

#### Viscoelastic Response (VisR) Ultrasound for Noninvasively Assessing the Viscoelastic Properties of Tissue

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### The Mechanical Properties of Tissue are Diagnostically Relevant



Breast







Abdominal Organs

Musculoskeletal System



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### The Mechanical Properties of Tissue May be Assessed by Ultrasound



1. Expedite detection and differential diagnosis of diseases

2. Improve accuracy of disease diagnoses

3. Monitoring response to treatment



# Ultrasound May Be Implemented to Assess Tissue Mechanical Property



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### ULTRASOUND Property Assessment by Ultrasound

- 1. Introduce mechanical excitation
  - Intrinsic or extrinsic
  - Static, periodic, or impulsive
- 2. Monitor tissue response - Deformation - Shear wave velocity

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ULTRASOUND			

### Acoustic Radiation Force

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"The acoustic radiation force is produced by a change in the density of energy and momentum of the propagating waves because of the absorption, scattering or reflection from inclusions or from spatial variations in propagation velocity."

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### **Optical Tracking of ARF Excitation**



ARF in Application to 2D Imaging

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# Peak displacement conveys elasticity. How to measure *viscosity*?











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#### UNC NEED VisR Relative Elasticity Distinguishes Material Elasticity







### VisR Relative Viscosity Distinguishes Material Viscosity







VisR in Application to Monitoring Dystrophic Degeneration in Duchenne Muscular Dystrophy



### ULTRASOUND Pre-Clinical VisR Demonstration in GRMD Dogs



### UNC NOR Discriminates Fibrotic RF Muscle Versus Control





## UNCENCED VisR Discriminates Fibrotic RF Muscle ULTRASOUND Versus Control











ULTRASOUND VisR τ Standard Deviation Versus MRI T2



### UNC NCSU



ULTRASOUND research consortium VisR τ Standard Deviation Versus MRI RP









VisR  $\tau$  Relatively Unchanged in Subject 1 Sartorius







VisR  $\tau$  Increases in Subject 1 Gastrocnemius









# Next Steps: Anisotropy

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Biological Tissue Exhibits Structural Anisotropy









VisR  $\tau$  is angle dependent for asymmetric, but not symmetric, ARF focal configuration





VisR  $\tau$  is Angle Dependent for Asymmetric, but not Symmetric, ARF Focal Configuration





#### Conclusions

- Ultrasound may be implemented to noninvasively assess the mechanical properties of tissue, which are diagnostically relevant.
- VisR ultrasound is a new acoustic radiation force-based approach to estimating tissue viscosity, elasticity, and degree of anisotropy.
- VisR has been applied to monitoring dystrophic muscle degeneration in Duchenne muscular dystrophy.
- Other applications under study include kidney and atherosclerosis.

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### VisR Relative Elasticity and Relative Viscosity in Excised Pig Kidney





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research consortium	
Siemens Medical Solutions USA, Inc. Ultrasound Division Gallippi Lab Members and Alumni • Mallory Selzo • Tomek Czernuszewicz • Chase DuBois • Robert Hinson • Rebecca Geist • Chris Moore	Preclinical Studies • Amanda Bettis • Sharla Birch • Dan Bogan • Janet Bogan • Janet Bogan • Jennifer Dow • Heather Heath-Barnet • Joe Kornegay • Gayle McGchee • Kathy Spaulding • Eric Snook • Martin Styner • Jiahui Wang • Janice Weaver
	FEM Simulations <ul> <li>Kathy Nightingale</li> <li>Mark Palmeri</li> </ul>

#### Thank You

Cli	nical Studies
٠	Melissa Caughe
•	Manisha Chonra

Melrose Fisher	
James Howard	J

Regina EmmettDiane Meyer

#### Funding Sources

- NIH Grants R01-NS074057, R01-HL092944, K02-HL105659
- The NIH Integrated Biomedical Research
- Training Program
  Muscular Dystrophy
- Association Parent Project Muscular Dystrophy



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