Compression OCE for combined assessment of linear and nonlinear tissue elasticity in application to fine differentiation of breast-cancer tissues

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Many soft biological tissues, including breast-cancer tissues manifest pronounced nonlinear elasticity In conventional ultrasonic elastographic examinations the fact of this nonlinearity is ignored, although a number of demonstrations were performed that indicated pronounced modification of elastographic scans for varying pre-loading of the tissue. Resolution of ultrasound elastography is insufficient for detailed characterization of tumor samples, whereas Optical Coherence Elastography enables much higher resolution better than 0.1 mm. Compression OCE (C-OCE) utilizing reference silicone layers opened unprecedented possibilities for obtaining nonlinear stress-strain curves. Combined assessment of linear and nonlinear parameters allows one to distinguish tissue subtypes even if they do not clearly differ by their Young’s moduli. In this study we used C-OCE to assess linear and nonlinear elastic properties of breast cancer samples from 50 patients. Significant differences were found among various subtypes of tumorous and non-tumorous tissues by comparing their conventionally measured Young’s modulus (for low stress <1 kPa) and nonlinearity parameter. For some tissue subtypes these elastic parameters taken separately demonstrated pronounced overlap, but their combined utilization made it possible to differentiate such tissue subtypes. In particular, fibrous stroma zones with small agglomerates of cancer cells and nearly pure fibrous stroma regions with isolated individual cancer cells do not yet demonstrate significant difference in the Young’s modulus. Nevertheless, these tissues appeared to be clearly singled out by their nonlinearity parameter. This fact is very important for finding clean resection boundary for surgically excised samples. The developed approach to morphological segmentation of OCE-images with accounting for both linear and nonlinear elastic parameters demonstrates good correspondence with the histological slices and can be used to radically improve diagnostic potential of C-OCE for a reliable clinical outcome, including intraoperative application.

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