Using MR Elastography to Evaluate Plantar Soft Tissue Damage in Diabetics

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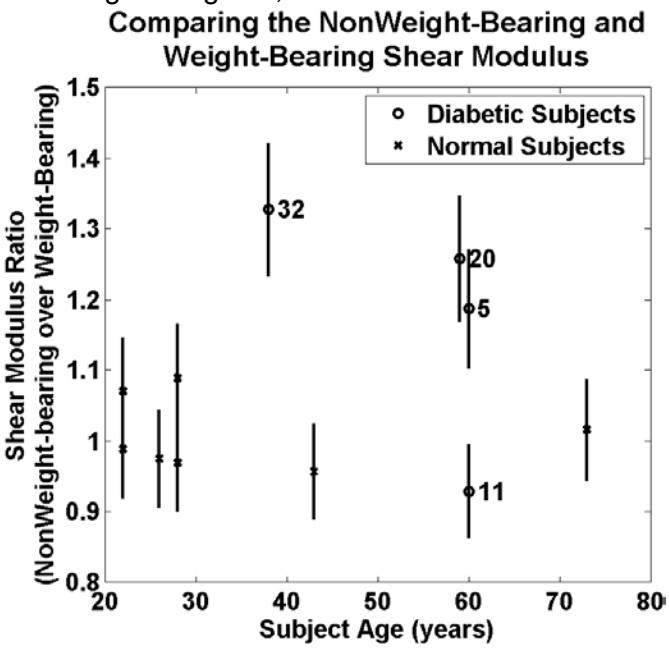
Introduction: Current research increasingly views diabetes as accelerated aging because the non-enzymic glucosylation of proteins, especially collagen, is identical in both processes. Advanced glycation end products, AGEs, which are produced by increased blood sugar in diabetes promote non-enzymic glucosylation of all proteins, but the most deleterious are the collagen cross links, similar to those observed in aging, which impact the stiffness and compliance of tissues. Most serious late complications of aging and of diabetes, including renal failure, cardiovascular disease and blindness, can be traced to that loss of compliance of collagen in the renal basement membrane, in the myocardium, in the arterial walls, and in the retinal capillaries. The loss of compliance of the collagen can be monitored in the plantar soft tissues where it is concentrated to distribute the forces induced during walking. However, the situation in those weight bearing tissues is complicated by the effects of physical wear.

Methods: We explored the effects of non-enzymic glucosylation on the collagen in the heel fat pad in diabetics by monitoring the stiffness of the tissue. To understand the effects of wear, we compared the shear modulus directly under the calcaneus, where the impacts of walking are highest, with the shear modulus to the side of the calcaneus where the forces are small.

The heel fat pads of 7 normal subjects and 4 diabetic subjects were imaged using MR elastography methods described previously [1,2]. The edges of the calcaneus were marked manually from the magnitude images independently of the shear modulus images. The average values of the shear modulus under the calcaneus and to either side of the calcaneus were calculated. The ratio of the shear modulus to the side of the calcaneus to that under the calcaneus was plotted at right. Each diabetic subject is labeled with the number of years the subject has had diabetes.



Results: The shear modulus under the calcaneus was essentially the same as the shear modulus to the side of the calcaneus in all of the normals (min p-value of 0.25 mean p-value was 0.6). Only one value was more than one standard deviation from one. Among the diabetics, three of the four had p-values of at least 0.97 indicating that the region under the calcaneus was softer than the region to the side of the calcaneus. In the remaining diabetic subject, the difference between the regions was not significant.

Conclusions: In this relatively small group of diabetic subjects, the region of the fat pad taking the largest impact during walking was significantly softer than peripheral regions indicating damage was being done to the fat pad from walking. Normals did not show any indication of such damage. The damage observed in the diabetic subjects increased monotonically with the number of years the subject has had diabetes. This is the first instance of imaging becoming important in evaluation of the mechanical properties of the heel.

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1) Van Houten et al A 3 Dimensional Subzone Based Reconstruction Algorithm for MR Elastography **Mag Reson Med 45**(5):827, 2001.
2) Weaver, et al, MR Elastography Using 3D Gradient Echo Measurements of Steady State Motion, **Med Phys**, **28**(8):1620-1628, 2001.