3d print of heart rhythm model with cryoballoon catheter ablation of pulmonary vein

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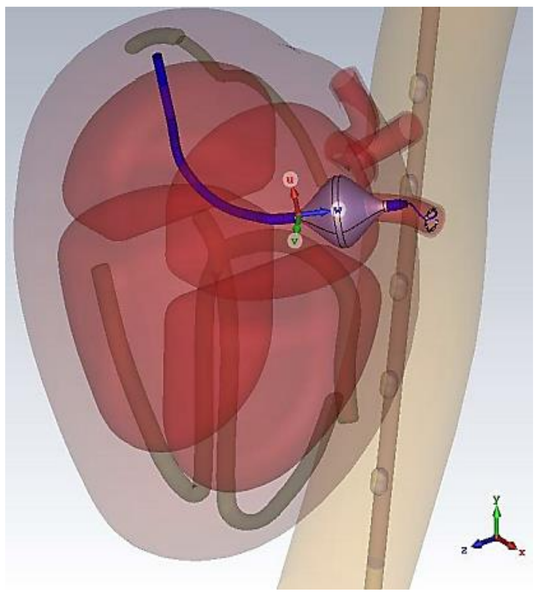
Introduction

The visualization of heart rhythm disturbance and atrial fibrillation therapy allows the optimization of new cardiac catheter ablations. With the simulation software CST® (Computer Simulation Technology, Dassault Systemes) electro-magnetic and thermal simulations can be carried out to analyze and optimize different heart rhythm disturbance and cardiac catheters for pulmonary vein isolation. Another form of visualization is provided by haptic, three-dimensional print models. These models can be produced using an additive manufacturing method, such as a 3d printer. The aim of the study was to produce a 3d print of the *Offenburg heart rhythm model* with a representation of an atrial fibrillation ablation procedure to improve the visualization of simulation of cardiac catheter ablation.

Methods

The simulation was carried out using the electromagnetic and thermal simulation software CST®. The Arctic Front Advance™ balloon catheter 28 mm and a circular mapping catheter were integrated into the *Offenburg heart rhythm model* at the position of the left inferior pulmonary vein (see Figure 1).



The catheter was modelled following the techn. manuals of the manu-facturer Medtronic.

Figure 1: Arctic Front Advance™ (28mm) in left inferior pulmonary vein of the Offenburg heart rhythm model using CST software

To print the model three-dimensionally, it had to be prepared with CAD software (see Figure 2). It could then be printed using two different 3d printing processes.

1. a binder jetting printer with polymer gypsum and
2. a multi-material printer with photopolymer.

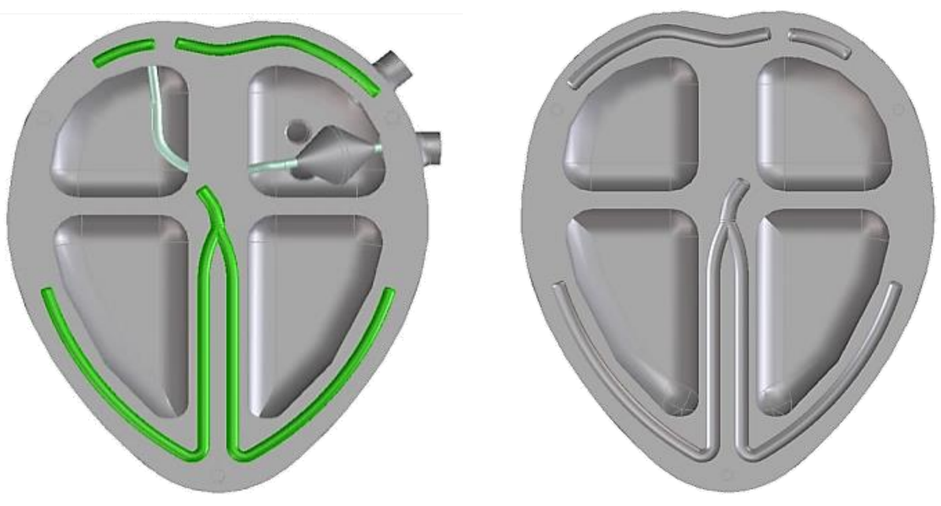
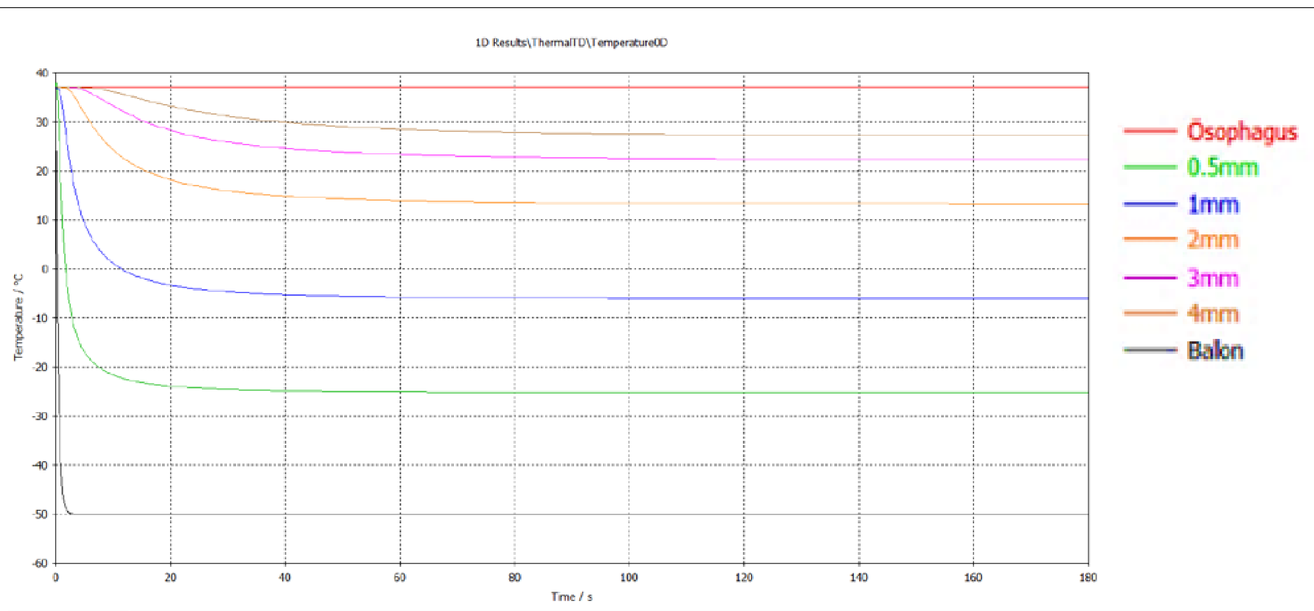


Figure 2: CAD-Model - Lower and upper part of the print model

Results

Simulation of pulmonary vein isolation

The pulmonary vein isolation of the left inferior pulmonary vein using a cryoballoon catheter was performed with a -50 °C heatsource and an exponential signal. Figure 3 shows the temperature profile over the whole cryoballoon catheter ablation procedure of 180 s.



Time	Temperature					
	Balloon surface	0,5 mm*	1 mm*	2 mm*	3 mm*	Öso-phagus
5 s	-50 °C	-17 °C	10 °C	32 °C	36 °C	37 °C
10 s	-50 °C	-21 °C	2 °C	24 °C	33 °C	37 °C
15 s	-50 °C	-23 °C	-2 °C	20 °C	30 °C	37 °C
80 s	-50 °C	-25 °C	-5 °C	14 °C	23 °C	37 °C

* Measured from the balloon in the myocardium

Figure 3: Temperature profile over the whole cryoballoon catheter ablation procedure of 180 s and temperature results after 5, 10, 15 and 80 s ablation duration

The simulation results shows an increased spread of the cold in the myocardium in contrast to the atrium filled with blood. From 80 s ablation duration the values remain approximately constant. A significant temperature difference can be observes up to 3 mm depth. The temperature measured in the esophagus was a constant 37 °C.

3d print of heart rhythm model

After the printing processes, two presentation models are now available. These are divisible into two halves. Inside the models, the conduction and the balloon catheter are shown (see Figure 4 and 5).

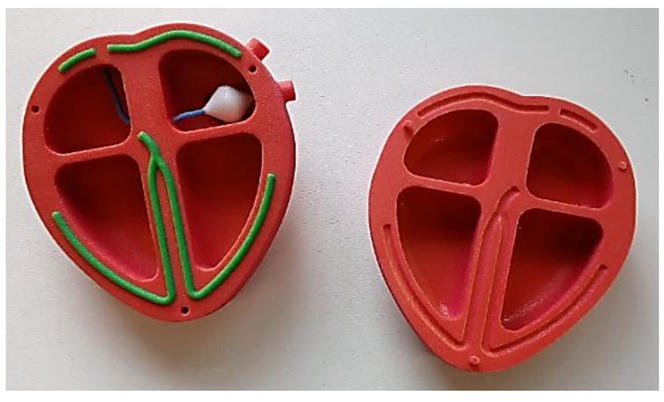


Figure 4: First 3d printed made of polymer gypsum

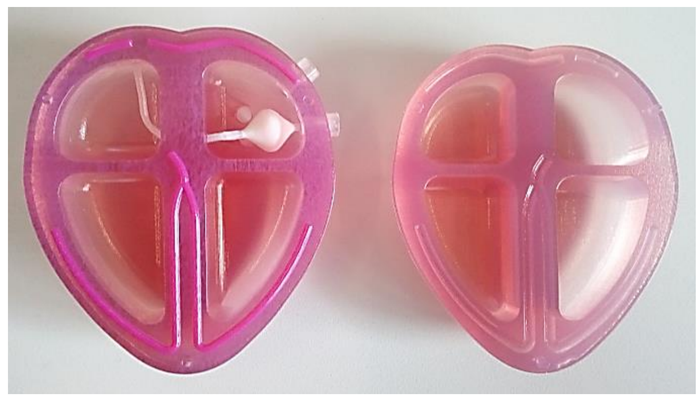


Figure 5: Second 3d printed model made of photopolymer

Conclusions

3d heart rhythm models as well as virtual simulations allow very clear visualization of complex cardiac rhythm therapy and atrial fibrillation treatment methods. The printed models can be used for optimization and demonstration of cryoballoon catheter ablation in patients with atrial fibrillation. In further work, various complex cardiac rhythm therapies could be created in the CST software and printed out in 3d.

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