Interaction of High Intensity Focused Ultrasound with Biological Structures

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Abstract
This work is motivated by possible medical applications of focused ultrasound in minimally
invasive treatment of a variety of disorders. The mechanical and thermal effects caused by
focused high-frequency ultrasound in different material systems are calculated. The temperature
distribution in the focal zone is also calculated. The results indicate that the heating efficiency of
the ultrasound energy in the focal region depends on the exciting frequency and the geometry of
the focal zone depends on the material being tested. The thermal effects in both linear and
nonlinear models are calculated and compared in a two-layered structure consisting of water and
bone. In order to apply this numerical analysis technique to future clinical applications, a realistic
problem consisting of a series of 2-D models of the human torso at the level of the second and
third lumbar vertebrae (L2-L3) is considered. The model is subjected to simulated focused
ultrasound with changing positions and angles of incidence. The purpose of this exercise is to
determine the operating parameters that minimize damage to the surrounding tissue and nerve
while focused ultrasound generates thermal energy within the intervertebral disk. The geometry
of the model was generated by digitizing the relevant structural elements from a transverse CT
image containing an intervertebral disk at L2-L3. Elements important to the model included the
internal and external bone contours, spinal cord, soft tissue boundaries, and skin envelope.

Keywords
Focused ultrasound, Finite Element Method (FEM), Thermic Field.