



RE-ENGINEERING AND COMPUTATIONAL
MODELLING OF VASCULAR GRAFTS
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Generally, cardiovascular diseases and related complications form a significant part of fatalities in the world, especially in the Global South. Africa as a continent is projected to be more vulnerable to cardiovascular diseases in the coming years. This will be due to

increased rates of hypertension, smoking, and obesity, among other causes. This has created the dire need for multi-field interventions to combat incidences of coronary artery diseases, which are yet to be optimally prevented or treated. One such strategy, I believe, will be to apply computational techniques and approaches in the design and testing of custom-made patient-specific vascular scaffolds for the support and repair of deformed arteries, which will be affordable for the population living in low-income countries in the Global South.

My Iso Lomso Fellowship at Wiko provided me with the much-needed platform to advance my innovations and ideas in re-engineering and computational modelling of vascular grafts; to me it was a golden opportunity to advance skills and knowledge that I acquired over time during my postgraduate studies and postdoctoral fellowships. Further, the prospect of working on this project at Wiko alongside some of the finest scholars from diverse backgrounds was fascinating, to say the least! It was a rare opportunity to learn from some of the greatest minds in academia, both scientists and non-scientists. For me it was a chance to explore novel ideas, acquiring new skills not only for my Wiko project, but also for my personal and career advancement.

My work during the 3-month residence period (13 September–15 December 2024) at Wiko was based on a project entitled “Computational Modelling of Tubular Fibrous Scaffold Structures for Cardiovascular Graft Applications.” This project envisaged that the design of tubular structures with desirable internal and external topology is a challenge for tissue engineering of cardiovascular grafts. Even though conventional vascular grafts have the capability of providing sufficient structural and biological support to tissues, they are expensive and susceptible to anatomical limitations. Hence, fibrous structures such as polymeric electrospun grafts have appeared as viable options for use in cardiovascular surgery, due to their suitable extracellular matrix for tissue regeneration, better compliance matching, and improved mechanical properties. However, due to random nanostructure occasioned by a non-uniform polymer assembly, which influences their surface topography, mechanical properties, cell proliferation, and cell growth potential, electrospun grafts still have inherent limitations in their design.

Meanwhile, 3D models of electrospun grafts for investigation of their deformation and performance have been based mainly on solid, three-dimensional (3D) structures without considering fiber placement within the structures. Whenever fiber alignment has been considered, such models have been based on planar fiber networks. Hence, there is

insufficient information on 3D computational models of tubular electrospun vascular grafts that could consider the constituent fiber alignment and randomness of their nanostructure. It is envisaged that the use of tubular vascular structures in 3D interface would be more realistic for in-depth investigation of their performance, which would further support their seamless integration as vascular implants.

The aim of this project therefore was to design tubular electrospun polymeric grafts that could consider the randomness and alignment of fibers. To design these structures, Computer-Aided-Drawing in 3D interface in custom-built programming scripts in python® and commercial FE software ABAQUS®/Explicit was used.

Eventually, the mechanical performance of the 3D tubular graft models was analysed using tensile, compressive, and bending loading criteria. This was accomplished using Finite Element Analysis (FEA) approaches based on 3D parametric models. Further, to mimic deformations of the vascular graft models, realistic boundary conditions were assigned, which were able to simulate the deployment and performance of grafts. The deformation criterion of the 3D tubular vascular graft models was then used to compute results in terms of displacement, uniaxial forces, and stress-strains levels in the structures.

In this regard, the residency period offered an excellent experience, and my productivity was for the most part satisfactory.