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Computational Feasibility Study of a Torsional Wave Transducer for Tissue Stiffness Monitoring

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Abstract : A torsional piezoelectric ultrasonic transducer design is proposed to measure shear moduli in soft tissue with direct access availability, using shear wave elastography technique. The measurement of shear moduli of tissues is a challenging problem, mainly derived from a) the difficulty of isolating a pure shear wave, given the interference of multiple waves of different types (P, S, even guided) emitted by the transducers and reflected in geometric boundaries, and b) the highly attenuating nature of soft tissular materials. An immediate application, overcoming these drawbacks, is the measurement of changes in cervix stiffness to estimate the gestational age at delivery. The design has been optimized using a finite element model (FEM) and a semi-analytical estimator of the probability of detection (POD) to determine a suitable geometry, materials and generated waves. The technique is based on the time of flight measurement between emitter and receiver, to infer shear wave velocity. Current research is centered in prototype testing and validation. The geometric optimization of the transducer was able to annihilate the compressional wave emission, generating a quite pure shear torsional wave. Currently, mechanical and electromagnetic coupling between emitter and receiver signals are being the research focus. Conclusions: the design overcomes the main described problems. The almost pure shear torsional wave along with the short time of flight avoids the possibility of multiple wave interference. This short propagation distance reduce the effect of attenuation, and allow the emission of very low energies assuring a good biological security for human use.

Keywords : cervix ripening, preterm birth, shear modulus, shear wave elastography, soft tissue, torsional wave
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