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OPTIMISATION DE PIÈCES EN FABRICATION ADDITIVE

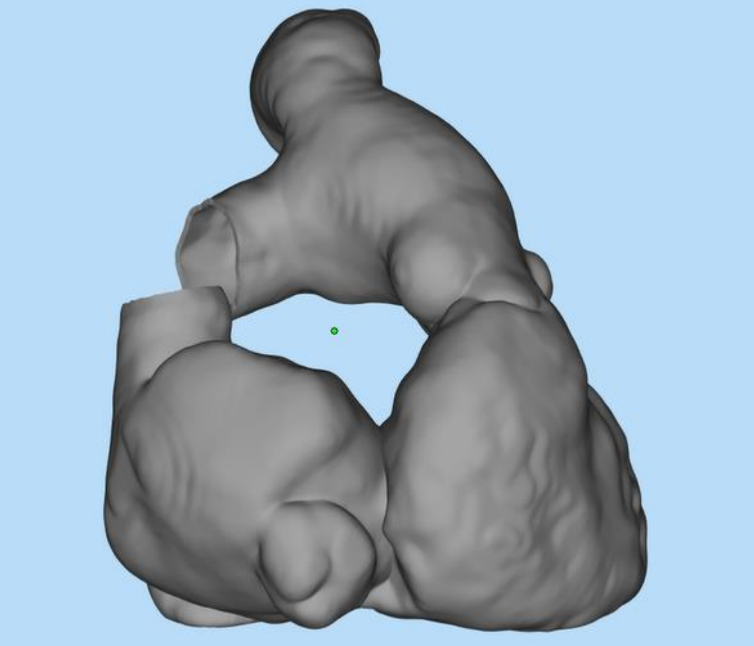
RÉALISATION DE SIMULATEURS CARDIAQUES PAR FABRICATION ADDITIVE

VLAD CIOBOTARU
MARCOS BATISTELLA

- Le médical est l'un des domaines d'application de la FA, et notamment du SLS, qui permet d'imprimer des implants, des prothèses et des modèles cardiaques, par exemple ;

- La société nîmoise 3D Heart Modeling développe des simulateurs des cœurs de patients pour préparer des opérations ;

- Dans le cadre du projet, différents modèles imprimés seront analyses en recherchant les paramètres de processus les plus adaptés pour l'objectif final.



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3D HEART MODELING

INTRODUCTION

- Développer des matériaux adaptés aux besoin des simulations mimant les propriétés mécaniques mais aussi les propriétés ultrasoniques (échographiques) ou en rayons X

- Développer des systèmes de simulateur cardiaques immergés dans des flux

- Conceptualiser l'intégration du 3D printing ou 3D Modeling dans la chaine décisionnelles et de planning procédural (Workflow)

ESC European Society of Cardiology
European Heart Journal (2018) 39, 1246–1254
doi:10.1093/eurheartj/ehx016
REVIEW

Translational medicine

Medical three-dimensional printing opens up new opportunities in cardiology and cardiac surgery

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Advanced percutaneous and surgical procedures in structural and congenital heart disease require precise pre-procedural planning and continuous quality control. Although current imaging modalities and post-processing software assists with peri-procedural guidance, their capabilities for spatial conceptualization remain limited in two- and three-dimensional representations. In contrast, 3D printing offers not only improved visualization for procedural planning, but provides substantial information on the accuracy of surgical reconstruction and device implantations. Peri-procedural 3D printing has the potential to set standards of quality assurance and individualized healthcare in cardiovascular medicine and surgery. Nowadays, a variety of clinical applications are available showing how accurate 3D computer reformatting and physical 3D printouts of native anatomy, embedded pathology, and implants are and how they may assist in the development of innovative therapies. Accurate imaging of pathology including target region for intervention, its anatomic features and spatial relation to the surrounding structures is critical for selecting optimal approach and evaluation of procedural results. This review describes clinical applications of 3D printing, outlines current limitations, and highlights future implications for quality control, advanced medical education and training.

Keywords 3D printing • Structural heart disease • Congenital heart disease • Cardiac surgery • Interventional

improved visualization for procedural planning, but provides substantial information on the accuracy of surgical reconstruction and device implantations. Peri-procedural 3D printing has the potential to set standards of quality assurance and individualized healthcare in cardiovascu-

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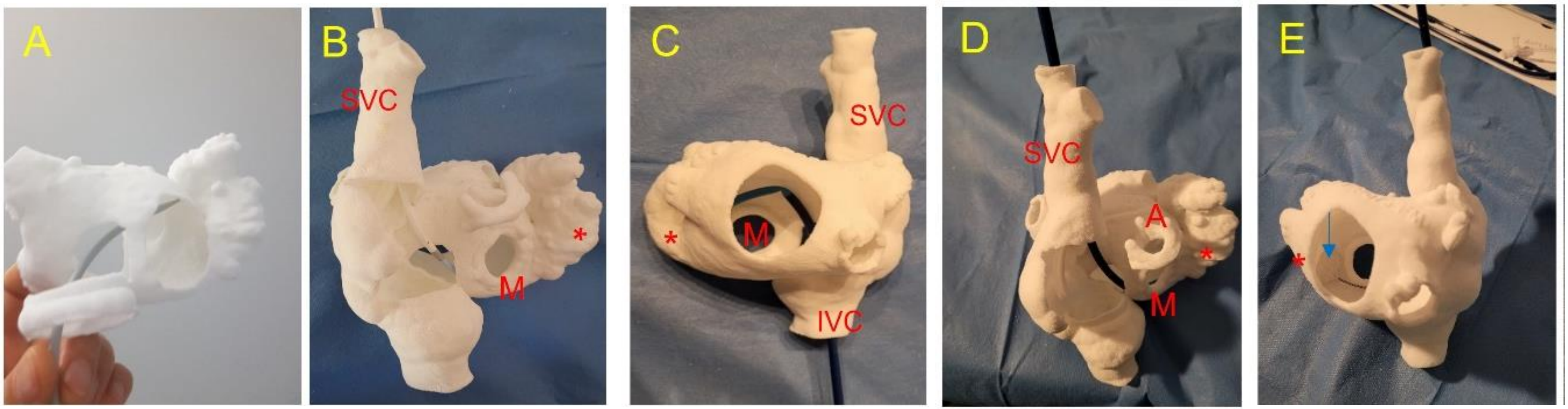
3D HEART MODELING



Left Atrial Appendage Closure Using a Tailored Trans-Jugular Approach

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3D HEART MODELING

CARDIOVASCULAR FLASHLIGHT

doi:10.1093/eurheartj/ehaa292

Multimodality fusion imaging to guide percutaneous sinus venosus atrial septal defect closure

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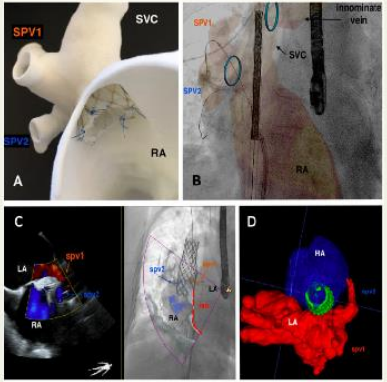
A 76-year-old woman with NYHA-WHO III dyspnoea was referred for chronic thrombo-embolic pulmonary hypertension. A sinus venosus atrial septal defect (ASD) with partial anomalous pulmonary vein return (PAPVR) was also diagnosed. Preoperative cardiac computed tomography (CT) was used to build an STL model to assess the feasibility of the recently developed percutaneous ASD closure technique. We created a printed 3D cardiac model to simulate stenting of the superior vena cava that would close the defect and redirect the PAPVR to the left atrium (*Panel A*).

During the procedure, the STL model extracted from CT data was merged with fluoroscopy. This fusion modality was useful for continuously checking the position of the innominate vein and PAPVR during the ballooning test and stent deployment (*Panel B*, Supplementary material online, *Videos S1–S3*). Another fusion procedure was conducted to combine real-time 3D transoesophageal echocardiography (TOE) and fluoroscopy. This fusion modality was particularly useful for monitoring PAPVR flow in colour Doppler on the fluoroscopy screen during stent deployment. Indeed, avoiding obstruction of the redirection pathway to the left atrium was the main concern (*Panel C*, Supplementary material online, *Videos S4 and S5*). The procedure was successful. The absence of residual leakage or pulmonary vein obstruction was confirmed by CT and 3D STL modelling (*Panel D*) before discharge. In this challenging case, multimodality and fusion imaging improved real-time 3D understanding and guidance of a complex percutaneous treatment for congenital heart disease.



(*Panel A*) Front view of the printed model: covered stent positioned within the superior vena cava, simulating the procedure (3dheartmodeling.com®). (*Panel B*) Front view of the CT scan and fluoroscopy fusion between during stent positioning, using Vesselnavigator® software (Philips Healthcare, Andover, UK). Blue circles are positioned on the CT scan view at the opening of the pulmonary veins into the superior vena cava and at the junction between the innominate vein and superior vena cava. (*Panel C*) View of the fusion between transoesophageal echocardiography (TOE) and fluoroscopy after stent deployment, using 3D echonavigator® software (Philips

2020

Premier cas en France

de traitement percutané de pathologie complexe

grâce à la simulation sur un model 3D print SLS TPU

3DHeartModeling- IMT Nîmes-Ales

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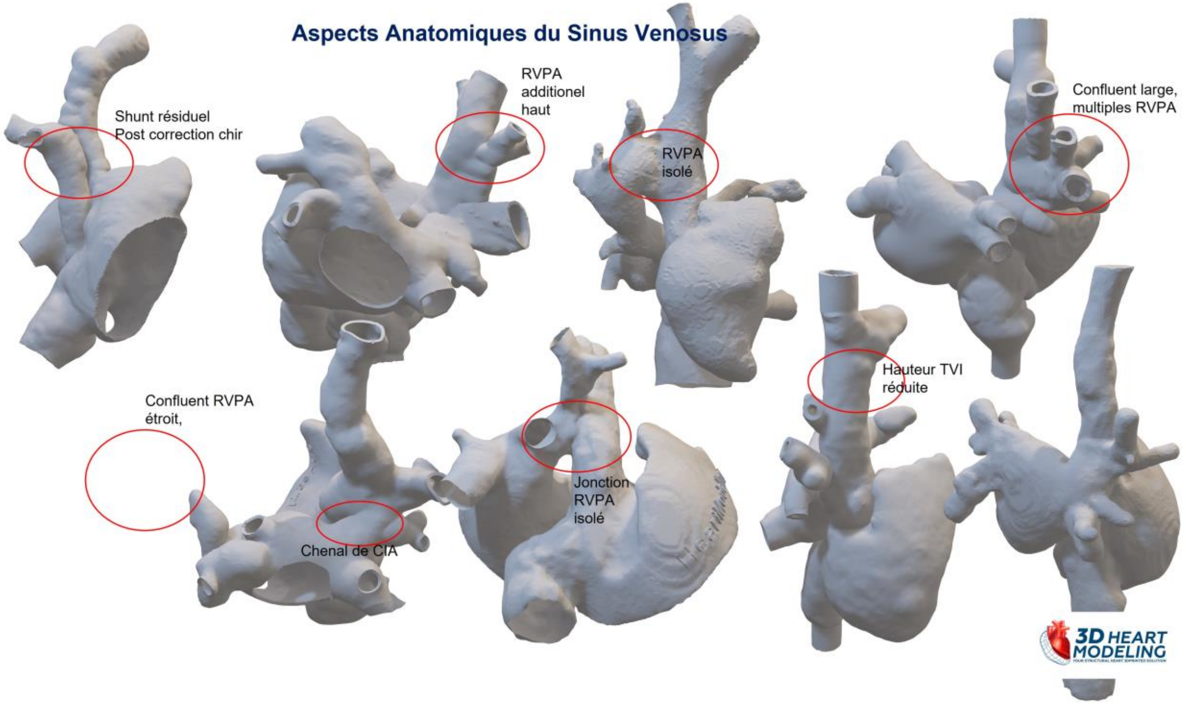
3D HEART MODELING

ASPECTS ANATOMIQUES

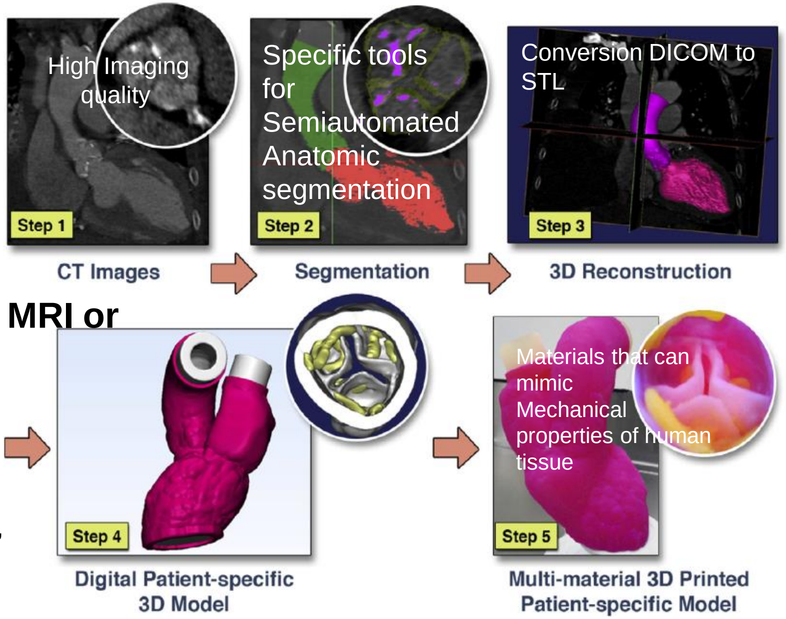


RÉALISATION DE MODÈLES PAR FABRICATION ADDITIVE

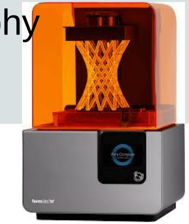
Signal intensity
Contrast
Spatial resolution

MRI or

Off-Line Workstation
STL modelling : smoothing, extraction, shell, layers, cutting

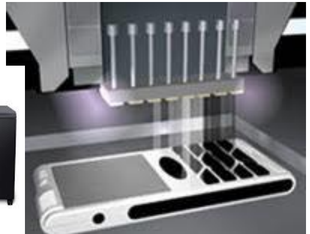


stereolithography



Laser sintering

polyjet



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3D HEART MODELING
YOUR STRUCTURAL HEART 3DPRINTED SOLUTION

Cahier de charges

- Modèle **fins et souples** : idéalement shoreA 50-80
- Résolution spatiale des détails (<0,3mm)
- Mémoire de forme,
- Résistants à la manipulation: traction, flexion, cisaillement
- Propriétés d’imagerie aux rayons X et ultrasons (Radiographie Echographie)
- Reproduisant les détails extérieurs et intérieurs des structures complexes avec des cavités
- Immergés : dans des systèmes de flux
- Fixation stable du model sur un bench test
- Fixation en positions anatomique

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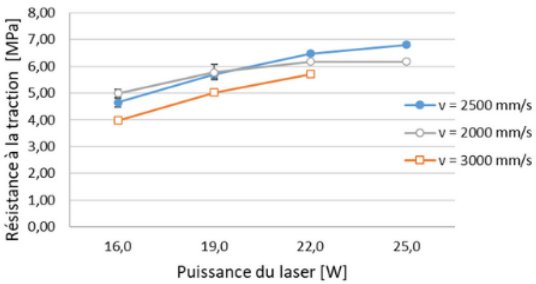
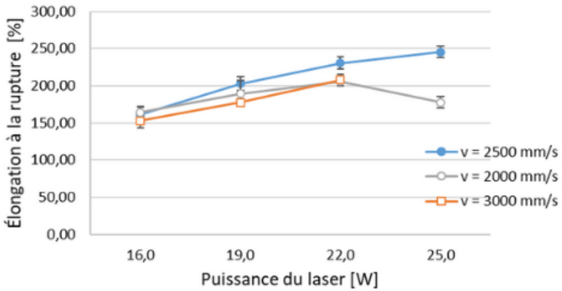
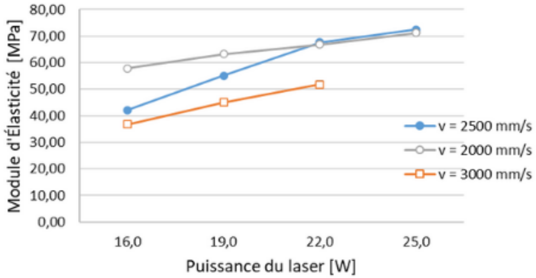
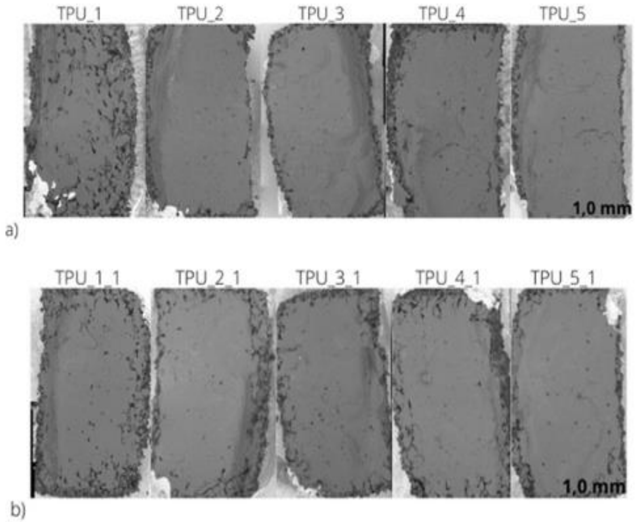
3D HEART MODELING







Porosité en fonction des paramètres d'exposition



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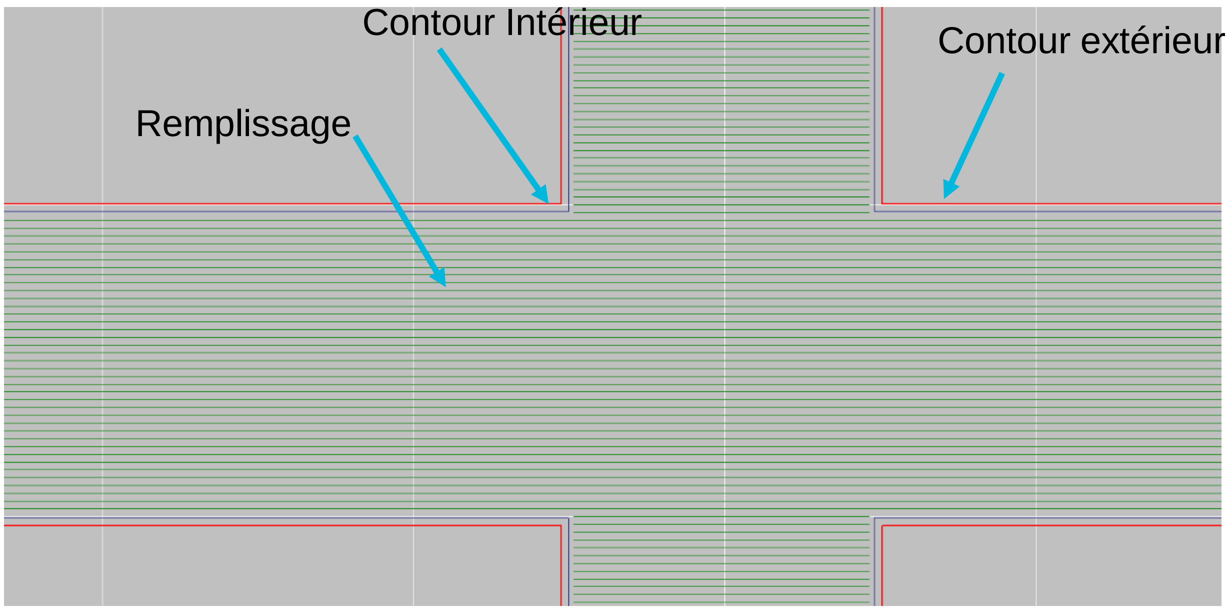
3D HEART MODELING

LA STRUCTURE DES COUCHES EN SLS



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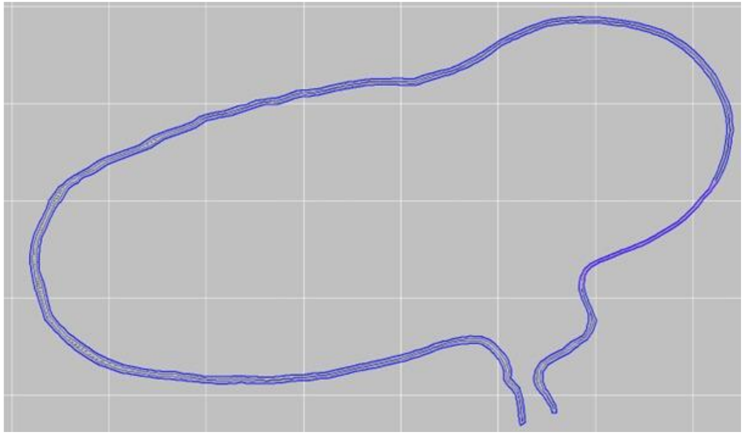
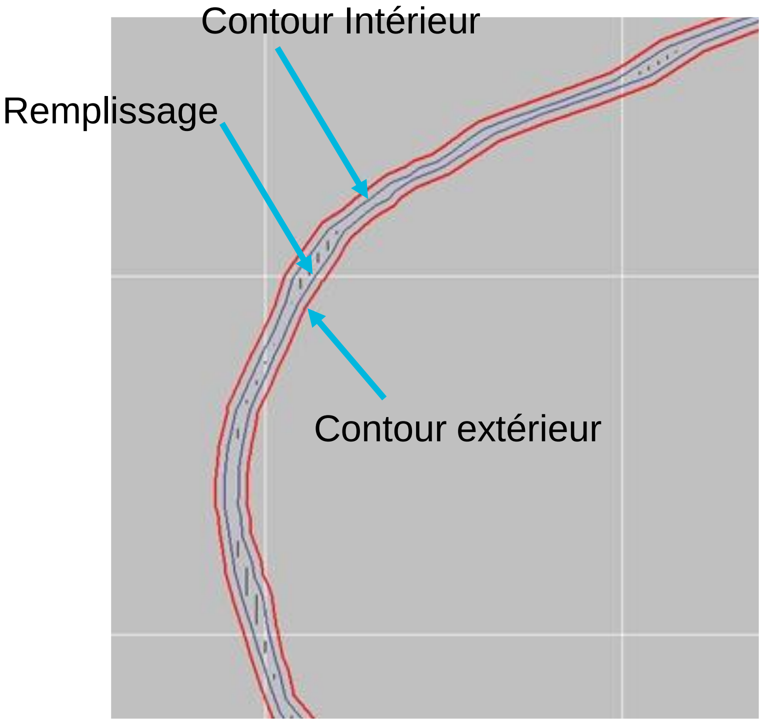
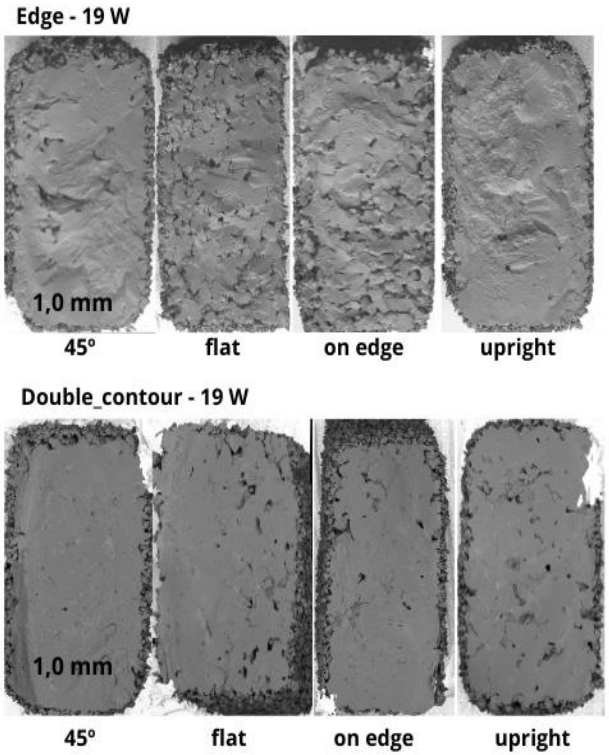
3D HEART MODELING

Chaque couche aura une structure différente, où normalement nous aurons un contour extérieur, un contour intérieur et le remplissage.

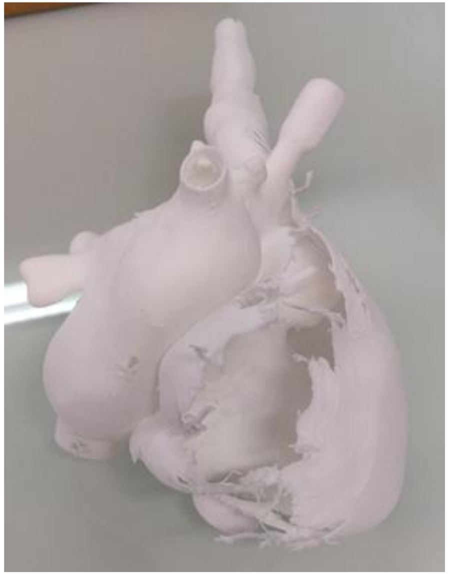




INFLUENCE DE L'ORIENTATION DE L'IMPRESSION



Porosité en fonction de l'orientation de la pièce



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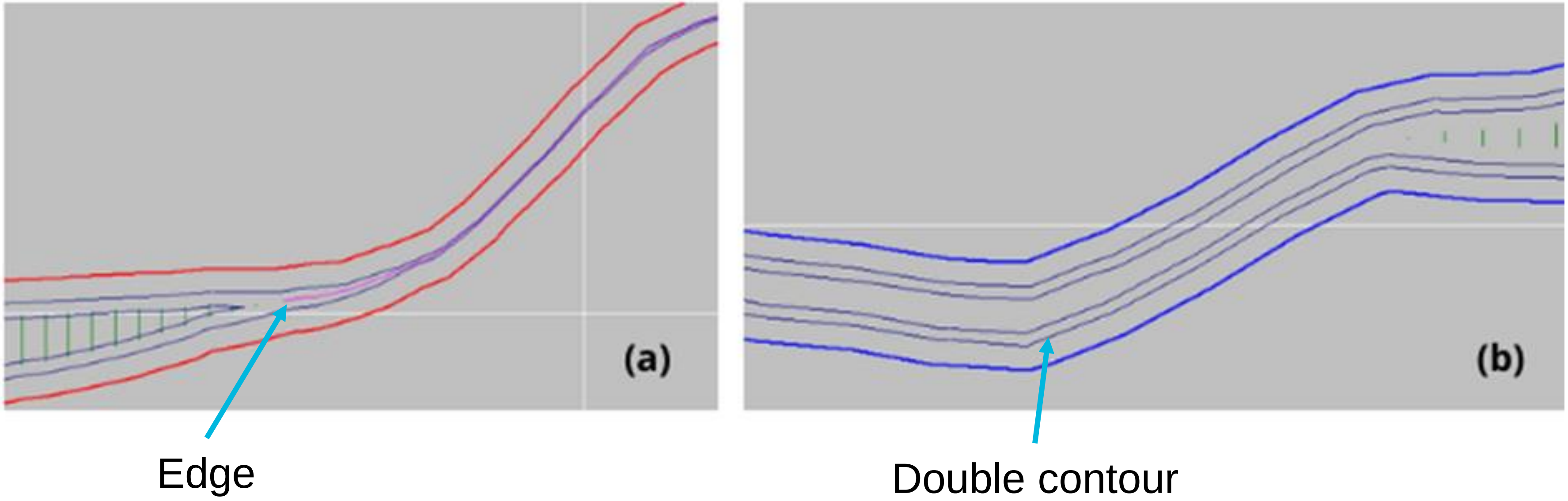
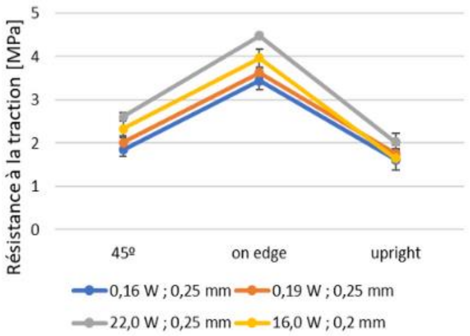
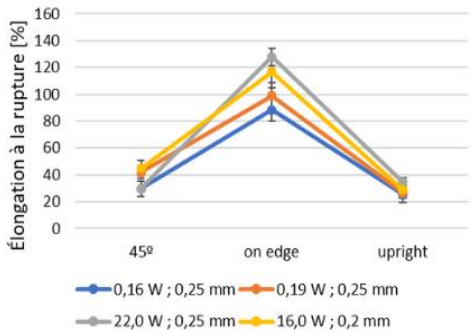
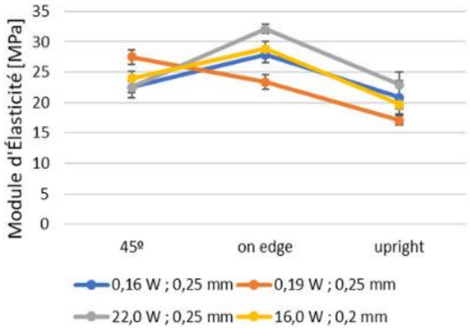
Logotype partenaire

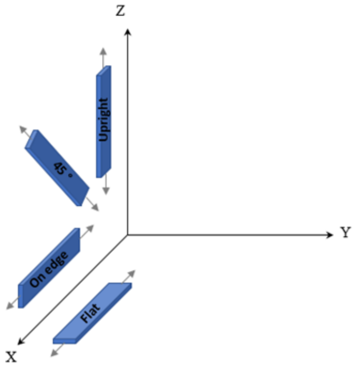
Structure des couches en SLS











Pour des éprouvettes en 0,5 mm :
Propriétés mécaniques dépendantes de l'orientation

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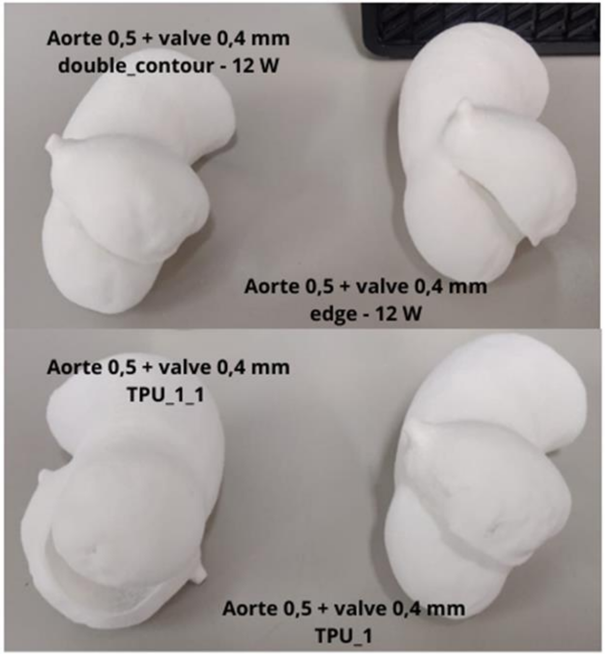
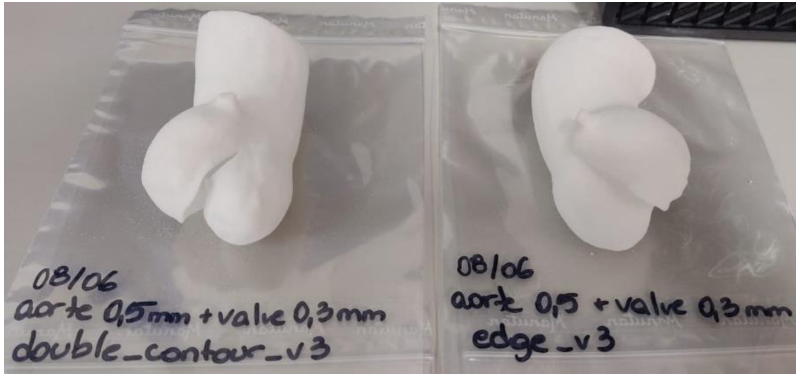


Variation des paramètres d'impression :
Varier la souplesse et la porosité



CONCLUSIONS

Etude 3D anatomique	Simulation 3D sur écran	Simulation sur print

Réelle utilité de la modélisation 3D
Etude précise d'éligibilité et de faisabilité de la procédure de correction percutanée du Sinus Venosus

Sécurité de la technique

Planification

Gain de temps

Préparation du geste

Affinage des critères d'éligibilité

Gestion du matériel custom-made

Compréhension de l'anatomie

Alimentation du registre

Gestion des risques

Optimisation du process

Travail collaboratif
Prospectif et rétrospectif

Communication → Interventionnel, Echographiste

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3D HEART MODELING

MERCI PAR VOTRE ATTENTION !

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3D HEART MODELING
YOUR STRUCTURAL HEART 3DPRINTED SOLUTION

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