Virtual design of minimally invasive medical devices using the Finite Element Method

Matthieu De Beule, Peter Mortier, Patrick Segers, Pascal Verdonck, Benedict Verhegghe

Institute Biomedical Technology (IBiTech)
Ghent University
Belgium

The trend in contemporary surgery is the evolution toward minimally invasive techniques, where smaller, more minute incisions are made, as opposed to traditional ‘open’ surgery. Through these small incisions the surgeon is able to manoeuvre minuscule surgical instruments and/or implants to the target site. A good example of minimal invasive surgery is the use of stents to treat narrowed arteries. Stents are tubular structures which are deployed in a narrowed artery section to enlarge the cross-section and to restore the local blood flow. World-wide more than 2 million stents are implanted annually, however, the market changes rapidly and there is still a need for innovative stent designs. Other minimal invasive devices are embolic protection filters, stent grafts, stented valves, ….

To date, these devices are still mostly developed using a trial and error approach: a first prototype is manufactured and physical tests are performed to check whether the design requirements are fulfilled. If this is not the case, the design is adapted and a new prototype is manufactured and tested. This approach is time-consuming, expensive and often incapable of providing a complete understanding of a product’s performance. Moreover, performing physical tests on these minuscule devices is an enormous challenge.

A promising strategy to design medical devices is virtual product development using the Finite Element Method (FEM). The main advantage of numerical modelling is that numerous ‘What if?’ scenarios addressing different materials and designs can easily be tested before devices are actually manufactured. Consequently, the design can be evaluated a priori in terms of strength, flexibility, etc. which enables the development of cost-effective, innovative designs and reduces the time to market. Our research focuses on the development of innovative methods to facilitate virtual product development of minimally invasive devices (for more information: http://www.stent-ibitech.ugent.be).

We have created a validated virtual design space to investigate and optimize the mechanics of minimal invasive devices with FEM. This general design tool is applicable to both balloon and self expandable devices such as stents in a variety of materials (stainless steel, cobalt-chromium, nitinol, etc.) and configurations (laser-cut, braided) [1-4].

References: