A feasibility study on 3D modelling of cardiac implants in children to improve outcomes in surgery

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Objectives: It is both cost effective and practical to computationally model and simulate cardiac implants in a non-invasive environment to identify failure modes and optimise design. This will ultimately improve surgical outcomes faced by children from early implant failure.

Methods: The geometries of 3 cardiac implants with increasingly complex features were captured using Agisoft Metashape, a photogrammetric processing software and converted to a 3D model. Anatomical geometries were segmented from a heart DICOM file using Mimics 22.0 and models generated to house the implants.

Results: Preliminary surface capturing and modelling was carried out with a 33 mm mitral annuloplasty Dacron ring. Point clouds were successfully generated with high precision and tessellated to generate a 3D model. This was housed in an anatomical model of the mitral annulus and left ventricular outflow tract and computational fluid dynamics carried out using ANSYS 19R2. Blood was modelled during a systolic cardiac cycle as pulsatile and K-epsilon turbulent and Carreau models applied for non-Newtonian blood flow.

Discussions: Through high resolution image capturing of the annuloplasty ring, surface features such as ribbing were possible to model. Work is ongoing to assess the feasibility of geometry capturing and computational analysis with a tilting disc and transcatheter aortic valve. Success in the use of these methods in this study will ensure transferability when modelling explanted cardiac implants to determine failure modes.

Conclusions: The application of photogammetry to medical devices provides a cost effective and non-invasive method of analysing critical failure modes of implants that can be missed in patient scans. This will lead to device optimisation and will improve outcomes in paediatric cardiac surgery.

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