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DEVELOPMENT AND PERFORMANCE CHARACTERISTICS OF AN ULTRASOUND ANGIOPLASTY DEVICE

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INTRODUCTION

The effect of atherosclerosis is well documented and many procedures such as balloon angioplasty and stent implantation have been developed to reopen occluded arteries. However, there are considerable differences in the material properties of various atherosclerotic lesions as they develop. Many authors have suggested that rigid calcified plaques may require specific procedures that target this rigid material through de-bulking or complete removal (Salunke et al, 1997).

Ultrasound angioplasty is the delivery of high power low frequency ultrasound via a wire waveguide to the lesion location. This results in distal tip wire displacements of up to 100µm peak-to-peak (p-p) at frequencies of between 20-45 kHz (Atar, 1999 and Yock, 1997). Ultrasound angioplasty was shown to be effective in the ablation of fibrous and calcified blockages in arteries (Siegel, 1993). At the displacements and frequencies mentioned the pressure field developed can produce disruptive cavitations around the distal tip (Gavin et al, 2004).

The principal objective of this study was to develop an ultrasound angioplasty device and investigate its performance characteristics both experimentally and numerically.

MATERIALS AND METHODS

Ultrasound was generated by a piezoelectric transducer driven by an ultrasonic generator. The ultrasonic generator drives the transducer at its resonant frequency, in the case of the present device, 22.5 kHz with output displacements of between 3-18 µm (p-p). This output was passed into an acoustic horn with a wire waveguide attached to the distal end. These amplify the displacement characteristics and the waveguide has a working flexibility similar to present balloon catheters and a working length of approximately 500mm. The wire waveguide was ensheathed in a catheter with the distal end of the wire protruding at the tip.

The output (p-p) displacements at the distal end of the wire waveguide were measured using an optical microscope with video acquisition and measurement.

The characteristics of the system along the length of the wire waveguide have also been numerically simulated using FEA

RESULTS

The output displacement characteristics of the wire waveguide showed achievable peak-to-peak output displacements of 15- 90 µm (p-p) at 22.5 kHz. Fig. 1 shows an image obtained by the optical measurement system of the distal tip of a 1mm wire waveguide subjected to ultrasonic energy.

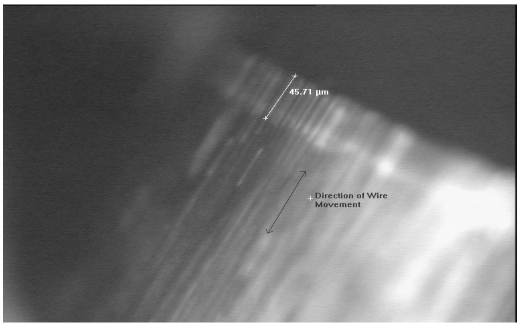

Fig. 1: Distal Tip Vibration (45.7 µm, 22.5 kHz)

DISCUSSION

This initial testing of tip displacements has proved promising and the comparison of the FEA and experimental results has shown good agreement.

Future studies involve identifying cavitations and testing is to be carried out on various materials that simulate plaque with a focus on rigid calcified lesions.

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