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BIOMECHANICAL PROPERTIES OF MESHES

Hypothesis / aims of study

Synthetic meshes are becoming more popular in incontinence and prolapse surgery. Previous studies have tested meshes to failure, which is non-physiological, and the effect of strain rate was not clearly defined and the elastic modulus was obtained at high stress levels.
The aims of this study are to assess the biomechanical properties of commonly used meshes in urogynaecological surgery.

Study design, materials and methods

Nine different types of meshes used in urogynaecological surgery were examined using uniaxial tensile tests. Each sample comprised a rectangle of mesh, the ends of which were gripped between flat steel plates and mounted on an Instron 8872 servo-hydraulic materials testing machine. A 250 newton dynamic load cell was used to measure the forces applied to the samples under tests to failure using ramp tests or when exposed to cyclical length change. The test length (distance between clamps) was standardised at 32mm for all samples.

Results

Tensile ramp loading to failure was conducted at an actuator displacement rate of 2 mm s^{-1}. Of the 9 mesh types, 6 tended to fail in a single catastrophic event (Atrium, IVS, Prolene, SPARC, TVT and Vypro II), whereas 3 (Dexon, Gynemesh and Vypro) tended to undergo multiple failure events prior to finally parting. Table 1 presents the mean load at which the first major failure event occurred (defined here as an abrupt $\geq$ 10% reduction in load) and the ultimate load achieved by each mesh type. The percent strains at which these events occurred are also given.
It is obvious that the strength and extensibility of the mesh designs differed considerably. Prolene was the strongest, at about five times the strength of Vypro II. IVS and Vypro were the least extensible mesh designs, only able to increase in length by about 50%, whereas TVT, Dexon and SPARC were able to withstand a doubling of their original length without failing.
Most mesh types exhibited curvilinear loading curves, in which the material stiffness started at relatively low levels, increased with increasing extension to finally become linear (relatively high stiffness). Prolene and IVS were the exceptions, with IVS displaying an initial, relatively high stiffness that gradually declined with further extension and Prolene had the same initial pattern, but changed to a high linear stiffness above about 50% of its failure strain.
Cyclical loading of mesh samples (20 $\pm$ 5 % strain, 1 Hz, 15 sinusoidal loading cycles) produced significant permanent deformation in all mesh designs. This non-recoverable extension ranged from about 8.5 % (SPARC) to 19 % strain (Dexon). At the levels of strain applied to the mesh samples the minimum loads experienced by the samples was broadly similar (range 0 – 3 N), whereas the peak loads varied markedly (Table 1). Hysteresis also varied considerably between materials, approaching 85% in Vypro II and as little as about 30% in IVS.

Interpretation of results

Previous examinations of full thickness anterior vaginal wall samples have demonstrated tensile strains of between 19 and 31% under applied stresses of 0.4 megapascals (a stress that all tissues could withstand (1). The results from tensile tests on these 9 meshes indicate that all are capable of such deformations without compromise. The stiffness profiles of some mesh types do, however, differ significantly from those for vaginal. As tested here, Atrium, IVS, Prolene and Vypro would appear to provide moderate to high levels of stress-shielding to repaired tissues. Dexon, TVT and Vypro II appear to be over compliant at low loads, with Gynemesh and SPARC having intermediate properties.

Table 1. Physical and mechanical properties of the nine mesh types studied.

Mesh Type	Mean Mesh Width (mm)	Load (N)		Strain (%)		Load at 25% strain (N)	Offset (mm)
		Ultimate	First Major Failure	Ultimate	First Major failure		
GYNEMESH	12.0	37.5±1.0	37.5±1.0	63.4±0.8	63.4±0.8	10.0	3.2
TVT	11.5	77.0±3.7	70.8±9.3	113.4±3.0	111.6±4.6	3.0	3.5
PROLENE	12.4	122.0±2.8	122.0±2.8	66.6±1.8	66.6±1.8	16.0	4.0
SPARC	10.9	66.8±6.7	66.8±6.7	135.3±7.2	135.3±7.2	4.1	2.7
VYPRO	14.2	100.0±1.4	81.7±2.9	74.1±2.3	57.2±2.3	25.0	5.0
DEXON	14.0	105.8±7.0	78.0±11.5	125.3±5.6	110.0±7.9	0.1	6.0
VYPRO II	12.2	24.5±1.0	24.5±1.0	81.3±5.4	81.3±5.4	0.7	4.0
ATRIUM	12.5	95.4±7.3	95.4±7.3	80.3±2.6	80.3±2.6	13.0	4.0
IVS	8.1	50.8±	50.8±	47.8±2.9	47.8±2.9	3.0	3.8

n= 4 for all tests

Concluding message

This paper provides further information on the mechanical properties of each of these 9 mesh designs. Further invivo studies are required to assess the effect of implanted meshes on biomechanical properties of tissues.

References

1. A new method to measure properties of plastic-viscoelastic connective tissue. Med Engin Phys 1998; 20(4): 308-314.