Benefits of Numerical Simulation When Planning Endografts

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Conflict of interest

Co-founder &
Chairman

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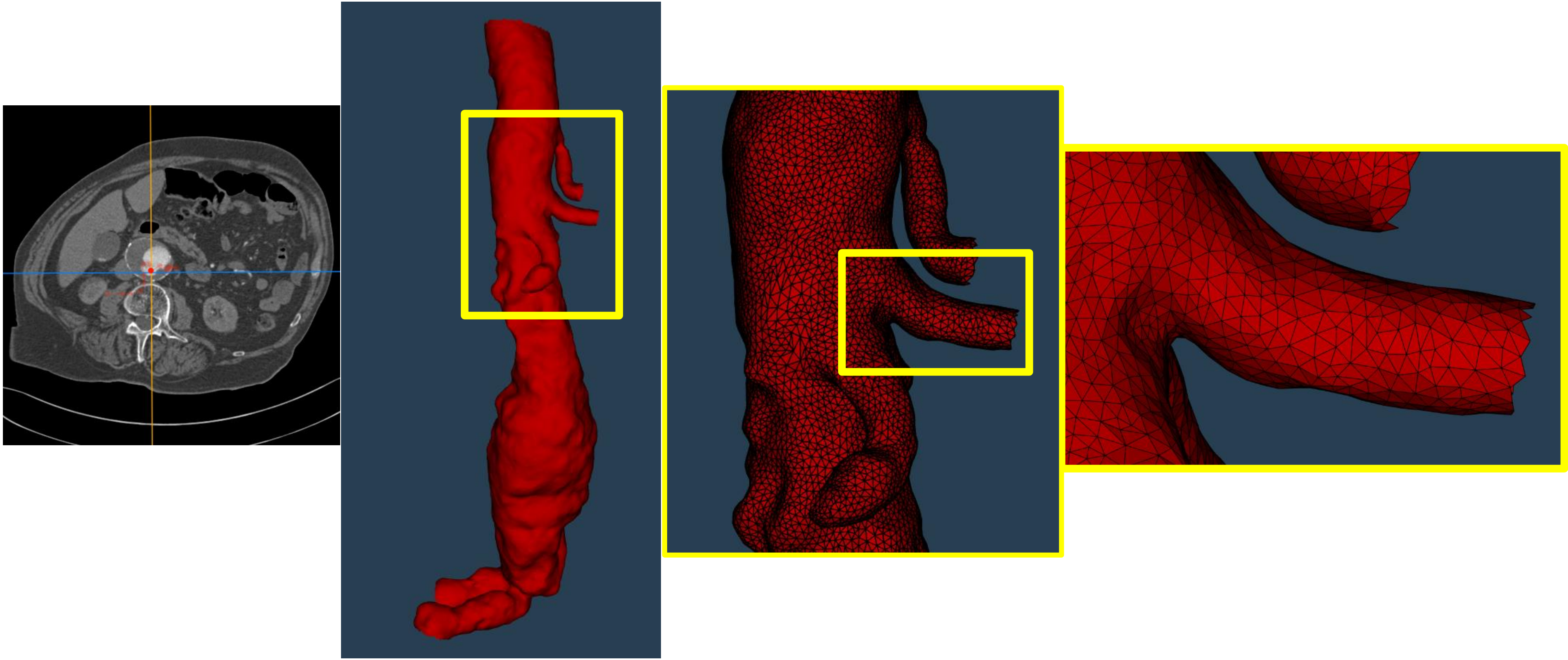
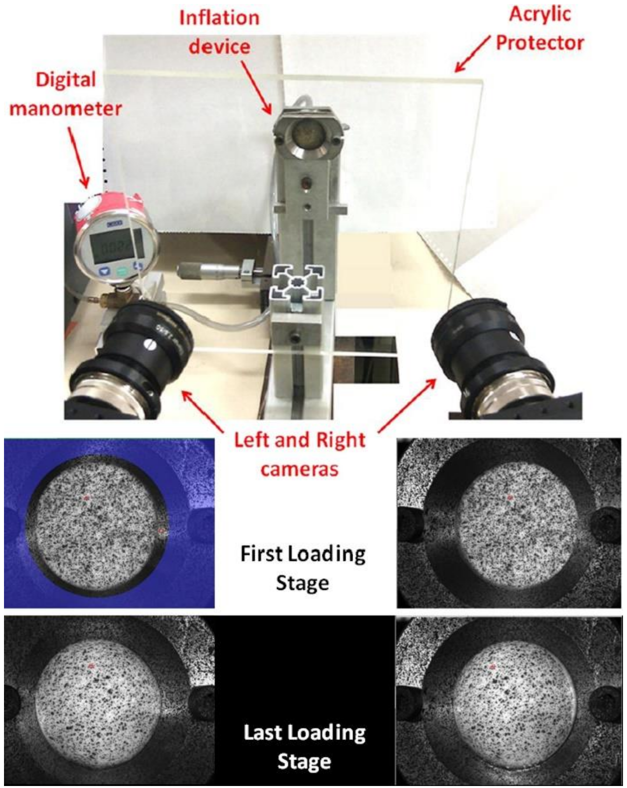
Patient-specific aortic aneurysm models
Aortic wall biomechanical properties



Aortic wall biomechanical properties
Example of experimental protocol



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Full length article

Biaxial rupture properties of ascending thoracic aortic aneurysms

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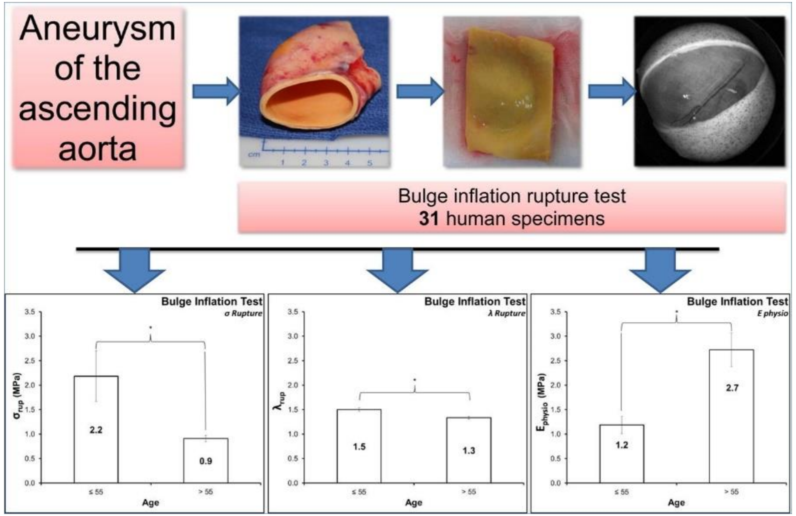
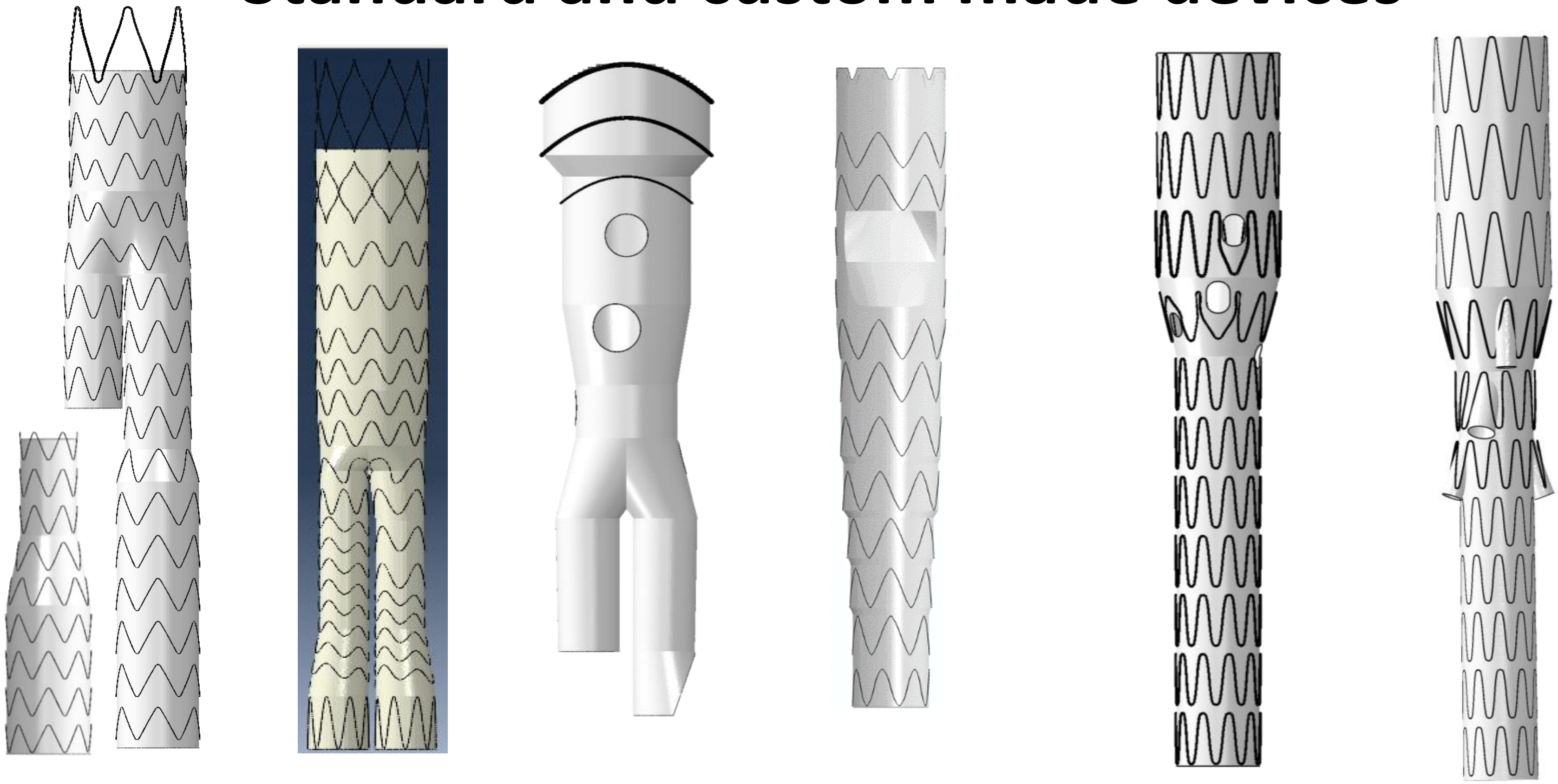
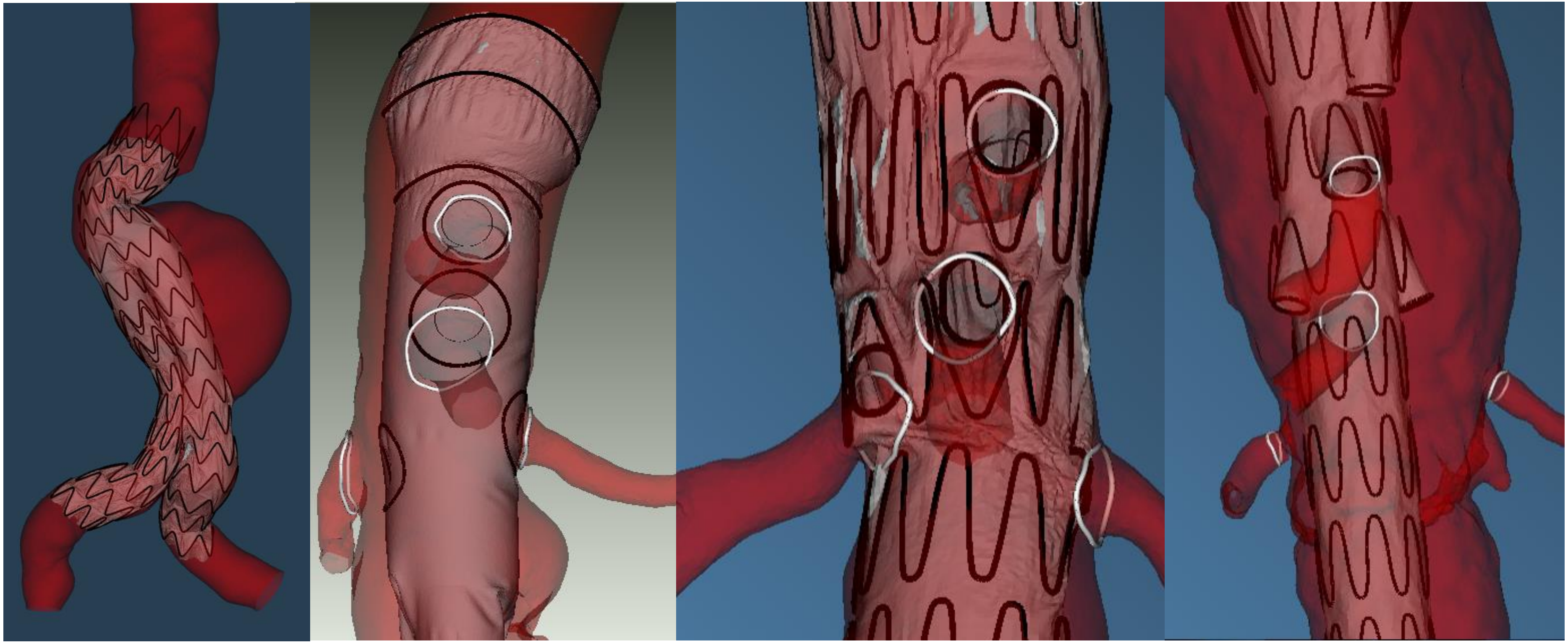


Stent-grafts 3D numerical models
Standard and custom made devices

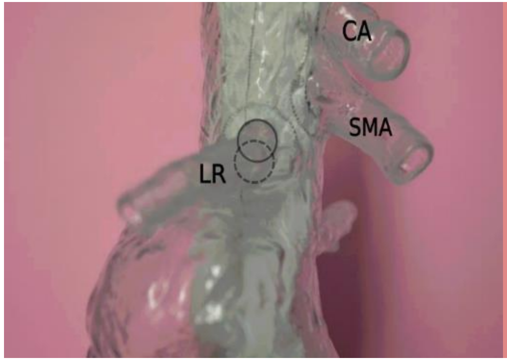


Simulation of stent-graft deployment

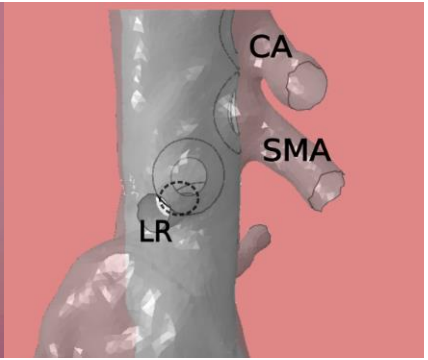


Automated sizing for fenestrated stent-grafts

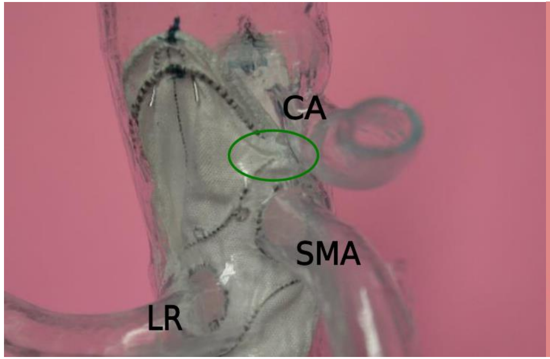
Fenestrated Anaconda: validation of fenestrations positions
Numerical simulation vs in-vitro test (Fensim 1 study)



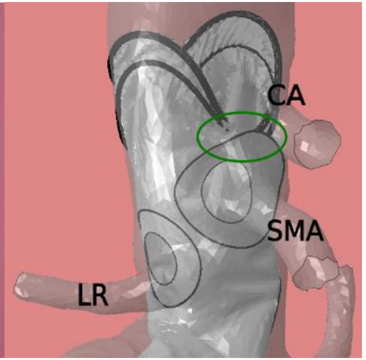
Real aorta model & prototype



Numerical simulation



Real aorta model & prototype



Numerical simulation

50 patients, 176 fenestrations

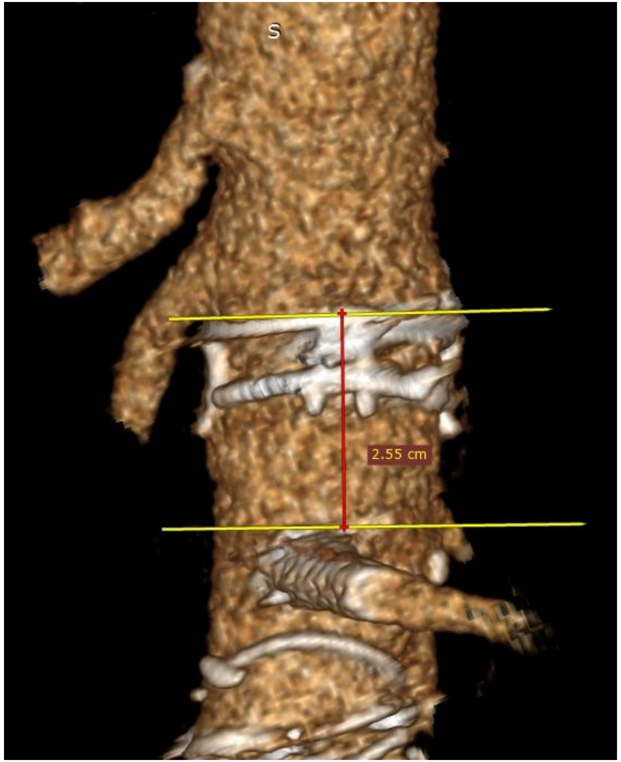
Δ fen position ≤	Longitudinal	Circumferential
2 mm	91 %	95 %
2,5 mm	**98 %**	**99 %**
3 mm	99 %	99 %

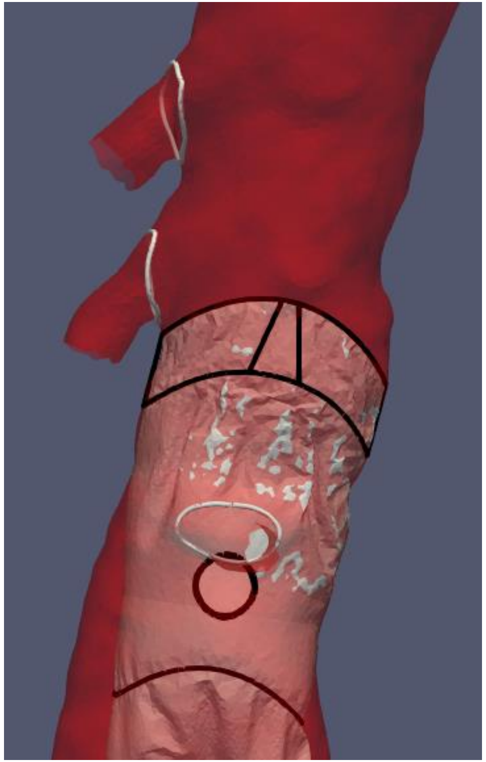
Assessment of fenestrated Anaconda stent graft design by numerical simulation: Results of a European prospective multicenter study

Miriam E. Kliewer, MD,[a] Marine Bordet, MD,[b] Bertrand Chavent, MD,[c] Michel M. P. J. Reijnen, MD,[d,e] Nicolas Frisch, MD,[f] Dominique Midy, MD,[g] Patrick Feugier, MD,[h] Antoine Millon, MD,[b] Jan-Willem Lardenoije, MD,[d] Afshin Assadian, PD, MD,[a] Jürgen Falkensammer, PD, MD,[a] Christian Muller, MD,[f] Jean-Pierre Favre, MD,[c] Sabrina Ben-Ahmed, PD, MD,[c] and Jean-Noel Albertini, MD,[c]
Vienna, Austria; Lyon, Saint-Etienne and Pierre-Bénite, France; Arnhem, and Enschede, The Netherlands; and Metz, Bordeaux

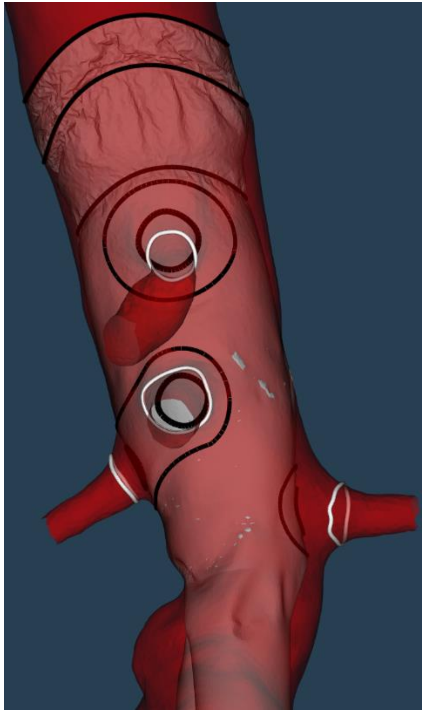
Kliewer et al, J Vasc Surg 2021(Aug)

Validation of simulated proximal stents shape vs in vitro test and post-op CT-scan





Anaconda: fenestrations positioned as per numerical simulation
Analysis of intra operative outcomes



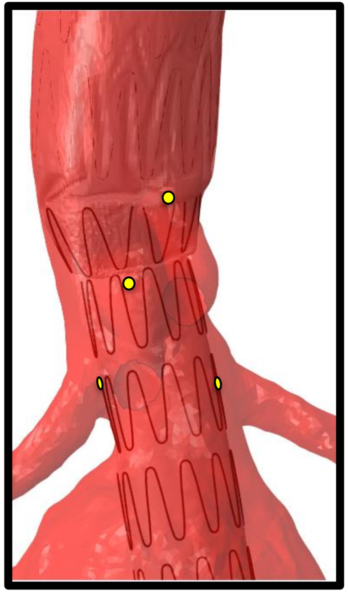
79 patients from 28 European centers	
302 fenestrations	
Technical success (fen. catheterization + stenting)	**100%**
Perfect fenestration alignment	**99.3%**
Median catheterization time (range 5-2100)	**60 sec**
Simulation median delivery time	**2 days**

Z stent based stent-grafts
Validation of fenestrations position (51 patients)

Eur J Vasc Endovasc Surg (2020) 59, 237—246

Patient Specific Computer Modelling for Automated Sizing of Fenestrated Stent Grafts

Lucie Derycke [a,b,*], Jean Sénémaud [b], David Perrin [c], Stephane Avril [a], Pascal Desgranges [b], Jean-Noel Albertini [d], Frederic Cochennec [b], Stephan Haulon [e]



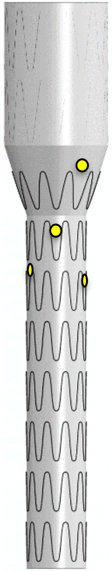
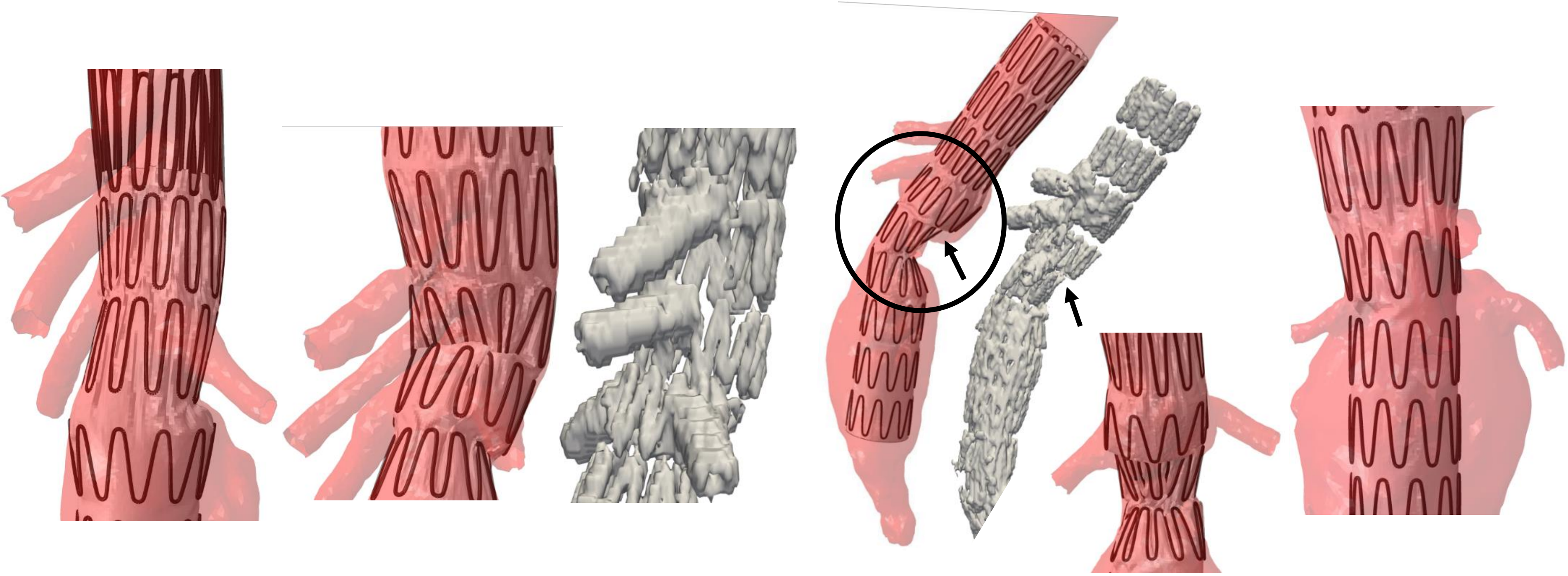


Table 2. Comparison results of longitudinal and clock positions obtained by the two steps of the simulation model and the pre- and post-operative sizing; and percentage of longitudinal and clock position discrepancies below the significance limits of 3 mm and 15°

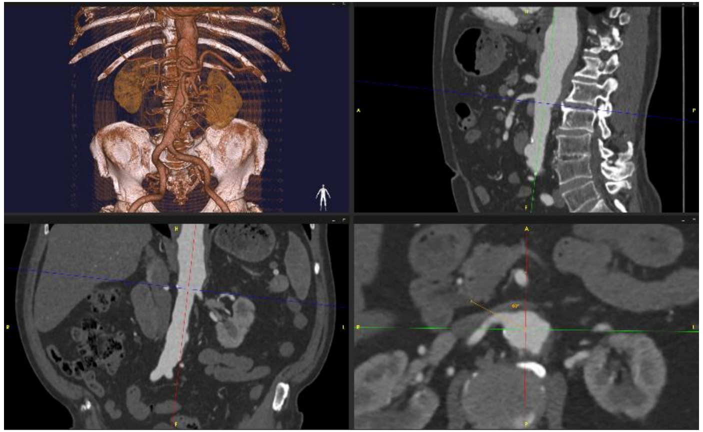
	Longitudinal position − mm				Circumferential position − °			
	Post-operative sizing		Pre-operative sizing		Post-operative sizing		Pre-operative sizing	
	Median ± SD (range)	$n \leq 3$ mm (%)	Median ± SD (range)	$n \leq 3$ mm (%)	Median ± SD (range)	$n \leq 15°$ (%)	Median ± SD (range)	$n \leq 15°$ (%)
Simulation	1.0 ± 1.1 (−5.9 to 6.0)	95	0.96 ± 0.97 (−4.6 to 5.0)	98	6.9 ± 6.1 (−44.3 to 25.1)	96	4.8 ± 3.6 (−21.8 to 19.3)	99
Pre-operative sizing	0.8 ± 0.8 (−4.0 to 4.0)	97			5.1 ± 5.0 (−37.1 to 18.4)	98		
Automated positions	3.0 ± 0.3 (−9.5 to 16.7)	93	1.2 ± 1.7 (−15.5 to 9.5)	93	11.0 ± 9.3 (−56.0 to 38.0)	91	6.5 ± 6.1 (−44.9 to 34.0)	93

SD = standard deviation.

Qualitative assessment of stent-graft behavior



PSS™ automated software for Z stent fenestrated stent-grafts



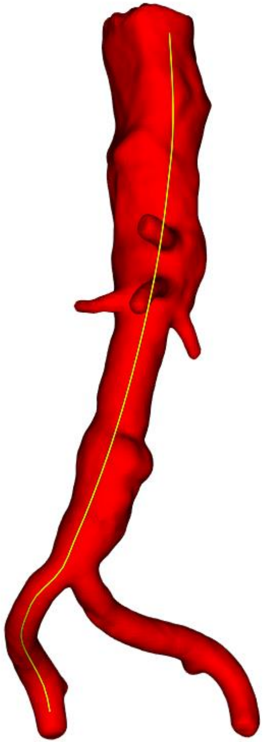
Automated sizing and graft plan generation in 15 min

Zenith fenestrated study

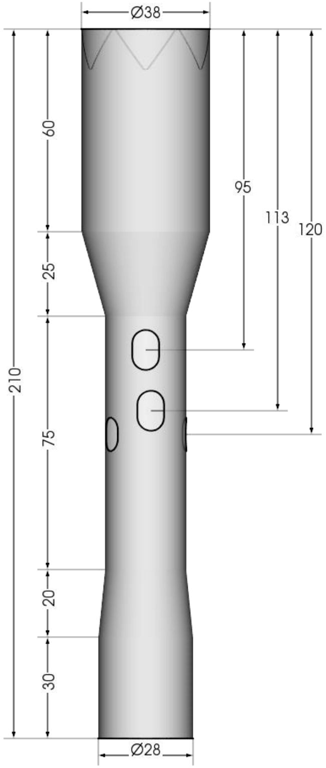
70 patients 197 fenestrations

Position difference with planning center

≤3mm	**99.5%**
≤15 min	**98.9%**

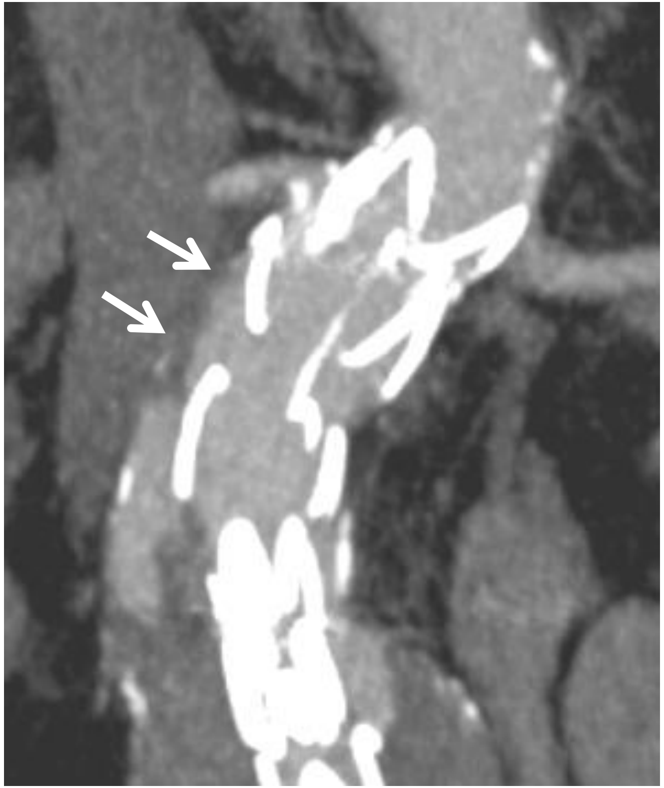


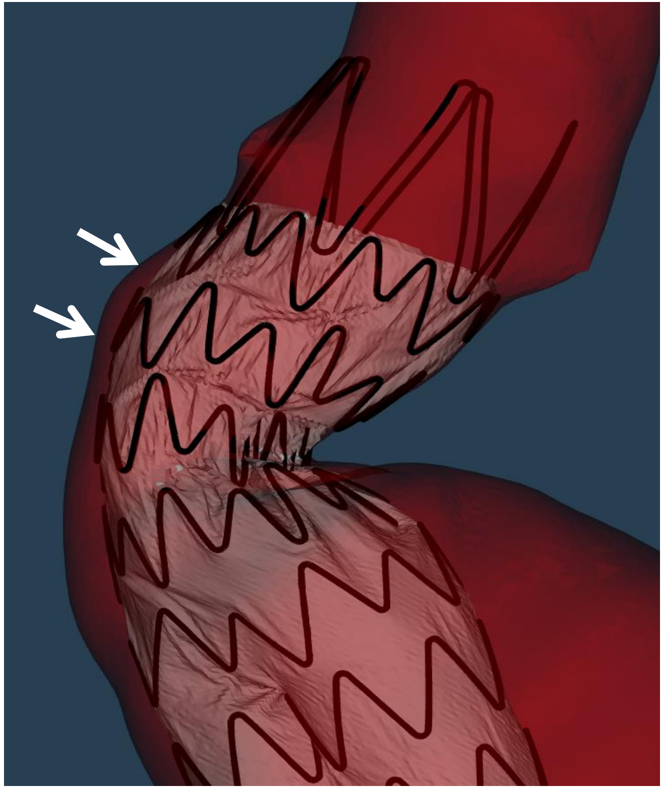
“Stiff-wired” centerline



Prediction of complications & intraoperative difficulties

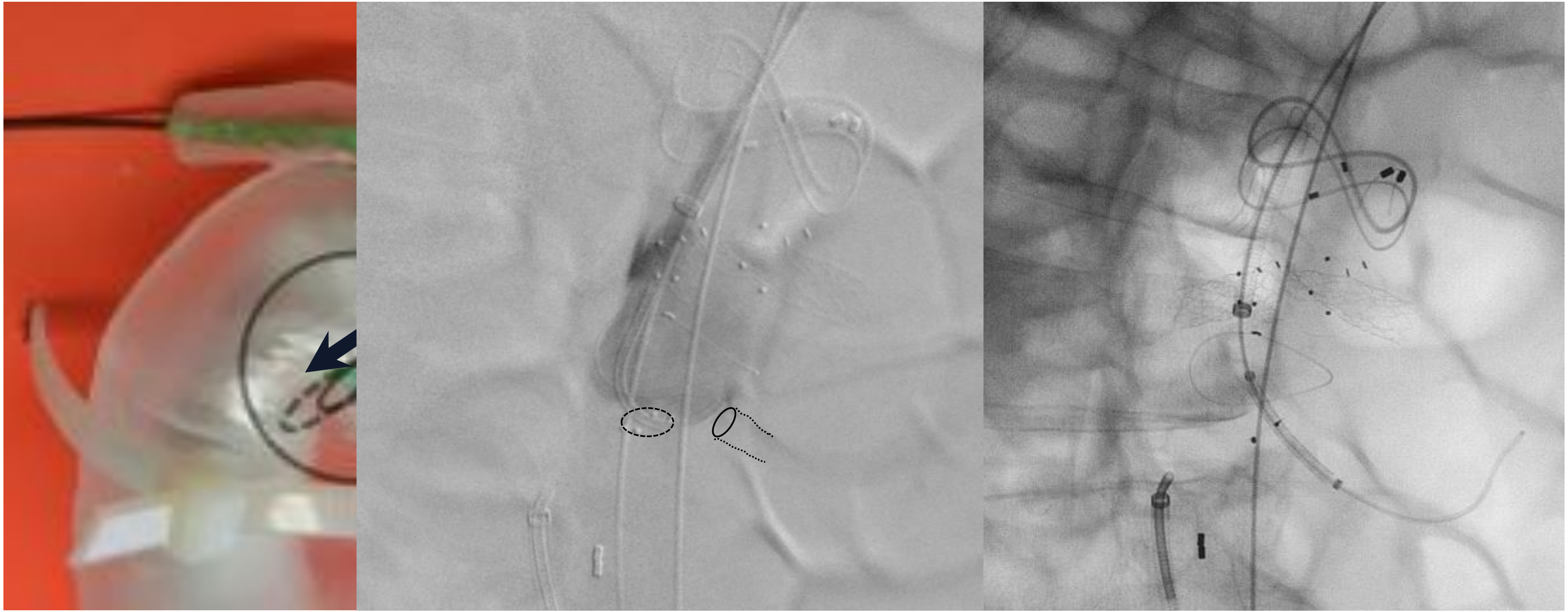
Type IA endoleak
Detection of suboptimal stent-graft application



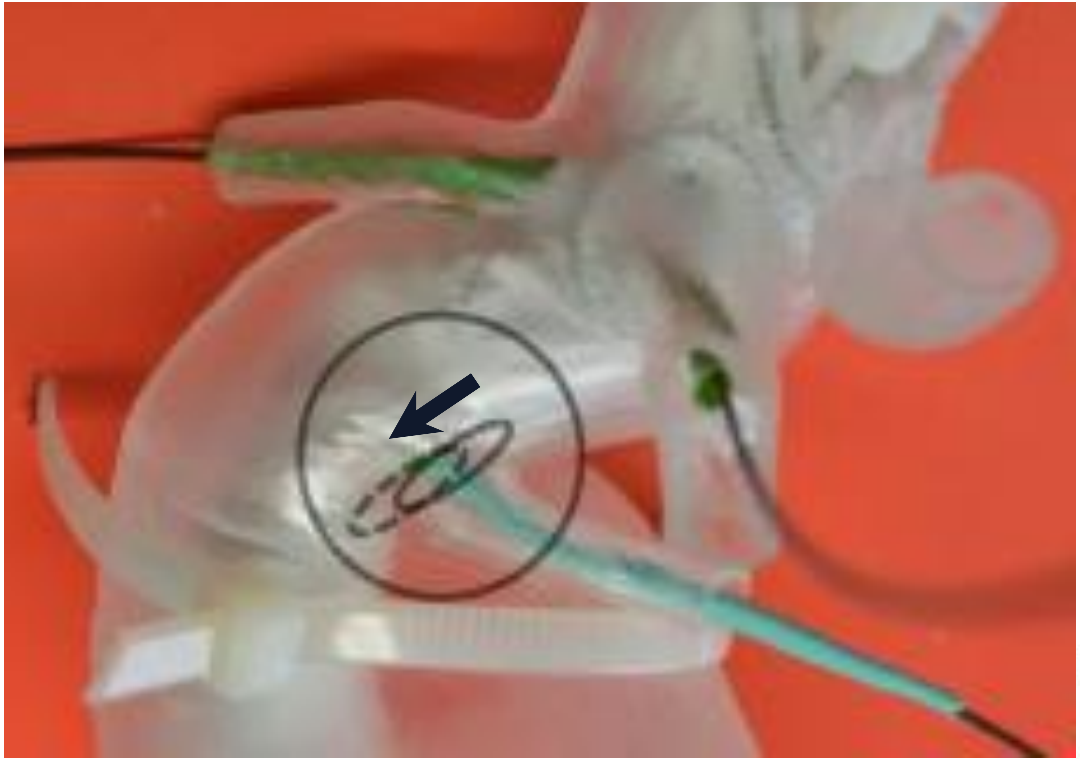


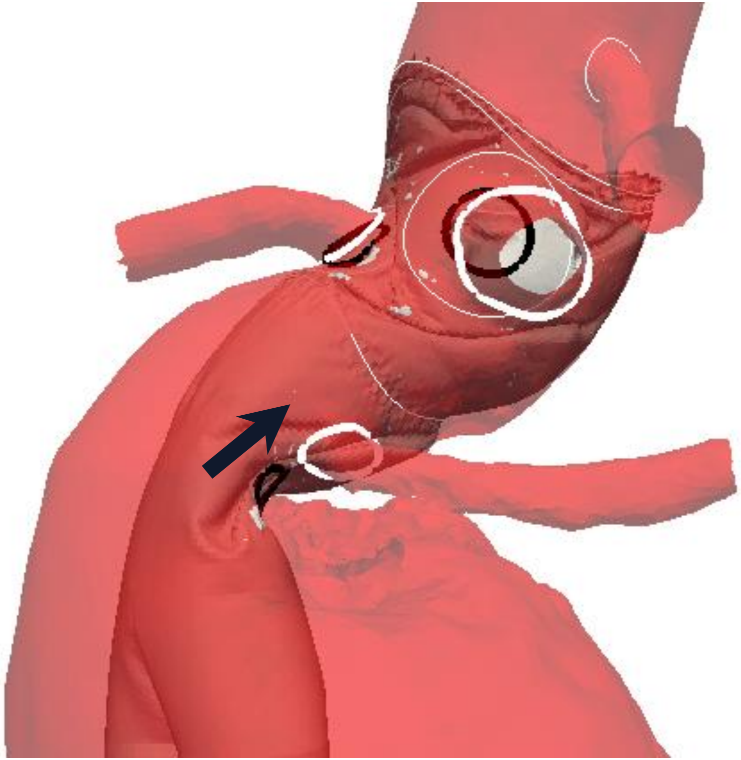
Fenestration related technical issues

Suboptimal fenestration position

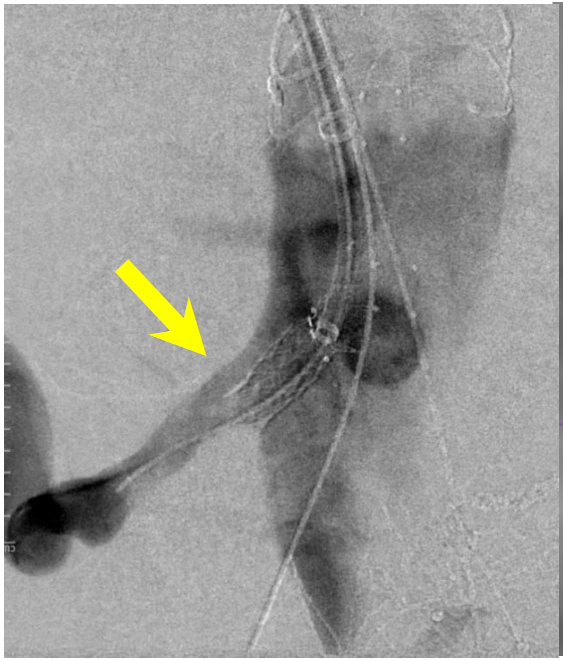


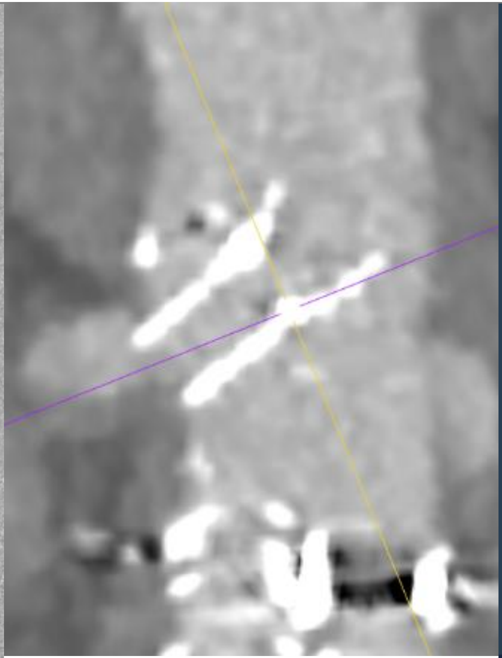
Benefits of numerical simulation
Optimisation of fenestration position

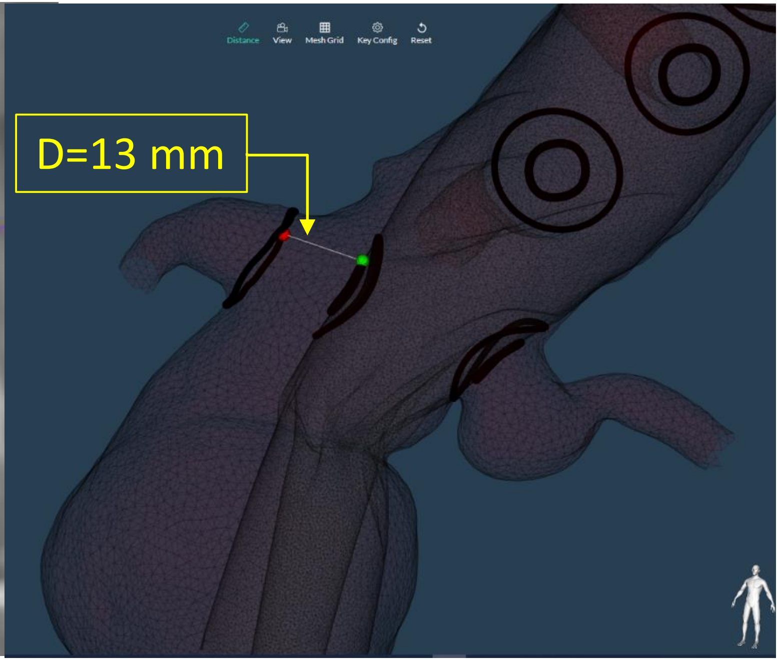




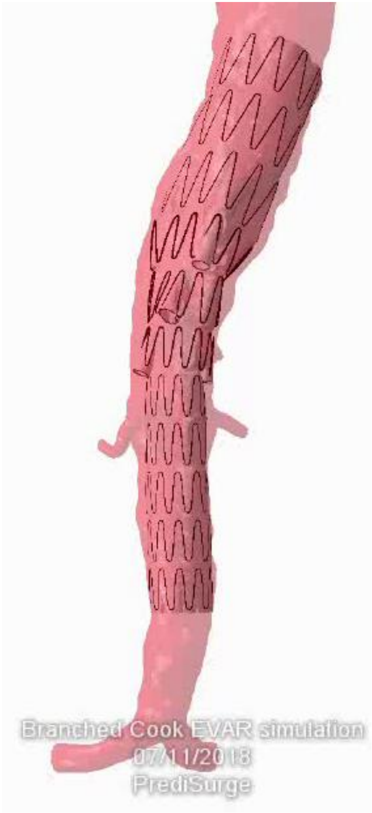
Prevention of type IC endoleak
by optimizing the choice of stent length

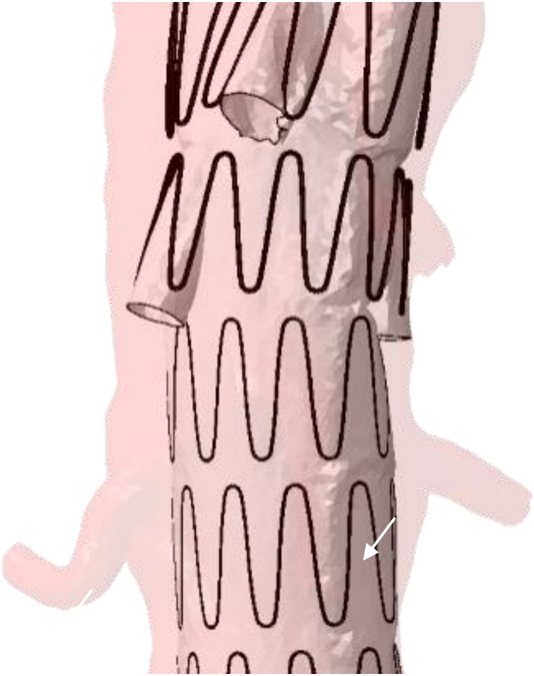




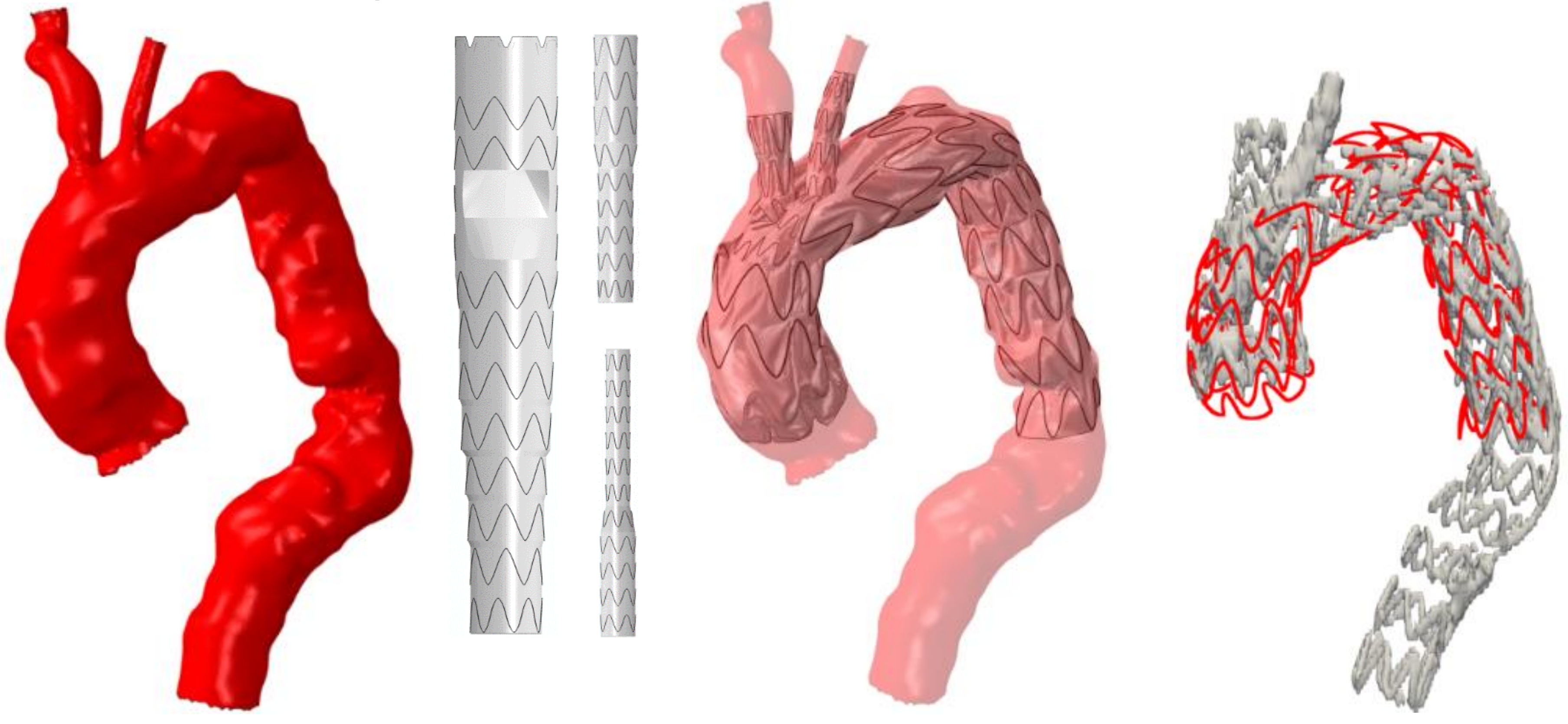


Left renal branch compression

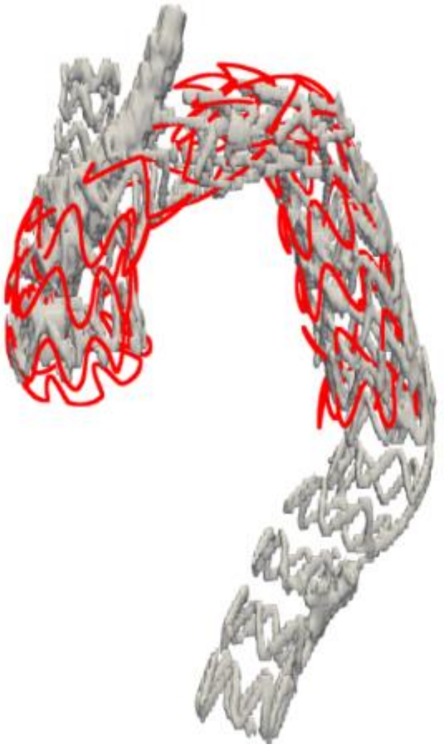


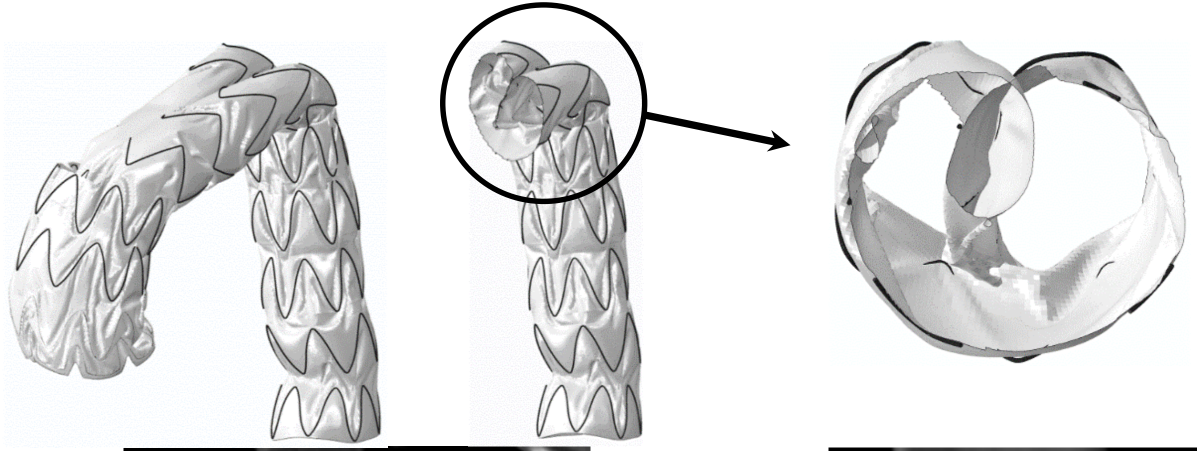


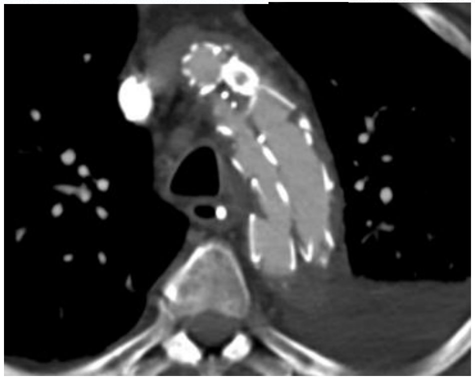
Relay double branch arch device

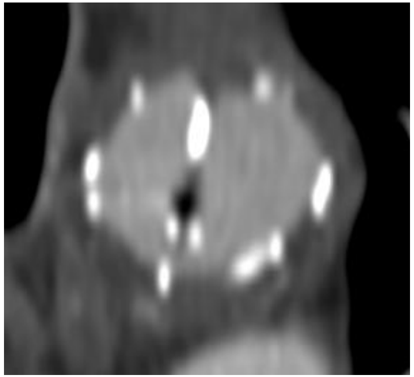


Stent-graft invagination by excessive oversizing









Conclusion

Numerical simulation provides a streamlined and reliable planning process for complex aortic aneurysm repair

A wide range of devices and anatomies are amenable to this technology

A dedicated research program on prediction of complications by numerical simulation including both academic and industrial partners has been set up: EndoVx project; PI Prof S Haulon