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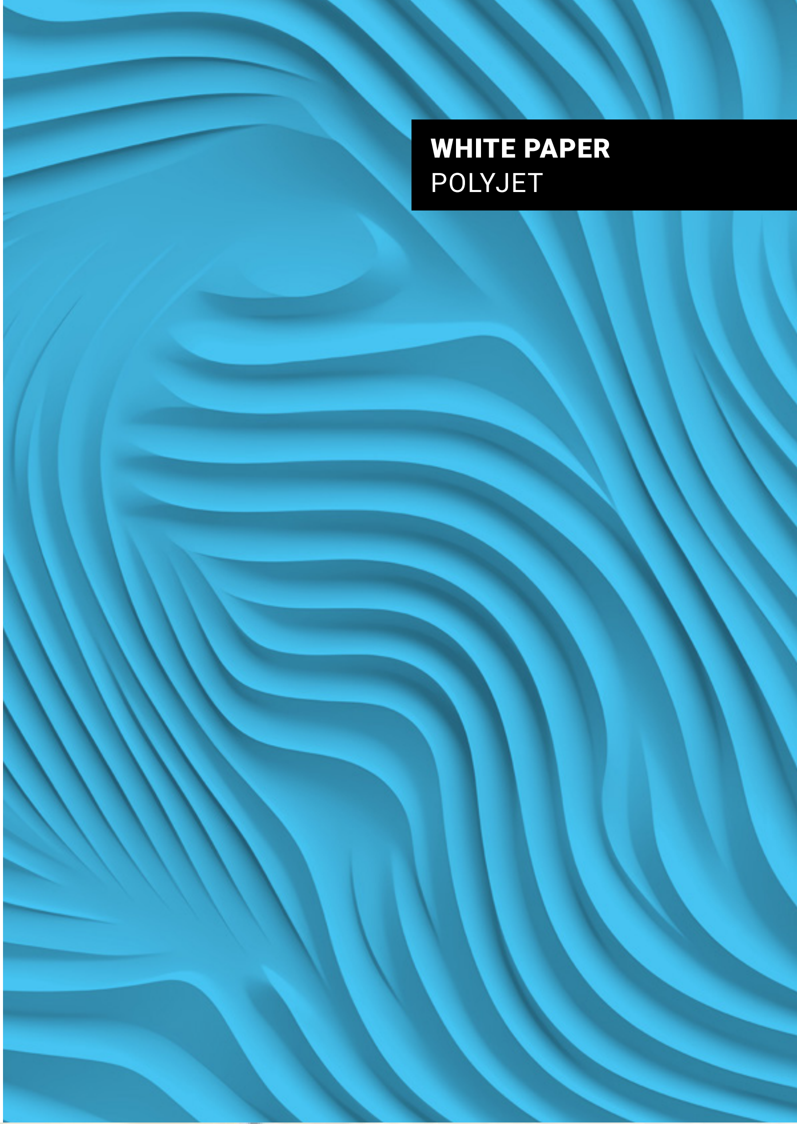
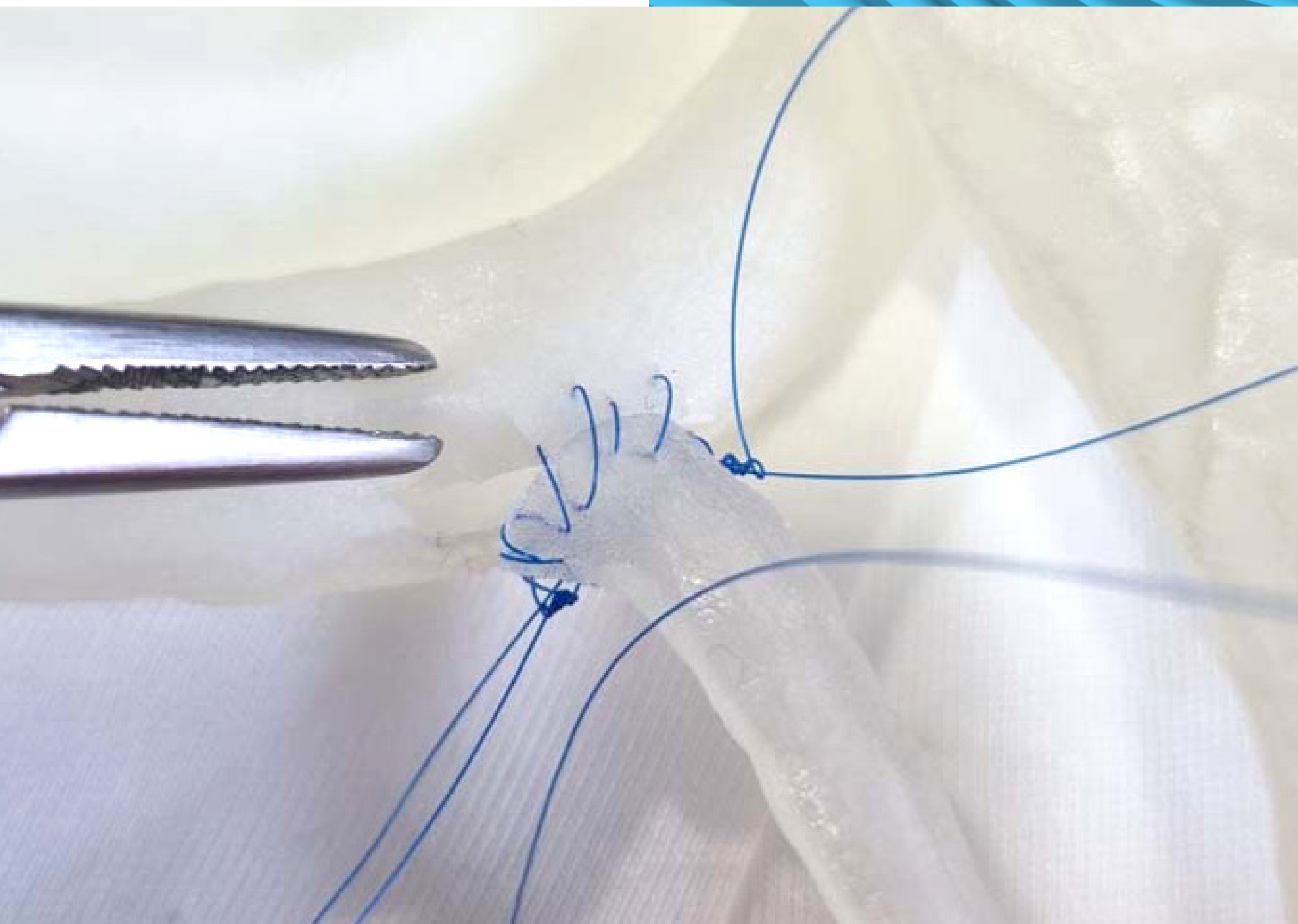


Biomechanical Tests Confirm the Potential for 3D Printing Suturable Vascular Models with the Stratasys Digital Anatomy Printer



Biomechanical Tests Confirm the Potential for 3D Printing Suturable Vascular Models with the Stratasys Digital Anatomy™ Printer

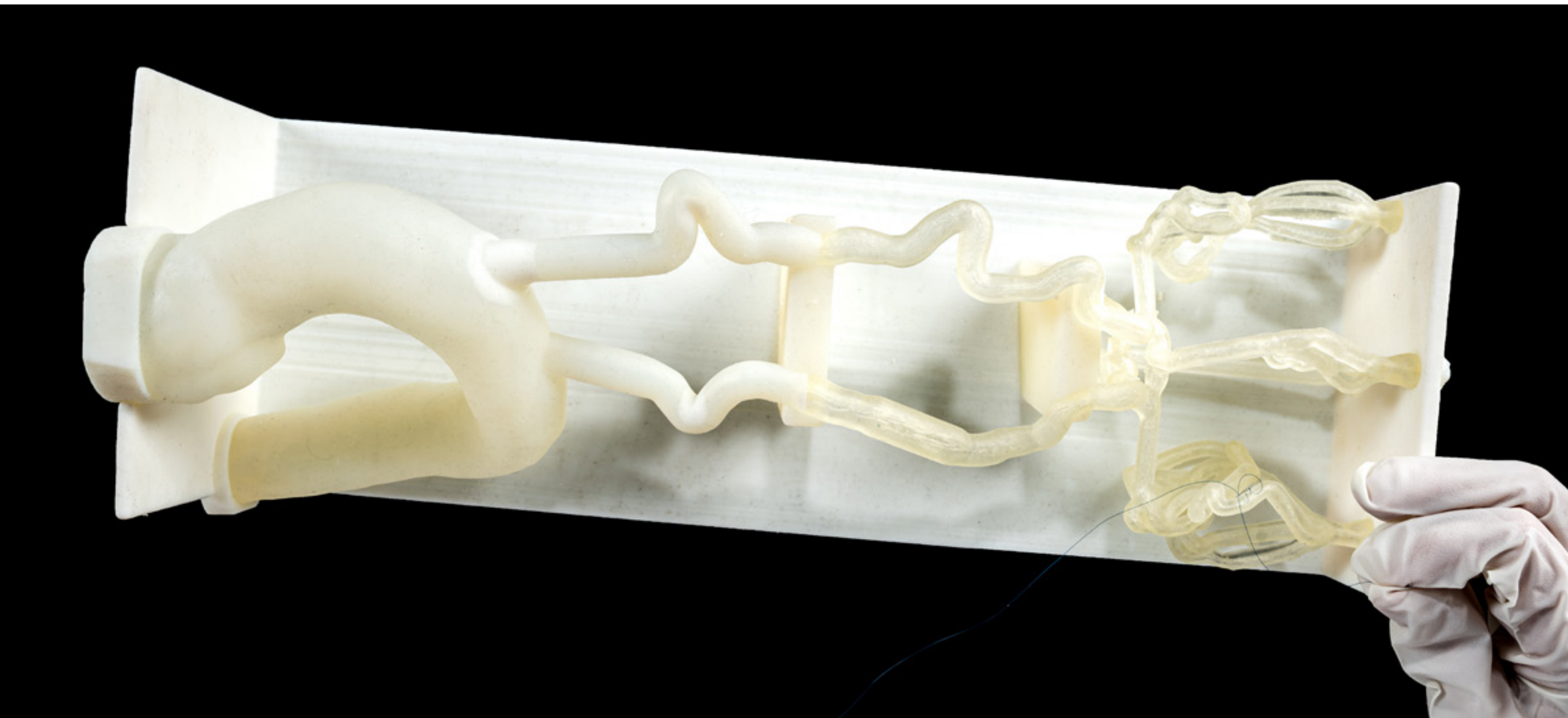
To create the most realistic, patient-specific simulation for surgical training, vascular models must mimic how native tissue responds to pressure, punctures, and stitches. Experiencing the behavior of biological blood vessels during anastomosis is a crucial part of preparing surgeons to treat patients safely and confidently, and materials must be chosen carefully to produce the most accurate anatomical models.

In 2021, researchers at the University of Pavia in Pavia, Italy evaluated the performance of blood vessel models printed on the Digital Anatomy Printer, comparing different material combinations to porcine tissue samples. Their research resulted in a new printing preset for suturable vascular models that mimics vessels' mechanical response during suturing.

In 2024, the same tests to create suturable vascular models were replicated using the J5 Digital Anatomy printer.

Method

In order to create the material mixture for blood vessel suturability, the researchers printed 37 different presets. Mechanical tests were performed to validate the compliance of the 3D printed models compared to fresh porcine tissue samples including single stich, puncture, tensile and suturing. The single stitch test is shown in Figure 1 and the tensile test is shown in Figure 2. Researchers thoroughly tested these combinations by performing 10 repetitions for each material and mechanical test type. Of the 37 samples, 6 showed the most accurate results compared to the real porcine tissue.



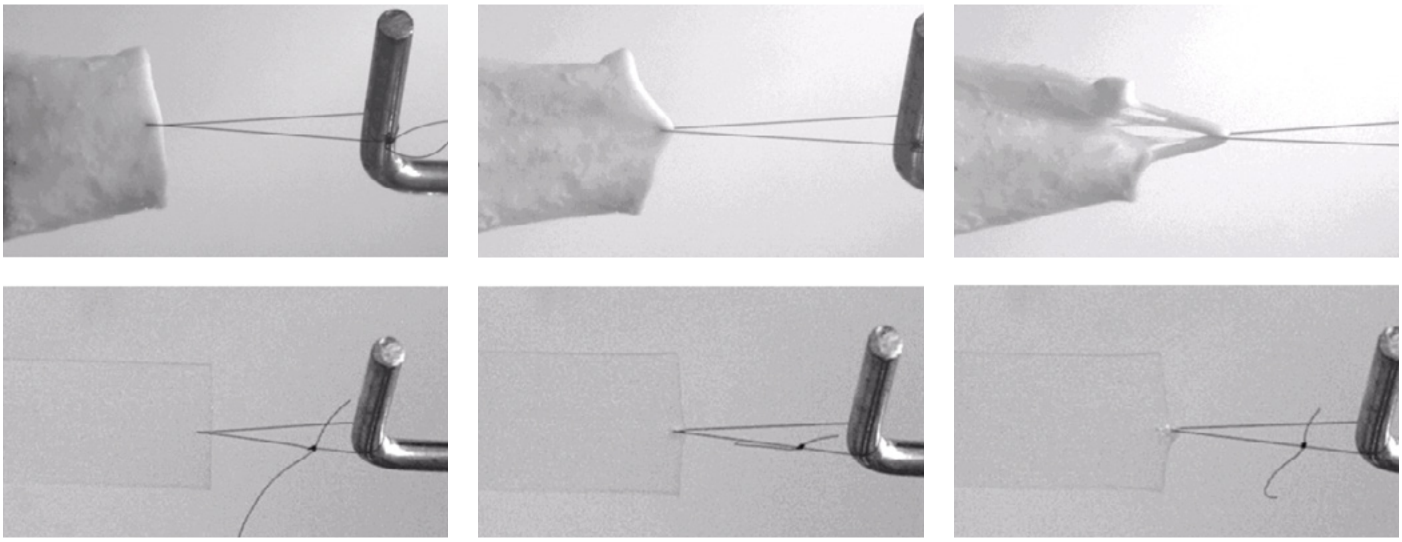


Figure 1: Comparison between single stitch mechanical tests performed on porcine aorta (up) and on a 3DP material (down).

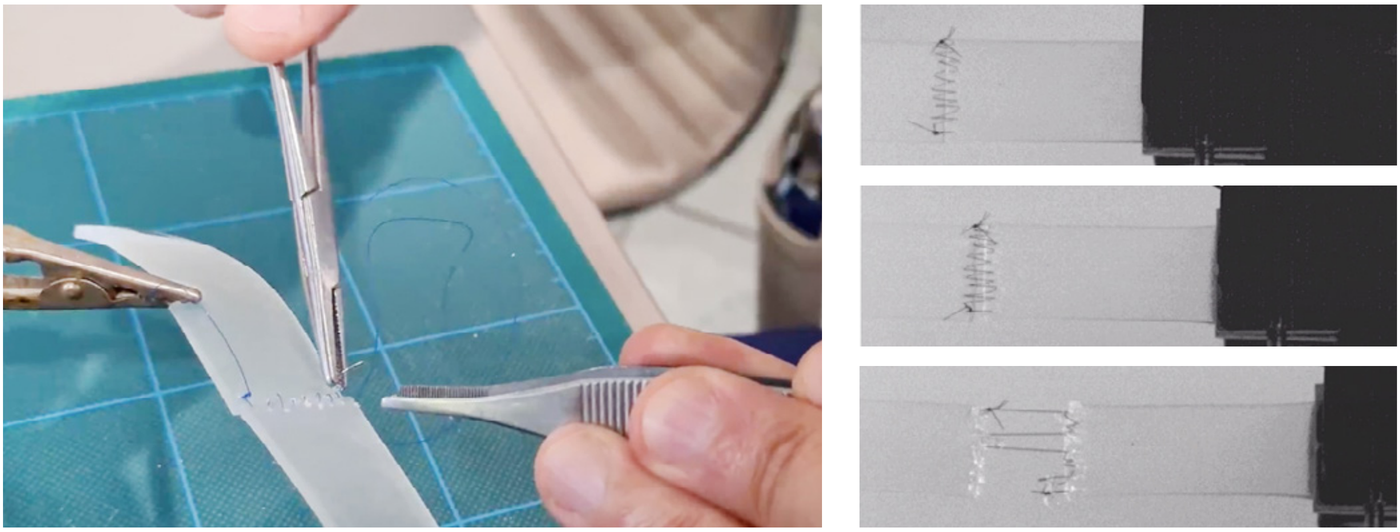


Figure 2: Uniaxial tensile test performed on a 3D printed sample sutured by an expert surgeon in order to mimic the surgical suture on a medium caliper arterial vessel

The Results

The following table (Figure 3) presents the selected material in comparison to porcine tissue in the different tests – puncture and single stich.

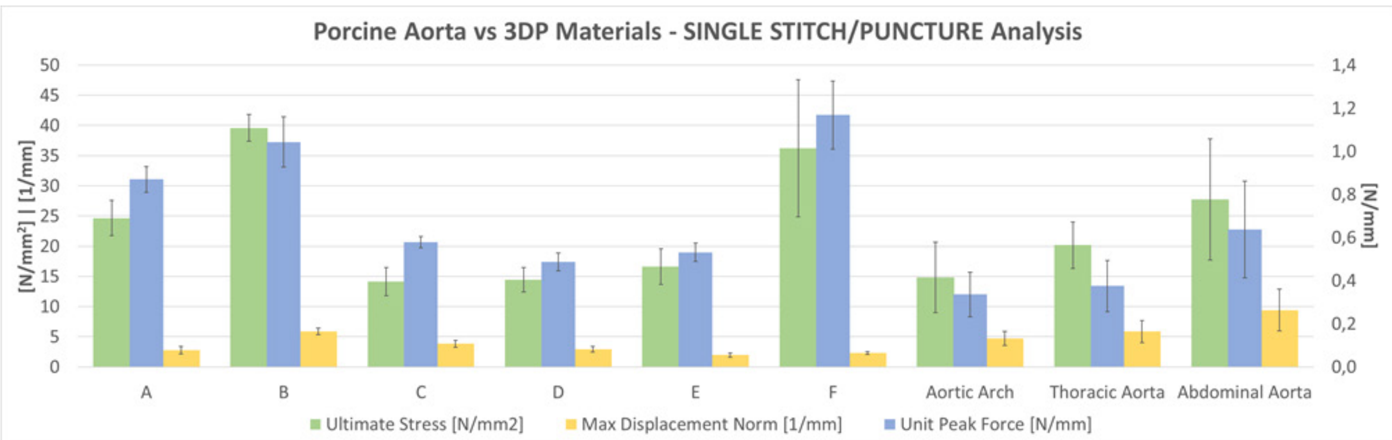


Figure 3: Overall results of puncture and single stich tests on the pool of 6 selected materials compared with porcine aorta tracts (namely aortic arch, thoracic aorta and abdominal aorta).

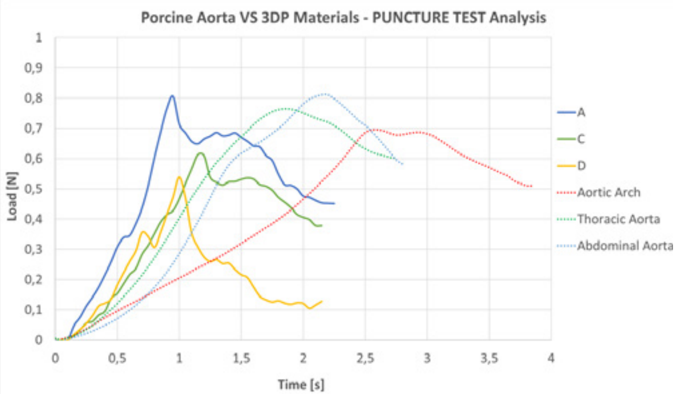


Figure 4: load-time curves acquired during puncture tests: Comparison between 3DP materials and different porcine aorta tracts on one representative curve per material (not normalized)

Materials	Thickness [mm]	#Samples	Puncture Tests Unit Peak Force [N/mm]
A	1	5	0,87 ± 0,06
C	1	4	0,58 ± 0,03
D	1	5	0,49 ± 0,04
AORTIC ARCH	2,2 ± 0,26	2	0,34 ± 0,10
THORACIC AORTA	2,18 ± 0,19	3	0,38 ± 0,12
ABDOMINAL AORTA	1,46 ± 0,19	3	0,64 ± 0,22

Table 1: Normalized puncture tests' results: comparison between 3DP materials and different porcine aorta tracts

Figure 4 above represents the load-time curves, in which values are not normalized according to the sample thickness. Table 1 shows the normalized values for the same test.

The values measured demonstrate repeatable results between the 3D printed models, while in the tissue samples, the standard deviation is much higher. The selected presets accurately resemble the measured values from the porcine vessels.

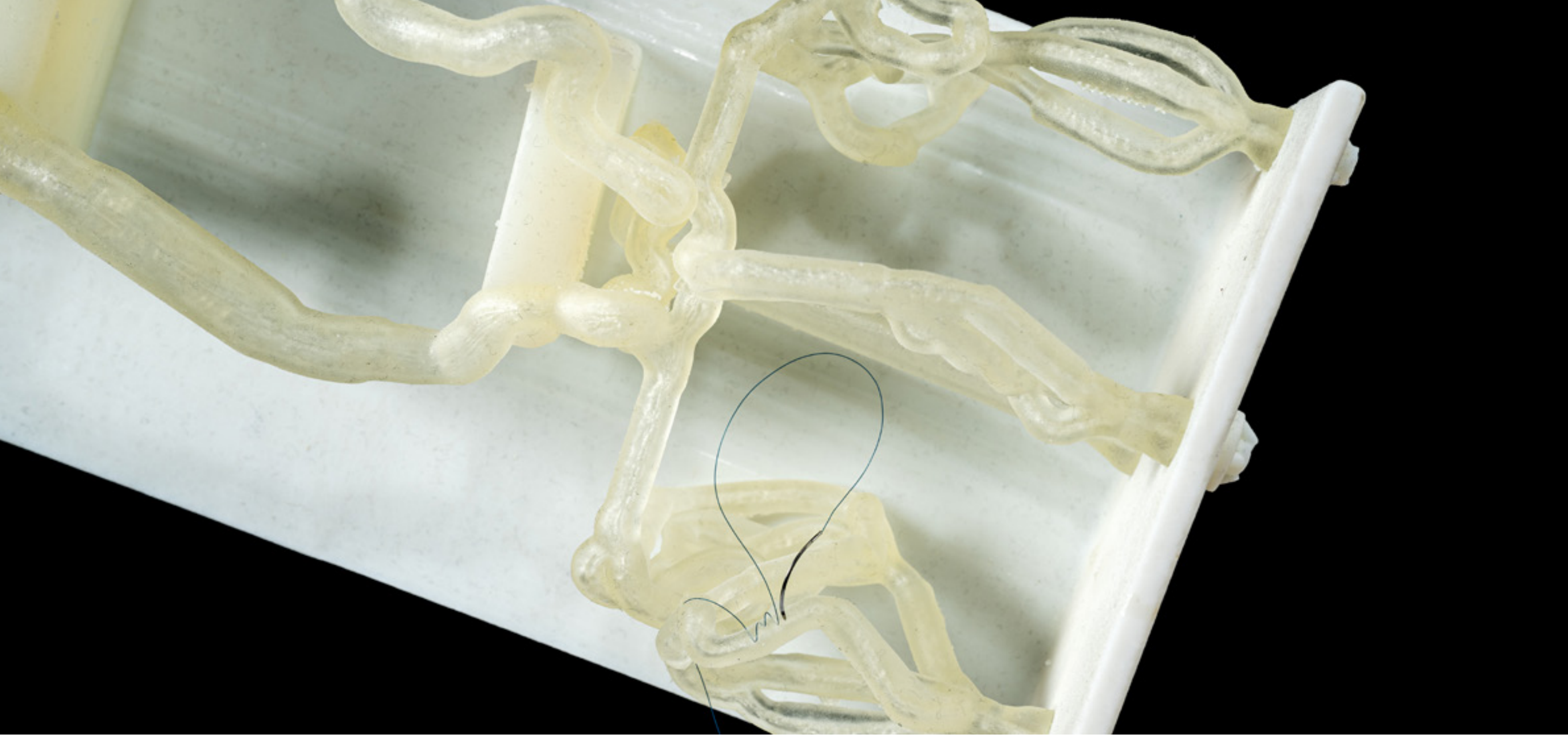
Two material combinations were identified as the most promising solutions for simulating and practicing surgical techniques on blood vessels. These materials could simulate the flexibility and softness of both minor and thicker vessels.

To evaluate the samples printed with J5 Digital Anatomy printer, researchers used the same testing methods and replicated the experiment. The results were compared to the previous J750 Digital Anatomy samples and to live porcine tissue.

		Unit Peak Fource [1/N]		**Ultimate Stress [N/mm2]**		**Max Displacements [1/mm]**	
	Number of samples	**Mean**	**STD**	**Mean**	**STD**	**Mean**	**STD**
High Strength vessel 2021 | J750 Digital Anatomy	10	0,87	0,87	24,64	2,92	3,69	0,99
High Strength vessel 2024 | J5 Digital Anatomy	10	0,88	0,88	27,26	3,67	6,26	1,22
Medium Strength vessel 2021 | J750 Digital Anatomy	10	10	10	0,03	14,15	2,35	6,43
Medium Strength vessel 2024 | J5 Digital Anatomy	10	10	10	0,04	15,44	2,10	9,82
Aortic ARCH	4	0,34	0,34	11,14	6,68	4,80	0,84
THORACIC Aorta	6	0,38	0,38	19,65	4,33	5,77	1,95
ABNOMINAL Aorta	5	0,64	0,64	33,79	13,63	7,94	1,91

Table 2: Overall results of single stitch traction and puncture tests on the Clear High and Medium Strength Suture Preset samples in the various tests, compared to biological reference values.

Table 2 shows the presets printed on the J5 Digital Anatomy Printer. Replacing Agilus30Clear with ElasticoClear follow the same trend as the previous presets, and the values are still comparable with the biological reference.



The Conclusion

Suturable vessel wall 3D models printed with the Stratasys Digital Anatomy Printer can provide surgeons and researchers biomechanically accurate blood vessel models for realistic treatment planning and training. Stratasys developed new software presets based on this research allowing clinicians to control the range of thickness and flexibility to mimic disease states and variations of human blood vessels on medical 3D printed models.

Unlock the power to simulate suturable blood vessels.

- Highly-realistic, low-risk training
- High repeatability between samples
- Physiological response of native vascular tissue
- Standardize surgical skills and delivery of care
- Tested material combinations create realistic models

View the complete study findings at the following link: **Quantitative Assessment of 3D Printed Blood Vessels Produced with J750™ Digital Anatomy™ for Suture Simulation**

Learn more about the Digital Anatomy™ Printer, materials and software at **https://www.stratasys.com/3d-printers/j750-digital-anatomy.**

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