

# Skin surface vibrations induced by cardiovascular dynamics: biomechanics of mechanical wave propagation through soft biological tissues

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## ABSTRACT

**Background** - The dynamics of the heart and the propagation of pressure waves in the arterial system induce mechanical disturbances that propagate as compressional and shear waves through the tissues (muscle and fat) to the skin surface, where they induce low amplitude displacements and vibrations that can be detected (e.g. with laser Doppler vibrometry). These signals might bear diagnostic and prognostic information, e.g., on the propagation speed of the pressure pulse in arteries (pulse wave velocity) or cardiac dyssynchrony. Skin vibrations might also reveal the presence of stenosis because of disturbed-induced fluctuations in superficial arteries. The physics of these mechanical waves is not well understood, and the accuracy, the sensitivity and the specificity of potentially novel diagnostic methods based on the assessment of the skin vibrations, are not known.

**Methods and results** - An integrated experimental-numerical approach is taken. Experimental models include both simple homogenous cylindrical structures subjected to forced oscillations and gel phantoms with embedded (stenosed) vessels, representative of the human anatomy and physiology. Experimental phantoms are made in PVA gel that is prepared by adding granulated PVA to deionised water and stirring the mixture while it is heating up to 90 °C. When cooled, the phantoms exhibit mechanical properties similar to biological tissues. Computer modelling is performed in Abaqus/Explicit (Abaqus 14.1). Constitutive model parameters (visco-elastic material model) are derived from experimental measurements, and boundary conditions are deduced from the experiments. Initial data demonstrate an excellent agreement between experimental observations of gel phantoms exposed to forced oscillations and the numerical simulations. After calibration and validation of the numerical model, the versatility of the computational model will be exploited to assess the determinants of mechanical wave propagation in soft biological tissues on patient-specific models of the neck and thorax region.

**Conclusions and perspectives** - The proposed integrated experimental-computational approach will provide insights into the physics of mechanical waves propagation in soft biological tissues and explore the theoretical limits of diagnostic techniques based on skin surface vibrations. These studies complement in-vivo research and will provide guidance for studies in patients.

## References

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