MR Elastography of the Weight-Bearing Tissues of the Foot Developed in the Effort to Reduce Diabetic Foot Amputations

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Diabetic foot infection is an enormous medical problem that is known to involve changes in the stiffness of the involved tissue. Foot infection accounts for 20% of hospital admissions in diabetic patients. An infected foot ulcer frequently precedes lower extremity amputation. There were approximately 86,000 amputations related to diabetes in 1999. The annual treatment cost of amputees within this group is estimated at $1.2 billion by the Centers of Disease Control in 1997. This number is going to dramatically escalate to what has been called an epidemic because the overall prevalence of diabetes, now involving 16 million Americans, is increasing rapidly.

Effective early intervention and prevention depends on understanding the development of the factors leading to foot infections in diabetics. One of the contributing factors is the deterioration of the weight-bearing structures in the foot such as the fat pads in the heel and on the ball of the foot that absorb and distribute the impacts of walking.

A recent innovation in magnetic resonance imaging (MRI) will enable the authors to study the deterioration of the soft tissues of the foot. MR elastography is being developed to detect breast cancer which is harder than normal tissue. MR elastography detects breast cancer by measuring stiffness, just as a woman or physician feels cancer as a hard lump in the physical examination except that elastography is quantitative and more sensitive than the physical examination. This study shows that MR elastography can also be used to study the stiffness of the weight-bearing fat pads in the foot.

In this study we used specially designed MR elastography methods to measure the stiffness of the fat pads in the foot which normally absorb mechanical impacts generated during walking. The results reported in this study are the first measurements of the intrinsic mechanical properties of the foot's fat pads. All previous measurements were only able to measure the gross properties of the heel.

Measurements of the stiffness are important for several reasons. It will help scientists understand how the degradation of the fat pads in diabetics contributes to the development of the ulcers that precede infection and amputation. It provides a mechanism to follow the progression of the disease and to evaluate treatment.

In addition, this study reports that fat pads exhibit an increased stiffness under load. This effect will impact our understanding of how the foot operates during walking because structures get stiffer as the body's weight presses down on the foot. Better understanding will lead to better diagnosis and better treatment. The increase in stiffness under load is a commonly observed effect in man made materials such as steel but it was the first time such an effect has been observed in tissue.