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Introduction

Percutaneous Transcetheter Coronary Angioplasty (PTCA) is the most common intervention for the treatment of a stenosed artery. Optimal results and minimal complications depend on the intervention strategy (balloon/stent size, inflation pressure) which is typically determined by angiographic images, patient clinical information and clinician's experience.

This work presents improvements to numerical technique for predicting the device/artery behavior during angioplasty. The goal of this numerical tool is to assist clinician in the selection of appropriate intervention strategy for a specific patient by using intravascular ultrasound (IVUS) imaging data to simulate the intervention.

Methods

A finite element modeling software developed at IMI for the analysis of large deformations of soft materials was used to solve angioplasty mechanics (Laroche 2003, Delorme 2004). The model computes the device/artery interaction and large deformations that occur during device insertion and deployment into the diseased artery. It predicts the resulting artery lumen patency, the stress distribution and the friction work distribution in the arterial wall.

The angioplasty balloon is modeled with membrane elements and the artery with incompressible solid elements, both with a hyperelastic constitutive model. An important contribution of this work is the development of a multi-body contact algorithm that is rapid and robust enough for handling complex contact and friction behavior between the balloon and the artery. The proposed algorithm performs implicit contact detection between virtual surfaces.

Results and conclusion

A proof-of-concept test was performed using IVUS images of one patient who underwent balloon angioplasty. A 3-D model of a 68 mm LAD artery segment was produced from IVUS images. The deployment of a 3.5 by 28 mm balloon was simulated by applying a 12 atm pressure.

The proposed model is capable of predicting the effect of intervention strategy on the artery deformation.

References

Delorme, S. et al (2004) *Annual Technical Conference (ANTEC) of the Society of Plastic Engineers*, Chicago, IL.
Laroche, D. et al (2003) *ASM Materials & Processes for Medical Devices Conference*, Anaheim, CA.