Surface Activation to Improve Adhesion between Nitinol Wire and Polyurethane Film.

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Statement of Purpose: Since the late 1980s, Nitinol has been utilized in an array of medical devices and, in some cases, has become one of the materials of choice for many designers and engineers. Similarly, polyurethane elastomers have been extensively used in many biomedical devices for over four decades because of their excellent biocompatibility and mechanical properties. One of the limitations in their use in the assembly of medical devices is the difficulty in bonding these elastomers to metallic components such as wire stents.[1] Embolic protection devices, whose skeletal structure consists of aforementioned materials faces a similar difficulty. The objective of this study was to determine which surface treatment would provide superior thermal bonding between nitinol wire and polyurethane film, which are usually used in designing embolic protection devices.

Materials and Methods: The polyether urethane film under study was supplied by American Polyfilm (Branford, CT).The film had a gauge of 5mil (i.e. thickness = 0.11 mm) and was optically clear in appearance. Silver colored, chemically etched and annealed 0.015 inch diameter nitinol wire was obtained from Fort Wayne Metals. Surface activation was attempted using radio frequency helium and helium-oxygen plasma treatments as well as mechanical roughening which was followed by thermal bonding to create a bonded pull-out test sample. Various combinations of treated and untreated surfaces were assessed using a modified ASTM pull-out strength test method to determine the level of adhesion. To characterize the differences between the untreated and treated polyurethane samples, scanning electron microscopy (SEM), x-ray photoelectron spectroscopy (XPS), and contact angle measurements were used.

Figure 1. Universal mechanical tester

A single composite pull-out test specimen required 4 film components and one straight wire component. A DC5 hot press (George Knight and Co., Brockton, MA), was used to assemble the 5 components by thermal bonding. The wire component was sandwiched between the front and back layers of the polyurethane film. A tabletop mechanical testing machine, Model 313 Series (Test Resources Inc., Minneapolis, MN) shown in Figure 1 was used to perform the pull-out strength test using a 250 N load cell, a crosshead speed of 0.1 mm/sec and pneumatic clamps (100 psi). For the radio frequency plasma treatment, the sample was moved into position under the plasma electrode emitting 750 watts of electric power for one minute.

Results The pull-out strength test results from the modified test method involving the as received nitinol wire and polyurethane film are given below.

Composite Sample	Pull-out Force (N)	
	Mean	Standard Deviation
Nitinol wire / film	18.45	1.97
Roughened Nitinol Wire/ film	20.76	4.36
Nitinol wire / He plasma treated film	11.67	1.86
Nitinol wire / He-O_2 plasma treated film	16.85	2.54

Conclusions: We found the level of adhesion was increased by roughening the wire prior to thermal bonding to the film. It was also observed that the radio frequency plasma treatment particularly in the case of the untreated wire and the helium plasma treated polyurethane film combination. This proved to be deleterious to the bonding strength between nitinol wire and polyurethane film. We also determined that the RF plasma treatment increased the level of oxygen content, as well as had a smoothing effect on the film, leading to lower levels of adhesion between the film and the wire.

References: 1. H Yoon, MW King, E Johnson. Designing vena cava filters with textile structures. MedTex07 Conference, Bolton, UK. July 16, 2007.