Poster Presentation
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Real-time patient-specific evaluation of deep plantar tissue stresses in the diabetic foot by integration of shoe pressure measurements with the Hertz contact theory

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Elevated stresses in deep plantar tissue of diabetic neuropathic patients were associated with risk for foot ulceration, however, in the clinic, only interfacial pressures are being measured to evaluate susceptibly to ulcers [1]. This study aims at developing a method for deep plantar tissue stress evaluation in diabetics, by integrating shoe pressure measurements with Hertz's contact theory. The biomechanical model considers the heel and metatarsal head pads, where most ulcers occur [1]. For calculating stress concentrations around the bone-pad interface, plantar tissue is idealized as elastic and incompressible semi-infinite bulk (with properties measured by indentation), penetrated by a sphere with the bone's radius of curvature (from x-ray). Hertz's theory is used to solve the bone-pad mechanical interactions, after introducing correction coefficients to consider large deformations. Foot-shoe forces are measured to solve and display in real-time the principal compressive, tensile and von Mises plantar tissue stresses. For example, in one patient monitored by 3 flexible force sensors (Tekscan) under the heel in a gait laboratory, peak principal compressive stresses in the deep heel pad were ~2.5-fold the peak interface heel-shoe pressures (with the patient's own shoes), which strengthen the theoretical computations in [1]. Our system can be miniaturized in a handheld computer, allowing plantar stress monitoring at the natural patient's environment, which is an advantage over our previous real-time finite element stress analysis system [2] that requires larger computational power. Additional patient studies are underway to obtain descriptive statistics of internal stresses in diabetic plantar tissue during level walking and stairs climbing.

Reference: *1. Gefen A. Plantar soft tissue loading under the medial metatarsals in the standing diabetic foot. Med. Eng. Phys. 2003; 25: 491-499.*
2. Yarnitzky G., Yizhar Z., Gefen A. Real-time subject-specific monitoring of internal deformations and stresses in the soft tissues of the foot: A new approach in gait analysis. J. Biomech., in press, doi:10.1016/j.jbiomech.2005.08.021