Realistic virtual radial strength testing of stents

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The most important task of a stent is to reopen the artery and support or scaffold the stenosed lesion in a target vessel. To that extent, the stent requires a sufficient radial strength. Experimental evidence has shown that, in addition to the material properties, this radial strength is also strongly design dependent (Rieu et al., Catheter Cardiovasc Interv, 1999). Its assessment, especially in the case of balloon-expandable stents, requires a sophisticated and accurate test set-up and dedicated experimental protocol.

Complementary to such experimental methods, we developed a virtual testing procedure which allows to gain valuable insights into the impact of certain design and material variants on the stent scaffolding potential without having to actually manufacture these prototypes and/or materials. This novel numerical procedure is developed by combining Abaqus with the open-source pyFormex design software (http://pyFormex.berlios.de). It allows to evaluate the following mechanical stent characteristics: elastic dilatation recoil, radial compliance after dilatation and collapse pressure. The developed virtual procedure is validated against experimental data of the PRO-Kinetic stent. The experimental data was provided by the manufacturer (Biotronik, Germany).

The virtual radial strength test is developed in accordance with the experimental setup in which the PRO-Kinetic stent is implanted into a PU-tube. The simulation strategy consists of three steps: (i) crimping of the stent using a radial displacement-driven surface and subsequent surface/stent contact removal in order to account for elastic recoil; (ii) expansion of the stent in the PU-tube using a radial displacement driven surface (De Beule et al., J Biomech, 2008) and subsequent surface/stent contact removal in order to account for elastic recoil and (iii) pressure loading on the outer surface of the PU-tube in order to assess the radial strength of the stent.

The proposed modelling strategy to examine the radial strength provides results in satisfactory agreement with the provided experimental data as the difference between the experimentally determined collapse pressure and the numerically predicted value is less than 2%.
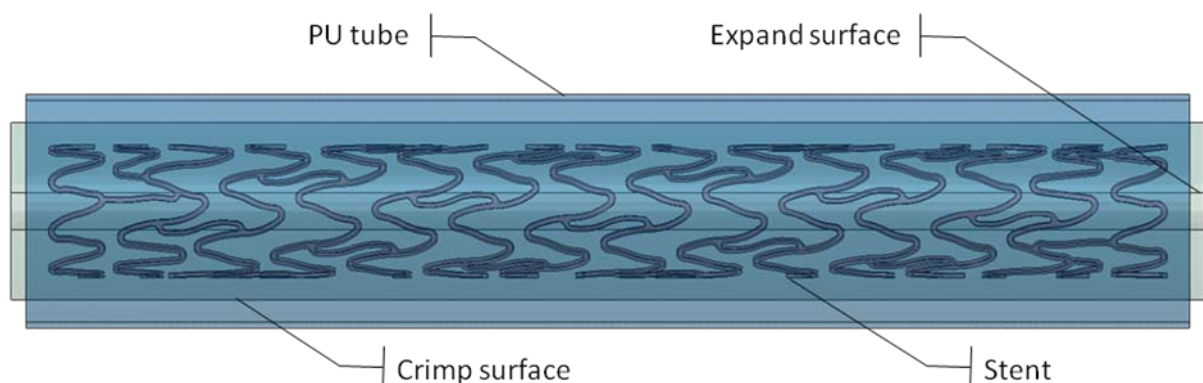
Figure: Virtual radial strength test developed by combining Abaqus with pyFormex