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FABRICATION OF MILI-SCALE CHANNELS FOR HEMODYNAMIC STUDIES

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ABSTRACT

An anatomical model representing a mili-scale bifurcation of an artery was constructed. A sequential method was developed to obtain a transparent PDMS model from a mold produced by rapid prototyping. The final objective is to manufacture transparent models that allow optical access to measure the velocity profiles of the flow of blood analogues by micro-particle image velocimetry (μPIV).

INTRODUCTION

From clinical practice, it is known that specific sites in human circulatory system are particularly sensitive to the development of cardiovascular diseases, such as atherosclerosis, stenosis and cerebral aneurisms (Akram, 2000). Local hemodynamic is believed to play an important role in the development of these lesions and so its knowledge is of great importance (Kristopher, 2005). Several researchers have been working on patient specific in vitro techniques that allow the experimental study of blood circulation in realistic configurations (Burgmann, 2009). This approach requires the construction of a model of the blood vessel under study. The models of complex geometries can be constructed by direct rapid prototyping from a 3D computational representation of the blood vessel or by casting in a mold produced by rapid prototyping.

RESULTS AND CONCLUSIONS

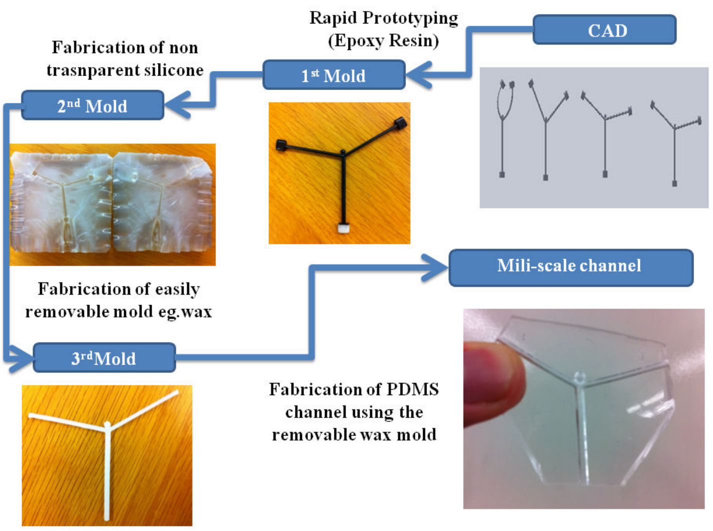

Fig. 1 - Fabrication method

In this work a four-step method was developed to create and replicate simplified models of arteries as shown in Fig. 1. Starting from the geometry previously created in CAD, a first mold made of an epoxy-resin was constructed by rapid prototyping using stereolithography. A negative version of the mold was then fabricated in non-transparent silicone. The next step was to use the silicone mold to cast a third mold using materials that can be easily removable from the final channel. This last mold is destroyed during the final step of fabrication, but we are able to use the second mold repeatedly to replicate anatomical models maintaining nearly the same characteristics. The final transparent channel is fabricated in polydimethylsiloxane (PDMS) and can be used in the hemodynamic studies using optical techniques.

Since the PIV technique requires an optical access, the refractive index of the PDMS was measured and a blood analogue solution that matches this refractive index was prepared (Fig. 2). The PDMS model was observed by microscopy (cf. Fig. 3) to verify the dimensions of the channels and the cross-section of the channels were compared to the original CAD-drawing (green lines in Fig. 3).

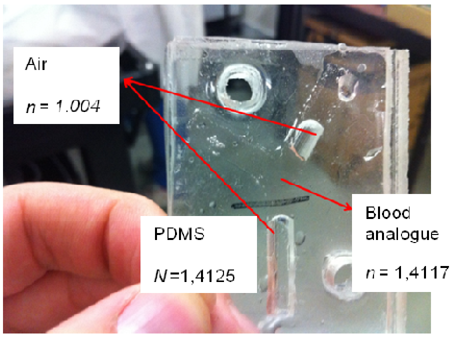

Fig.2 - Refractive index matching of blood analogue and PDMS.

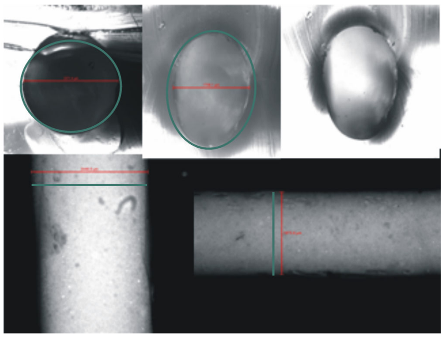

Fig.3 - Visualization of the mili-channels by microscopy.

This study shows that refractive index of the PDMS and the refractive index of a blood analogue can be matched and the dimensions of the channels are similar to the ones of the CAD model. Work is under way to visualize the flow of blood analogues by fluorescence microscopy and μPIV techniques.

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