Mechanical properties of the Duplex stainless steel embolization coil for thermal occlusion of blood vessel

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Introduction

It is a useful characteristic that a recently developed thermocoil made of Duplex Stainless Steel (DSS) can generate therapeutic heat within a magnetic induction field. It may progress faster blood coagulation than a conventional embolization coil without any severe damage of surrounding tissue. A thermocoil maintains rectilinear shape within a catheter during the introducing process. However, the coil shape may recover its original circular shape after dropping from the catheter lumen as shown in figure 1. If the mechanical property of the thermocoil is not suitable for angioplasty then it may hurt blood vessel wall. Therefore the mechanical properties of thermocoil are considered important criteria during embolization procedure at abnormal sites. In this investigation, the radial strength and tensile characteristics of thermocoil were tested and analyzed with load-displacement curves.

Methods

Thermocoils were manufactured with 0.15mm diameter of DSS wire for mechanical tests. The average external diameter of the thermocoils was 4.52mm, the spring thickness was 0.49mm and the straightened coil length was 50mm.

Figure 1. Photograph of DSS thermocoil

The tensile test and the radial strength test were performed using an MTS 858 Bionix (MTS System corp., MN, USA) and a 250N load-cell. The stem moving speed was chosen as 0.05mm/sec during the tests, and the displacement and the load data were collected and recorded to a computer.

a) Tensile test

A hydraulic jaw was used for holding a tensile specimen and which is shown in figure 2. The upper limit of tensile test was set as 100mm.

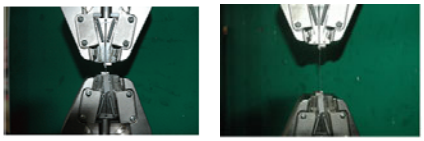

Figure 2. Photographs of tensile test with holding jaws

b) Radial strength test

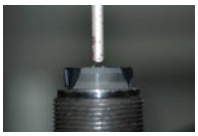

Figure 3. Fixture of thermocoil for radial strength test

A fixture for radial strength test of thermocoil was made of transparent acrylic polymer is shown in figure 3. The maximum actuator moving limit was preset as 2mm.

Results and discussions

In tensile test, we could observe the initial elastic slope and the second slope beyond the yield point as shown in figure 4. The average tensile load and yield strain of rectilinear thermocoils at yield point were 3.22N and 0.42 respectively. The average spring constant of rectilinear thermocoil was 7.75N.

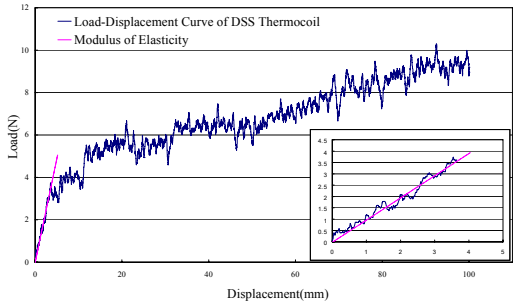

Figure 4. Load-displacement curve of tensile test of a DSS Thermocoil

The average radial strength was calculated from the cyclic compression-tension curves shown in figure 5. The radial strength of thermocoil which may against blood vessel wall is about 3.07N/m.

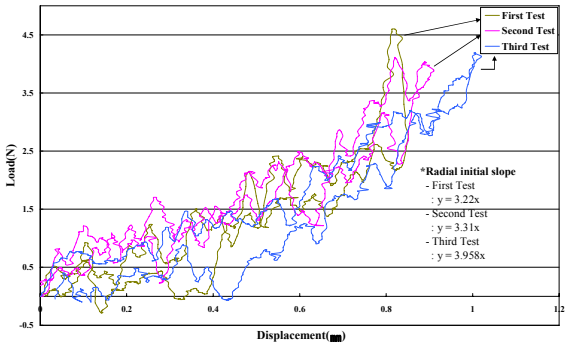

Figure 5. Cyclic compression-tension curves of the DSS thermocoil

Conclusions

The radial strength, spring constant and yield point of the newly developed DSS thermocoils were successfully measured with an MTS and fixtures. The results may be useful for future in vivo experimental design.

References

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