Image Modalities to Visualize Polyester Fabric in Endovascular Stent Grafts

[1]Tong Yao, [2]Kyle Mathews, [2]Ian Robertson, [3]David S. Lalush, [4]Leonard W. Tse, [5]Gilles Soulez [1,6]Martin W. King,
[1]College of Textiles and [2]College of Veterinary Medicine, North Carolina State University, Raleigh, NC, 27695,
[3]Joint Department of Biomedical Engineering, North Carolina State University and University of North Carolina at Chapel Hill, Chapel Hill, NC, USA, [4]Division of Vascular Surgery, Toronto General Hospital, University of Toronto, ON, Canada
[5]CRCHUM, Université de Montréal, PQ, Canada, [6]College of Textiles, Donghua University, Shanghai, China.

Statement of Purpose: Implantable endovascular stent grafts have become a frequent option for the treatment of abdominal and thoracic aneurysms[1] and their long-term biostability needs to be addressed. For example, abrasion between the fabric graft and metal stent is known to occur and will eventually form holes after prolonged periods of implantation[2, 3]. In addition, in order to ensure blood flow to adjoining arteries it is sometimes necessary to make openings or fenestrations in the tubular graft fabric[4]. In such cases it is important to follow the size of the fenestration area and to monitor any subsequent changes that occur over time *in vivo*. The aim of this research study is to evaluate alternative visualizing modalities in order to determine which technique can be used to visualize polyester graft fabric either *in vivo* or during accelerated *in vitro* fatigue testing.

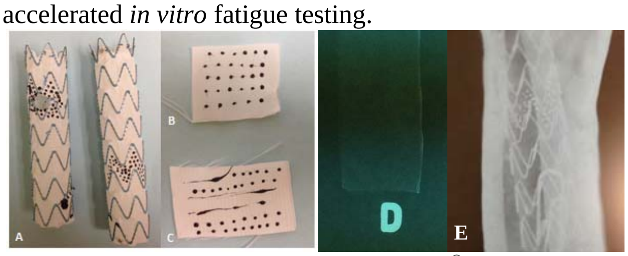

Fig.1 A: Painted stent-grafts. B: Cook Zenith® flat fabrics and C: Cook low profile flat fabrics. D: Radiographs of the nanosliver coated polyester fabrics and E: stent grafts coated with silicon based radio-opaque ink.

Methods: Two types of coatings were applied to polyester graft materials to make the graft material radio-opaque to x-rays: 1) nano-silver layer coating and 2) commercial silicon based radio-opaque ink. The polyester materials used were from the Medtronic Endurant® stent-graft, Cook Zenith® flat graft fabric, and Cook low profile (TX2®) flat graft fabric. (Fig 1) After coating, x-ray visualizations were done using a Faxitron cabinet imaging system. Then uncoated and radio-opaque ink coated Medtronic Endurant® endovascular stent-grafts were deployed inside a custom designed polyurethane aortic arch aneurysm phantom (Fig 2) designed to perform accelerated fatigue testing. Both a clinical CT scan and a micro CT scan were performed in order to visualize the polyester graft material inside the phantom. Wet and dry bursting tests were carried out before and after coating the flat polyester fabric to measure the effect of the coating on the mechanical properties.

Results: The results of the radiographs, clinical CT and micro CT scans are shown in Figures 1 & 2. These results showed that when viewed under x-rays in the Faxitron cabinet, the nano-silver coated polyester could not be distinguished from the uncoated polyester material. The silicon based radio-opaque ink dots were visible on the polyester fabric (Contrast noise ratio (CNR) between dots and fabric = 42.65) when viewed by x-ray radiography and by CT or micro CT. The radio-opacity of the silicon based ink was very similar to that of the nitinol metal stent material (CNR between dots and stent = -0.70). In addition, the application of the silicon based radio-opaque ink and water had no effect on the bursting strength, elongation at break and initial modulus of the polyester fabrics (Fig 3). However with contrast agent added to the clinical CT or micro CT scans there was insufficient contrast to visualize the uncoated polyester fabric separately from the water background.

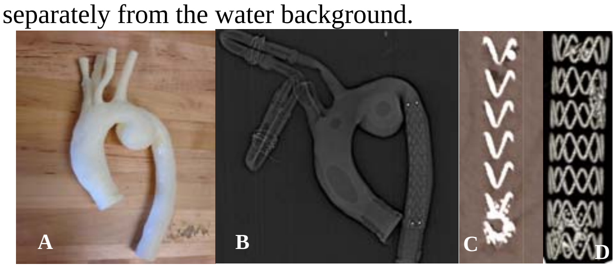

Fig.2 A:Custom designed polyurethane phantom of an aortic arch aneurysm, B:CT scan of uncoated and C:silicon based ink coated stent graft deployed inside the phantom with contrast agent. D: CT 3D volume rendering of the silicon based ink coated Medtronic Endurant stent graft with two fenestration holes.

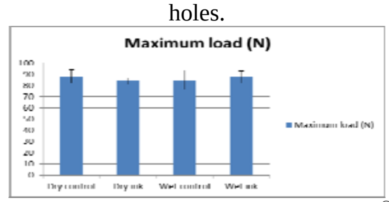

Fig.3 Bursting strength of Cook low profile (TX2®) flat graft fabric before and after coating ($p > 0.05$)

Conclusions: Nano-silver particles are not able to provide enough radio-opacity for polyester fabrics to be observed under x-ray. When silicon-based radio- opaque ink is coated on polyester fabric, it provides adequate radio-opacity with x-ray imaging systems and CT modalities for location purposes but not for measuring dimensions to within $\pm$ 1mm. The application of this ink does not affect the mechanical properties of polyester graft fabric. Clinical CT and micro CT scanning are not suitable imaging modalities to visualize the polyester material as a component of a stent graft either when viewed with contrast agent or in air.

References:

1. Duarte M,Maldjian C. Cardiol Rev 2009;17:112–114.
2. Guidoin R, Marois Y, Douville Y, King MW, Castonguay M, 2000;7:105–122.
3. Yao T, Choules BD, Rust JP, King MW. J of biomedical materials research. Part B. 2014;102(3):488-99.
4. Tse, L. Journal of Endovascular Therapy, 2012; 19(6), 721-722.