

PROSTHETIC MESHES IN INCISIONAL HERNIA REPAIR

Types, Properties, Selection and Complications

Teaching notes for MBBS undergraduate students

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1. Introduction

Incisional hernia complicates 10–20% of laparotomy wounds, and the figure rises to 30% or more in the presence of obesity, wound infection, malnutrition, chronic steroid use, diabetes, chronic cough or previous failed repair. The underlying defect is a failure of collagen maturation in the linea alba, so the tissue available for repair is intrinsically abnormal.

Primary suture (anatomical) repair carries a recurrence rate of 30–60%. Tension-free prosthetic reinforcement with mesh reduces this to roughly 5–15% and is therefore the standard of care for almost every incisional hernia. Mesh acts as a scaffold that provokes a controlled fibroblastic response; the resulting scar-plus-prosthesis composite bears the load instead of the weakened fascia.

The surgeon must therefore be able to answer three questions for every case: which material, which weight and pore size, and in which anatomical plane.

2. Properties of an Ideal Mesh

The classical criteria of Cumberland and Scales (1952), still quoted in Bailey & Love, state that a prosthesis should be:

- Chemically inert and not physically modified by tissue fluids
- Non-carcinogenic and non-allergenic; provoking no inflammatory or foreign-body reaction
- Resistant to mechanical strain, yet pliable enough to conform to the abdominal wall
- Capable of being sterilised without alteration
- Able to be cut and fashioned to the required shape

Modern additions to the list:

- Macroporous, to permit ingrowth of fibroblasts, capillaries and macrophages
- Resistant to infection and to biofilm formation
- Non-adhesiogenic on its visceral surface if it is to lie intraperitoneally
- Minimal shrinkage after implantation
- Compliant with the physiological elasticity of the abdominal wall (about 30% at 32 N/cm)
- Affordable and readily available

No single mesh satisfies all of these, which is why several classes remain in clinical use.

3. Classification of Meshes

Meshes may be classified along four independent axes. A given product is described by its position on all four — for example, Prolene is a non-absorbable, synthetic, heavyweight, macroporous monofilament mesh.

3.1 By material of origin

- **Synthetic non-absorbable** — polypropylene, polyester, ePTFE, PVDF. The workhorses of hernia surgery.
- **Synthetic absorbable** — polyglactin 910, polyglycolic acid, poly-4-hydroxybutyrate, glycolide-trimethylene carbonate copolymer. Provide temporary support only.
- **Biological (biologic)** — acellular collagen matrices of human, porcine or bovine origin.
- **Composite** — a non-absorbable parietal layer bonded to an anti-adhesive visceral layer.
- **Hybrid / biosynthetic** — permanent synthetic fibres combined with an absorbable or biological component.

3.2 By pore size (Amid classification, 1997)

Type	Pore characteristics	Examples	Clinical relevance
Type I	Totally macroporous; pores > 75 µm	Polypropylene (Prolene, Marlex)	Admits macrophages, fibroblasts, collagen and vessels — good incorporation, relatively infection-resistant
Type II	Totally microporous; pores < 10 µm	ePTFE (Gore-Tex)	Bacteria (~1 µm) enter but neutrophils (~15 µm) cannot — infection cannot be cleared; mesh usually needs removal
Type III	Macroporous with multifilament or microporous components	Polyester (Mersilene), braided polypropylene, PTFE mesh	Interstices harbour bacteria; higher infection risk than Type I
Type IV	Submicronic pores	Silastic, Cellgard, preclude sheets	Not used for reinforcement; used as adhesion barriers

Pore size is the single most important determinant of tissue integration and of behaviour in the face of infection. This is a favourite examination point.

3.3 By weight (density of polymer)

Category	Weight (g/m²)	Features
Heavyweight	> 80	Small pores, high tensile strength (far in excess of the 16 N/cm needed), dense scar plate, stiff abdominal wall, more chronic pain and 'mesh feel'
Midweight	50–80	Current compromise; most widely used today

Category	Weight (g/m ²)	Features
Lightweight	35–50	Large pores, less polymer, more elastic scar, less pain and better compliance; adequate strength when used in an intact plane with wide overlap
Ultralightweight	< 35	Very compliant; risk of central mesh fracture if used to bridge a large defect

Trend: reduced polymer load and larger pores give better long-term function without loss of durability, provided the mesh is placed in a well-vascularised plane with 4–5 cm overlap on all sides.

3.4 By filament structure

- **Monofilament** — single strand; no interstices for bacterial sequestration; stiffer. Preferred when contamination is possible.
- **Multifilament / braided** — softer and more pliable, but interstices < 10 µm shelter bacteria; higher infection and sinus formation rates.

4. Individual Meshes in Detail

4.1 Synthetic non-absorbable meshes

Polypropylene (Prolene, Marlex, Surgipro, Optilene)

- Monofilament, macroporous (Amid Type I), hydrophobic, knitted or woven.
- The most widely used prosthesis worldwide; cheap, strong, available in heavy, mid, light and ultralight forms.
- Excites a brisk fibroblastic response with excellent incorporation; the best behaviour of any synthetic in a contaminated field, and a superficial infection can often be salvaged with drainage and antibiotics.
- Shrinks by about 20–30% in the first few months — hence the need for generous overlap.
- Chief drawback: dense visceral adhesions and a risk of enterocutaneous fistula if placed in direct contact with bowel. Must not be used bare in the intraperitoneal position.
- Oxidative degradation over decades causes stiffening; heavyweight forms may be felt as a plate.

Polyester (Mersilene, Parietex, Dacron)

- Multifilament, hydrophilic polyethylene terephthalate; very pliable and conforms well to the abdominal wall, with rapid tissue ingrowth.
- Popular in Europe, particularly in the retromuscular Rives–Stoppa plane where it lies flat.
- Multifilament structure and hydrophilicity mean a higher rate of infection, chronic sinus and mesh-related bowel complications than polypropylene.
- Undergoes slow hydrolytic degradation with loss of tensile strength over years.
- Should be avoided in any potentially contaminated field.

Expanded polytetrafluoroethylene, ePTFE (Gore-Tex, DualMesh)

- A microporous sheet rather than a knitted mesh (Amid Type II); soft, inert and very smooth on its visceral surface.
- Provokes minimal adhesion formation, so it was the original choice for intraperitoneal placement.
- Poor fibrous incorporation — it is encapsulated rather than integrated, so it depends entirely on its fixation and is prone to central sagging and 'pseudo-recurrence'.
- Pore size excludes neutrophils: once infected, the mesh cannot be salvaged and must be explanted in almost every case.
- Expensive. Largely superseded by composite meshes.

Polyvinylidene fluoride, PVDF (DynaMesh)

- Monofilament fluoropolymer with lower bending stiffness and less oxidative degradation than polypropylene.
- Available as DynaMesh IPOM, in which a visceral PVDF surface is combined with a parietal polypropylene surface for intraperitoneal use.
- Promising long-term stability; evidence base still smaller than for polypropylene.

4.2 Synthetic absorbable meshes

These provide temporary reinforcement only; the abdominal wall is left with scar alone once the mesh has resorbed, so recurrence is the rule if they are used as a definitive repair.

Mesh	Polymer	Absorption time	Main use
Vicryl mesh	Polyglactin 910	2–3 months	Temporary abdominal wall closure, laparostomy, protection of bowel in the open abdomen, bridging in frankly infected fields
Dexon mesh	Polyglycolic acid	2–3 months	As above
Phasix	Poly-4-hydroxybutyrate	12–18 months	'Resorbable but load-bearing' — contaminated or high-risk fields where a permanent implant is undesirable
TIGR Matrix	Glycolide/lactide + trimethylene carbonate	About 36 months	Long-term resorbable reinforcement
Vicryl/Bio-A hybrid	Trimethylene carbonate + glycolide	6–7 months	Contaminated fields, reinforcement of primary closure

4.3 Composite and dual-surface meshes

Designed for intraperitoneal onlay (IPOM), especially laparoscopic repair, where one surface must integrate with the abdominal wall while the other must not adhere to viscera.

Product	Parietal side	Visceral (anti-adhesive) side
Proceed	Polypropylene	Oxidised regenerated cellulose (absorbs in ~4 weeks)
Sepramesh / Ventralight ST	Polypropylene	Sodium hyaluronate + carboxymethylcellulose hydrogel
Parietex Composite	Polyester	Absorbable collagen–polyethylene glycol–glycerol film
Composix / Bard Composite	Polypropylene	Permanent ePTFE layer
DynaMesh IPOM	Polypropylene	PVDF
C-Qur	Polypropylene	Omega-3 fatty acid (fish oil) coating

Note that most barriers are absorbable and protect the bowel only during the critical first 7–30 days, when adhesions form. They are expensive, and an incorrectly oriented composite mesh is a recognised cause of dense adhesions and fistula — always confirm orientation before fixation.

4.4 Biological meshes

Acellular collagen scaffolds from which all cells and antigens have been removed. They are gradually infiltrated by host fibroblasts and vessels, remodelled and eventually replaced by the patient's own collagen.

Product	Source	Cross-linked
AlloDerm, FlexHD	Human cadaveric dermis	No
Strattice	Porcine dermis	No
Permacol, CollaMend	Porcine dermis	Yes
Surgisis	Porcine small-intestinal submucosa	No
Veritas, Tutopatch, Peri-Guard	Bovine pericardium	No / Yes

Cross-linking resists collagenase and prolongs strength, but slows revascularisation and behaves more like a synthetic implant when infected. Non-cross-linked grafts incorporate faster and tolerate infection better, but stretch more.

Advantages:

- Best tolerance of contaminated and infected fields — can be used where synthetic mesh would have to be avoided.
- Safe in direct contact with bowel; minimal adhesions.
- Useful in children and in young patients where a growing or lifelong implant is a concern.
- Options in loss of domain, parastomal reconstruction, and following mesh explantation for infection.

Disadvantages:

- Very expensive — a major limitation in routine Indian practice.
- High rates of eventration, bulging and laxity, particularly when used to bridge rather than reinforce.
- Recurrence rates are not superior to synthetic mesh in clean fields; there is no indication for their routine use.
- Variable quality between batches and manufacturers.

5. Mesh Position and the Choice of Prosthesis

The plane of placement determines which mesh may be used, and is at least as important as the material itself.

Plane	Description	Suitable mesh	Comment
Onlay	Above the anterior rectus sheath, subcutaneous	Uncoated polypropylene or polyester	Technically easy; extensive subcutaneous dissection, high seroma and infection rates, higher recurrence
Inlay (bridging)	Sutured edge-to-edge into the defect	Any; often composite	Highest recurrence — no overlap. Should be avoided except when closure is impossible
Sublay — retrorectus (Rives–Stoppa)	Between rectus muscle and posterior sheath	Uncoated lightweight/midweight polypropylene or polyester	The gold standard for open repair; mesh compressed by intra-abdominal pressure, well vascularised, isolated from bowel and from skin
Preperitoneal	Between peritoneum and posterior sheath / transversalis	Uncoated mesh	Used in extended repairs and eTEP; peritoneum protects the viscera
Intraperitoneal onlay (IPOM)	Inside the peritoneal cavity against the parietes	Composite or dual-surface mesh only	Standard for laparoscopic repair; needs 4–5 cm overlap and transfascial or tacker fixation
Component separation ± mesh	Posterior (TAR) or anterior separation	Uncoated large-pore mesh	For loss of domain and large defects; allows fascial closure over the mesh

Whichever plane is chosen, the mesh must overlap the defect margin by at least 4–5 cm in all directions, and the fascial defect should be closed over or under the mesh whenever possible ('reinforcement' rather than 'bridging').

6. Selecting a Mesh in Practice

The Ventral Hernia Working Group grading of the operative field is a useful framework:

Grade	Field	Recommended prosthesis
Grade 1	Low risk, clean, no history of infection	Synthetic non-absorbable — lightweight or midweight polypropylene, retromuscular
Grade 2	Co-morbid (obesity, smoker, COPD, diabetes, immunosuppression)	Synthetic non-absorbable; optimise the patient first
Grade 3	Potentially contaminated — stoma present, violation of GI tract, previous wound infection	Monofilament macroporous polypropylene, long-term resorbable, or biological mesh
Grade 4	Infected — infected mesh, septic dehiscence, established fistula	Biological or absorbable mesh; often staged repair. Avoid permanent synthetic

Additional practical rules:

- Bare polypropylene or polyester must never be left in contact with bowel.
- In laparoscopic repair use only a composite/dual-surface mesh, oriented correctly.
- In a young woman planning pregnancy, prefer a retromuscular repair with a large-pore lightweight mesh.
- In a strangulated incisional hernia with bowel resection, either stage the repair, or use monofilament polypropylene in the retromuscular plane, or a biological prosthesis.
- Cost matters: heavyweight polypropylene remains the commonest choice in most Indian hospitals and gives good results when correctly placed.

7. Mesh-Related Complications

- **Seroma** — the commonest; related to dead space and to onlay placement. Usually managed conservatively; aspirate only if symptomatic or infected, using strict asepsis.
- **Surgical site / mesh infection** — 1–8%. Type I monofilament mesh can often be salvaged; ePTFE, multifilament polyester and cross-linked biologics usually require explantation. Presents as a chronic discharging sinus.
- **Adhesions, obstruction and enterocutaneous fistula** — from bare mesh or a malorientated composite in contact with bowel. The most feared late complication.
- **Shrinkage / contraction** — 20–30%; causes recurrence at the mesh margin if overlap was inadequate.
- **Chronic pain and stiffness** — 'mesh feel'; associated with heavyweight mesh, small pores, dense scar plate and tacker or transfascial fixation. Less with lightweight large-pore mesh.
- **Migration and erosion** — into bowel, bladder or through the skin; more with poorly fixed and with microporous meshes.
- **Mesh fracture / central failure** — ultralightweight mesh used to bridge a large defect.
- **Recurrence** — most often at the margin, from inadequate overlap, inadequate fixation, missed adjacent defects (Swiss-cheese hernia) or infection.

8. Key Points for Revision

- Mesh repair reduces recurrence of incisional hernia from 30–60% to 5–15%; suture repair alone is obsolete for all but the smallest defects.
- Cumberland and Scales criteria define the ideal prosthesis.
- Amid classification is based on pore size: Type I macroporous (polypropylene), Type II microporous (ePTFE), Type III mixed/multifilament (polyester), Type IV submicronic.
- Polypropylene is the standard mesh — cheap, macroporous, monofilament, well incorporated, relatively infection-tolerant, but adhesiogenic.
- ePTFE is non-adhesiogenic but poorly incorporated and must be removed if infected.
- Composite meshes (polypropylene plus an absorbable barrier) are mandatory for intraperitoneal and laparoscopic placement.
- Absorbable synthetics give temporary cover only; biological meshes are for contaminated and infected fields and are limited by cost and by bulging.
- Lightweight, large-pore mesh gives a more compliant abdominal wall with less chronic pain.
- Retromuscular (Rives–Stoppa) sublay placement with 4–5 cm overlap and closure of the defect is the gold standard.
- Commonest complication is seroma; most feared is mesh-related enteric fistula.

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