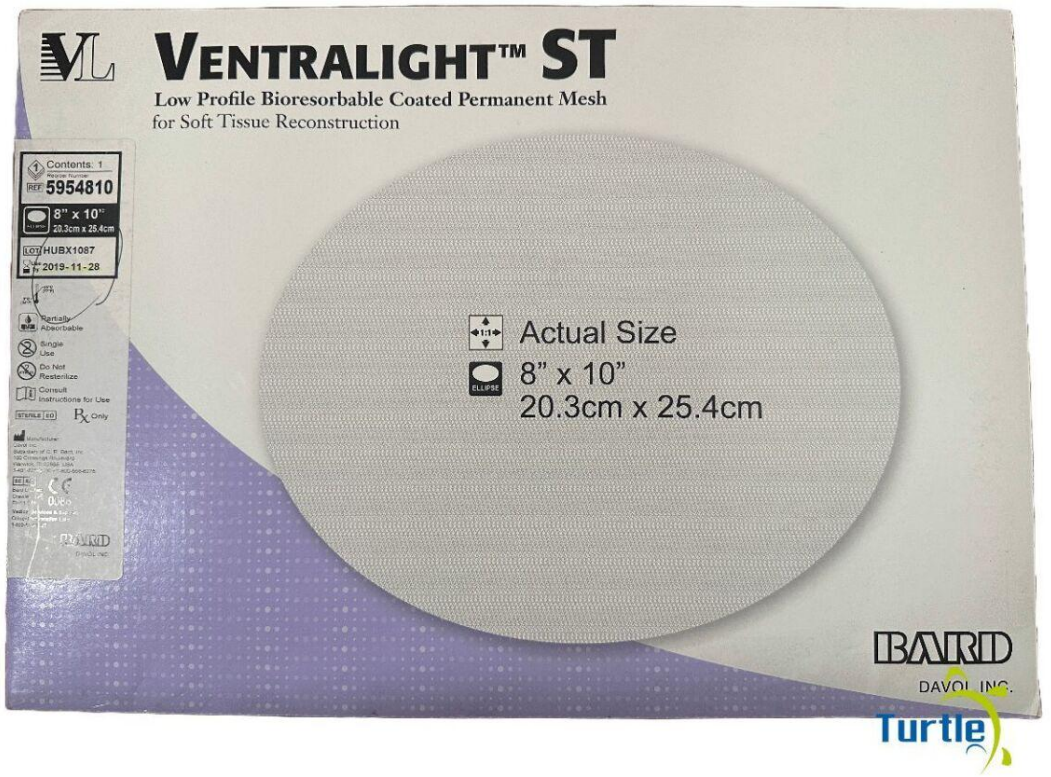
- ✓ Hydrophilic
- ✓ Micro pore → encapsulation
- ✓ 幾乎不引起組織沾黏
- ✓ 一旦感染，免疫細胞無法進入

Composite mesh

- ✓ Invented for intraperitoneal onlay mesh (IPOM)
- ✓ Parietal side: PP or PET
- ✓ Visceral side: absorbable barrier (collagen, cellulose, hydrogel)
- ✓ Physiomesh: 早期的composite mesh, 設計時因太過偏向防沾黏,因此組織整合能力低下, 造成復發率過高, 於2016全球下架

Composite mesh

PET + collagen

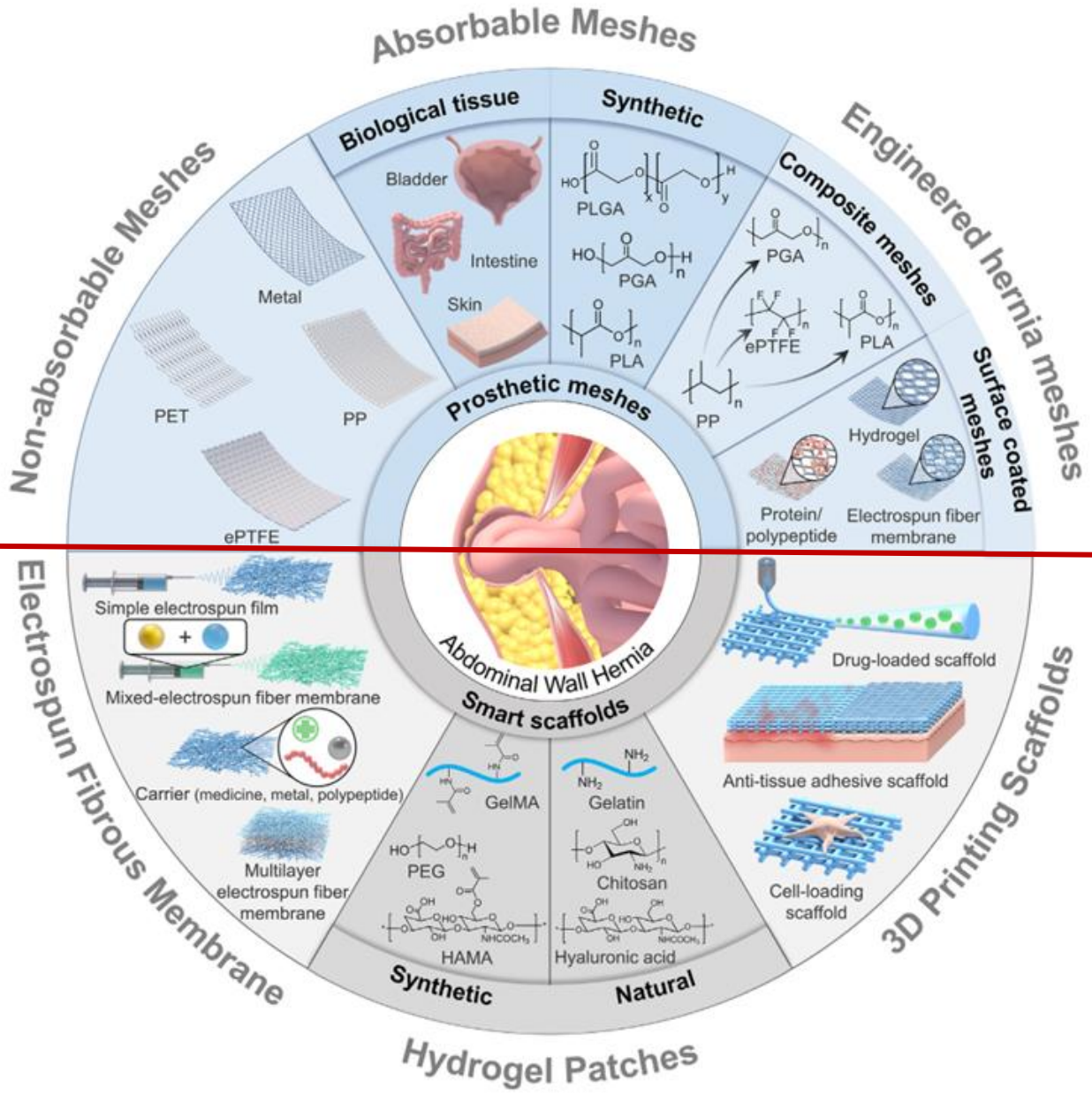


Light PP + hydrogel

Mesh materials: now and future

Current

Future



Biological mesh

Characteristics:

- ✓ Acellular Dermal Matrices (ADM) derived from human or animal
- ✓ Non-immunogenic collagen scaffold → Host tissue growth
- ✓ Very expensive

Non- cross linked	Cross-linking
Native collagen	Chemical cross-linking
Might be degradation by host	Less degradation
Rapid remodeling	Encapsulation
Infection resistance	Poor bacterial clearance
Less strength	More strength

Biological vs. Synthetic

▸ Cureus. 2025 Sep 17;17(9):e92557. doi: 10.7759/cureus.92557

Efficacy of Biological Versus Synthetic Mesh in Ventral Hernia Repair: A Systematic Review and Meta-Analysis of Long-Term Outcomes and Recurrence Rates

Cureus
Publishing Beyond Open Access

Hernia Recurrence (Primary Outcome):

- ✓ **Significantly HIGHER with Biological Mesh.**
- ✓ **Rate:** Biological **25.1%** vs. Synthetic **12.7%**.
- ✓ **Stats:** OR **2.30** (95% CI 1.15–4.53, p=0.01).

Safety & Complications:

- ✓ **Mesh Infection:** No significant difference (4.8% vs. 3.1%, p=0.65).
- ✓ **Reoperation Rate:** Higher in Biological group (16.9% vs. 10.4%), though statistical significance was inconsistent in the report.

Biosynthetic mesh (resorbable synthetic)

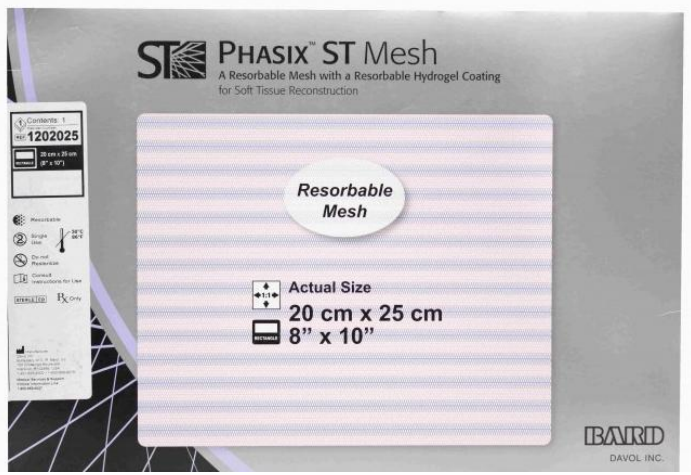
Characteristics:

- ✓ Absorb completely over a prolonged period (6-24 months)
- ✓ Providing strength before absorbed
- ✓ Leaved reinforced scar

Biosynthetic mesh (resorbable synthetic)

Poly-4-hydroxybutyrate (P4HB) - Phasix (BD)

- ✓ P4HB is derived from bacterial fermentation (E. coli K12)
- ✓ P4HB → 4-hydroxybutyrate
- ✓ No acidic microenvironment
- ✓ 5-year recurrence is 15.9% in high-risk patient (VHWG grade 3)
- ✓ Superior bacterial clearance in MRSA model



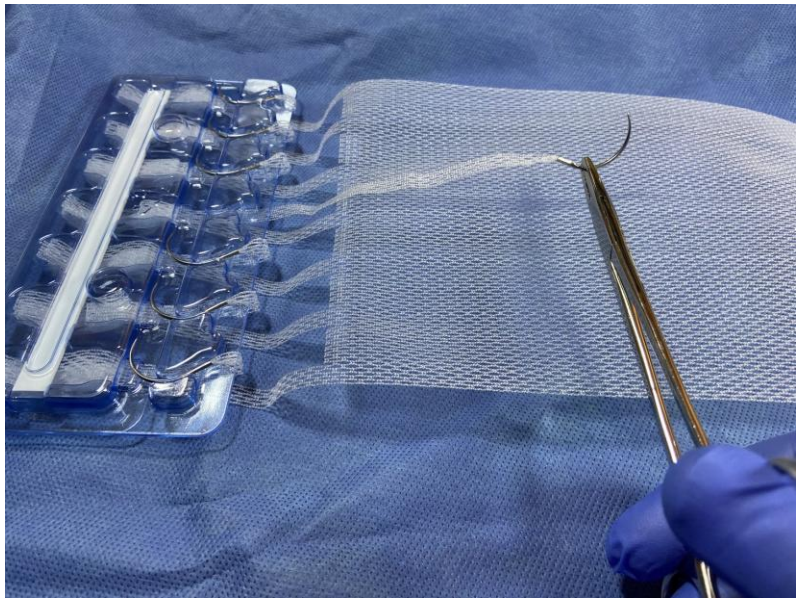
Biosynthetic mesh (resorbable synthetic)

OviTex (Tela Bio)

- ✓ Ovine Forestomach Matrix (95%) + polymer sutures (5%)
- ✓ Biologic ECM reduces inflammation
- ✓ Polymer grid provides reliable mechanics

Fixation solution

- ✓ Self-gripping mesh (ex: Progrip)
- ✓ 3D contoured (ex: 3DMax, Parietex 3D)
- ✓ Hernia staples / glues
- ✓ T-line mesh (Deep blue medical)



Future smart mesh

- ✓ Drug-eluting mesh: antibiotics, anesthetics
- ✓ Sensor mesh: strain or pH monitor
- ✓ 3D printing: patient-specific implants
- ✓ 4D printing: 3D + shape memory & self unlock
- ✓ Electrospun fibrous meshes

Clinical decision

CDC wound classification

Class I (clean)	Class II (clean-contaminated)	Class III (contaminated)	Class IV (dirty)

VHWG modified classification

Grade 1	Grade 2	Grade 3
No comorbidity No wound infection	Smoker Obese DM Immunosuppressed COPD	CDC class III/IV

Clinical decision

VHWG modified classification

Grade 1	Grade 2	Grade 3
No comorbidity No wound infection	Smoker Obese DM Immunosuppressed COPD	CDC class III/IV

Heavy synthetic

Light synthetic

Biosynthetic

Biologic

Summary

- ✓The "Dream Mesh" Remains Elusive
- ✓Synthetic Mesh Trade-offs
- ✓Biological Mesh Reality
- ✓The Biosynthetic Advantage
- ✓Future Directions