An Assessment of Finite Element Computations in the Structural Analysis of Diverse Coronary Stent Types: Identifying Prerequisites for Advancement

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Abstract : Coronary artery disease, a common cardiovascular disease, is attributed to the accumulation of cholesterol-based plaques in the coronary arteries, leading to atherosclerosis. This disease is associated with risk factors such as smoking, hypertension, diabetes, and elevated cholesterol levels, contributing to severe clinical consequences, including acute coronary syndromes and myocardial infarction. Treatment approaches such as from lifestyle interventions to surgical procedures like percutaneous coronary intervention and coronary artery bypass surgery. These interventions often employ stents, including bare-metal stents (BMS), drug-eluting stents (DES), and bioresorbable vascular scaffolds (BVS), each with its advantages and limitations. Computational tools have emerged as critical in optimizing stent designs and assessing their performance. The aim of this study is to provide an overview of the computational methods of studies based on the finite element (FE) method in the field of coronary stenting and discuss the potential for development and clinical application of stent devices. Additionally, the importance of assessing the ability of computational models is emphasized to represent real-world phenomena, supported by recent guidelines from the American Society of Mechanical Engineers (ASME). Validation processes proposed include comparing model performance with in vivo, ex-vivo, or in vitro data, alongside uncertainty quantification and sensitivity analysis. These methods can enhance the credibility and reliability of in silico simulations, ultimately aiding in the assessment of coronary stent designs in various clinical contexts.

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