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A NUMERICAL ACOUSTIC FLUID- STRUCTURE SIMULATION OF THERAPEUTIC ULTRASOUND ANGIOPLASTY

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INTRODUCTION

Therapeutic ultrasound angioplasty is the delivery of high amplitude ultrasonic displacements to the distal-tip of small diameter wire waveguides with the goal of disrupting atherosclerotic plaques. This is a minimally invasive procedure that may have potential in the treatment of complicated chronic total occlusions. The disruption of plaque is due to direct contact ablation and also cavitation, pressure waves and acoustic streaming in the fluid surrounding the vibrating waveguide distal-tip [1]. Cavitation appears to play a major role and some authors have suggested that plaque ablation is only evident above the cavitation threshold [2].

Makin and Everbach [3] performed experimental measurements of the acoustic pressures in the field surrounding a vibrating wire waveguide distal-tip (frequency = 22.5 kHz, displacement amplitude = 65μm, tip diameter = 2.46mm). The measured acoustic pressures in the region ahead of the distal-tip are shown in Figure 1. No measurements could be made in the region close to the tip but the authors concluded that these pressures would be sufficient to cause the cavitation that was observed, based on the trend in Figure 1.

This work describes a numerical acoustic fluid-structure model of the wire waveguide and fluid surrounding the distal-tip. The model will predict wire waveguide behaviour to a prescribed ultrasonic input displacement and will predict pressures developed around the distal-tip.

METHODS

An axisymmetric numerical model of the wire waveguide and fluid surrounding the distal-tip based on the device description by Makin and Everbach [3] was developed in ANSYS©. The model consisted of both structural elements (Plane42) for the waveguide and acoustic elements (Fluid29) for the fluid. A fluid-structure interface was placed at element couplings and infinite acoustic boundary elements (Fluid129) defined the extremities of the model preventing acoustic reflection

RESULTS

A comparison of the experimental [3] and the numerical results are shown in Figure 1. A close comparison is achieved and, in addition, the numerical model can predict pressures at the fluid-structure interface. With the inclusion of a cavitation threshold (C_T), displacements and frequencies required to cause cavitation can be predicted

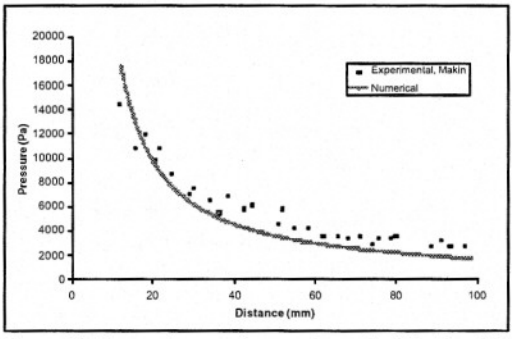

Figure 1: Comparison of experimental (Makin [3]) and numerical predicted acoustic pressures directly ahead of 2.46mm tip

CONCLUSION

The validated model can be used to investigate the effects of changing device parameters such as frequency of operation, displacement amplitudes and geometry, on both waveguide structural response (displacements and stresses) and pressures developed in the surrounding fluid.

REFERENCES

[1] Atar et al. *Eur. J. Ultrasound.*, 9, pp 39-54, 1999.
[2] Yock et al. Circulation, 95: pp 1360- 1362, 1997.
[3] Makin et al. *J. Acoust. Soc. Am.*, 100(3), pp 1855-64, 1996.