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BIOMECHANICAL PROPERTIES OF THREE DIFFERENT MESH TYPES: IMPLICATIONS FOR A NOVEL SURGICAL TECHNIQUE, THE PUBORECTALIS SLING.

<u>Hypothesis / aims of study</u>

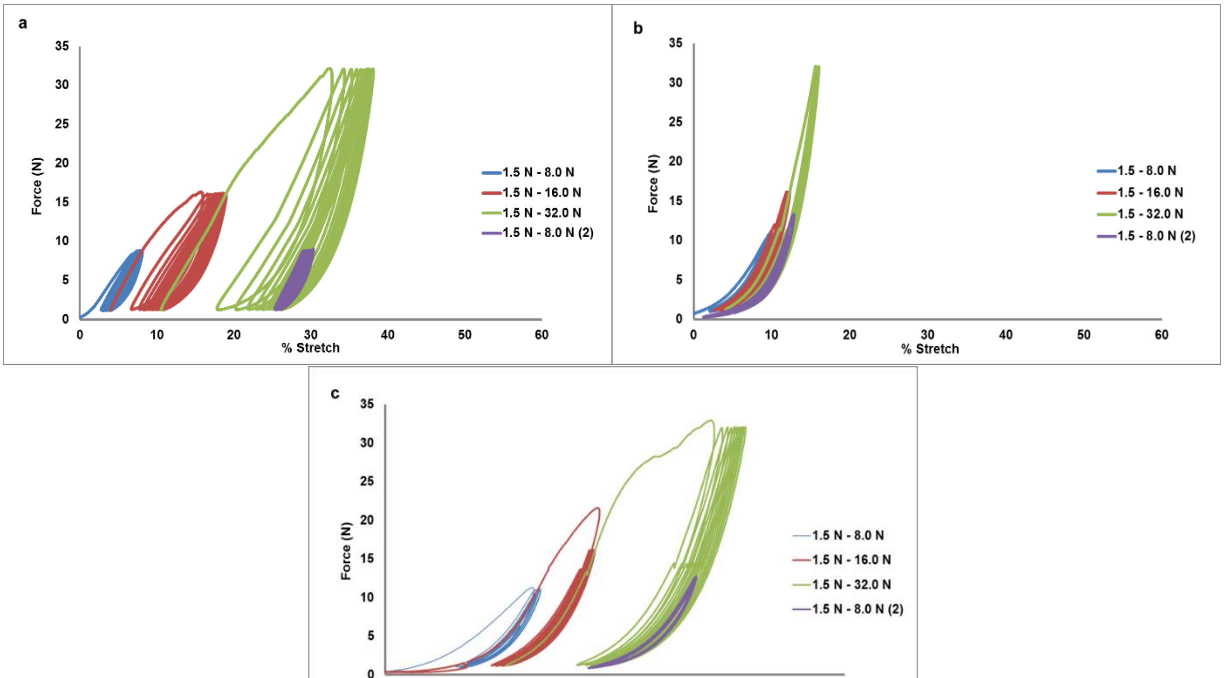
Female pelvic organ prolapse (FPOP) has been shown to be strongly associated with levator avulsion and excessive levator hiatal distensibility. A larger hiatus seems to be a risk factor for FPOP recurrence[1]. Thus, reducing the size of the levator hiatus may enhance success rates after FPOP surgery. A previous pilot study has shown that the levator hiatal area can be significantly reduced by using a strip of mesh placed around the levator hiatus known as a puborectalis (PR) sling [2]. The PR sling procedure involves placement of a mesh strip (50 mm width x 250 mm long, cut from a 150 mm x 150 mm piece of type 1 polypropylene mesh) through a post-anal tunnel developed following FPOP repair. The PR sling is then secured onto the periosteum of the inferior pubic rami with delayed absorbing sutures. The aim of this study was to compare the biomechanical properties of synthetic mesh (Prolene) and biological grafts, both cross-linked (Permacol) and non-cross-linked (Biodesign) to determine the optimal material for the PR sling surgery.

<u>Study design, materials and methods</u>

Six 20 mm by 40 mm samples of each mesh type were cut into a dog-bone shape and subjected to a series of uniaxial mechanical tests using an Instron™ 5800 in the following order: cyclic loading; creep; cyclic loading and failure test.
Cyclic Tests were performed to mimic the effects of repetitive sub-failure loading, similar to expected in vivo loads. Loads were calculated using Laplace's Law assuming that 16 N/cm is required to withstand the maximum intra-abdominal pressure[3]. Using this estimate, we calculated an equivalent maximum force of 32 N which would act on the 20 mm wide mesh samples. Each sample was preloaded to 1.5 N and cycled repetitively to 8 N, 16 N, 32 N and then back to 8 N, with 10 cycles at each level.
Creep tests were conducted to characterise the behaviour of each sample during prolonged loading. Each sample was subjected to 30 N at 1 N/s and held for 30 minutes. The samples were then released back to 0 N and held for 60 minutes.
Failure Tests: Each sample was stretched to failure at a loading rate of 1 mm/s. The relative stretch was expressed as the change in length as a percentage of the initial length of the mesh sample.

<u>Results</u>

Hysteresis was observed in all three mesh types, indicating the viscoelastic mechanical properties. The rightward shifts of the hysteresis loops indicated permanent plastic elongation of the mesh, or possibly long-term viscous creep, which was found to be force-dependent. The non-cross-linked Biodesign graft exhibited the greatest stretch (30 %) whereas the relative stretch for the synthetic Prolene and cross-linked Permacol were only 26 % and 7 %, respectively. (Figure 1).
The time-dependent creep responses of the three mesh types are shown in Figure 2. Biodesign was the most compliant mesh with the largest permanent stretch of 52 %, which was 3.2 and 1.1 times larger than the Permacol and Prolene samples, respectively. Permacol exhibited the stiffest response with the lowest maximum permanent stretch of 16 % and 12 %, respectively.
All three samples exhibited nonlinear tensile mechanical properties during the failure tests. The failure stretch values were similar for the Prolene and Biodesign samples, but the failure force for Prolene (174 N) was 2.9 times higher than Biodesign (60 N). Permacol exhibited the highest failure force (229 N) and the smallest failure stretch (0.32), which was 2.3 times smaller than the Prolene and Biodesign.



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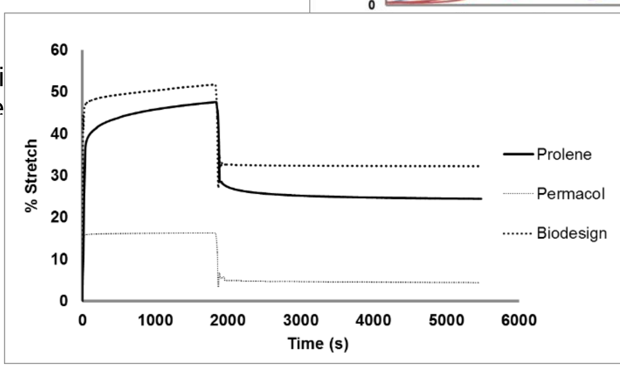

Figure 2 Stretch vs. time for Prolene, Permacol and Biodesign mesh samples

Mesh Type	Failure force (N)	% stretch at failure
Prolene	174.13	0.74
Permacol	228.60	0.32
Biodesign	59.63	0.73

Table 1 Force and stretch at failure for Prolene, Permacol and Biodesign mesh

Interpretation of results

The right-shifted hysteresis loops observed during the cyclic tests revealed the viscoelastic properties and sustained elongation in all three mesh types. Irreversible deformations such as these would indicate the susceptibility of mesh to elongation and thus potential movement from its intended position, which could compromise the reinforcing function of the implants. Of the three mesh types, it was noted that the non-cross-linked Biodesign graft had the most compliant mechanical response with the greatest degree of permanent stretch, whereas the cross-linked Permacol mesh exhibited a significantly lower amount of permanent deformation. Permacol had the stiffest response with the highest failure force and lowest failure stretch, which might provide strong mechanical support of the native tissues. On the other hand, the highly compliant Biodesign mesh may fail to support the anatomical structures due to the significant permanent stretch and relatively low failure force. For the PR sling surgery, a stiffer graft may provide a sustained reduction in the levator hiatal area, and thus a reduction in FPOP recurrence.

Concluding message

This study characterised and compared the ex vivo mechanical behaviour of Prolene, Permacol and Biodesign materials, three potential candidates for use in surgery designed to restrict levator hiatal distensibility. Permacol exhibited the highest stiffness, the least permanent deformation and the highest loads to failure, making it potentially most suitable for hiatal reduction surgery. However, in vivo tissue incorporation is likely to alter mechanical properties over time, especially for biological implants.

References

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Disclosures

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