Clemson University
TigerPrints

Focus on Creative Inquiry

Research and Innovation Month

2014

Detachable force sensor for an ultrasound probe to improve rotator cuff injury diagnosis

M. Showers

C. Kerr

H. Cash

C. Cobett

E. Kowal

See next page for additional authors

Authors
M. Showers, C. Kerr, H. Cash, C. Cobett, E. Kowal, H. Scruggs, M. Hanschke, D. Dean, and D. Kwartowitz

Force Sensor Ultrasound Probe Design for Better Rotator Cuff Injury Diagnosis

Hannah Cash, Cheryl Corbett, Megan Hanschke, Charles Kerr, Emily Kowal, Haley Scruggs
Kate Showers, Delphine Dean, PhD., David Kwartowitz, PhD.

CLEMSON UNIVERSITY

Department of Bioengineering, Department of Genetics and Biochemistry
Clemson University, Clemson, SC 29634

Creative Inquiry CLEMSON

INTRODUCTION

A majority of rotator cuff disease cases occur in the population that is over 60 years of age.
Manifestation of rotator cuff disease can range from tendinitis, or minor pain, to a complete tear which may be debilitating.
It is believed that in many cases rotator cuff disease is degenerative, and can be attributed to repetitive misuse of the shoulder muscles, for example rotator cuff injuries are commonly found in baseball pitchers.
Injury to the musculo-tendenous tissue of the rotator cuff can also occur as a result of acute trauma such as an impact or fall (Board, 2011).
Treatment for rotator cuff disease can range from physical therapy to surgery or a combination thereof.

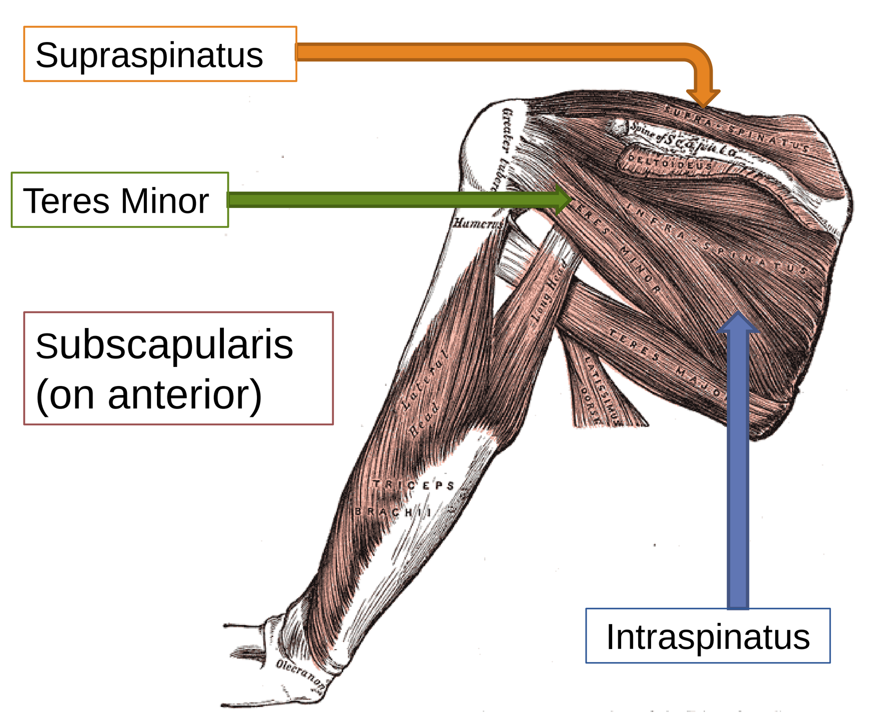

Figure 1: Posterior view of the left shoulder representing the four tendons that make up the rotator cuff.

Ultrasound is the second most common device used to look at rotator cuff injuries, and is the least expensive method.
Ultrasound imaging inherently lacks contextual information and has a high level of interimage variability and operator bias, which may make comparing images difficult.

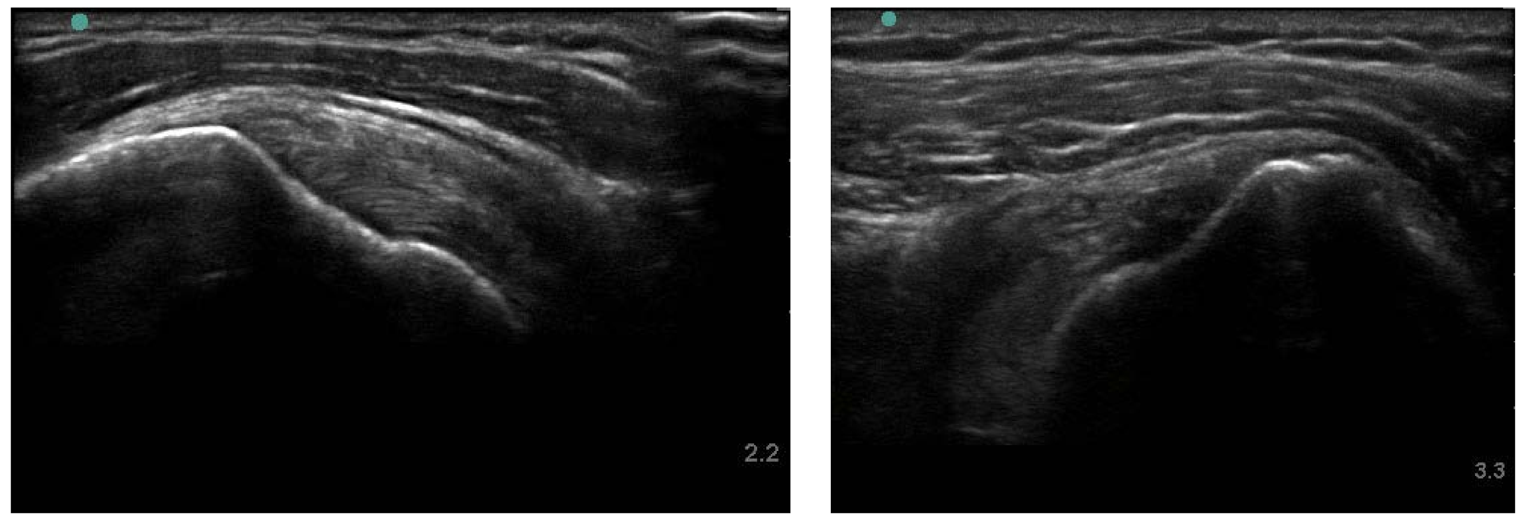

Figure 2: Ultrasound Images of rotator cuffs.

We aim to create an ultrasound imaging system that measures the amount of pressure being applied to the patient, thus giving the operator more information and helping better compare the images.

GOALS

- ➢To design a new ultrasound probe attachment capable of measuring applied pressure
- ➢To quantitatively measure tissue modulus using the feedback from the pressure sensor
- ➢To predict rotator cuff tears and long-term prognosis using the calculated tissue modulus and annotated images
- ➢Better assess rotator cuff injuries in a quicker and less expensive manner than MRI
- ➢Eliminate dependence on the skill and experience of the operator

DESIGN

A six layer sandwich was constructed using common cotton sewing fabric, stretch conductive fabric, and Ex-static fabric (Less EMF Inc., Latham, NY). The six layers were sewn together with non-conducting thread to create a pad. The pad is then attached to a probe attachment design that clicks onto the probe head. The impedance of each pad is measured using a simple Wheatstone Bridge circuit using a DAQ with 0.005V resolution. Under load, the impedance of the pad is reduced proportional to the magnitude of force experienced. The measured forces are then compared to the corresponding ultrasound image data.

Figure 3: Ultrasound probe attachment design.

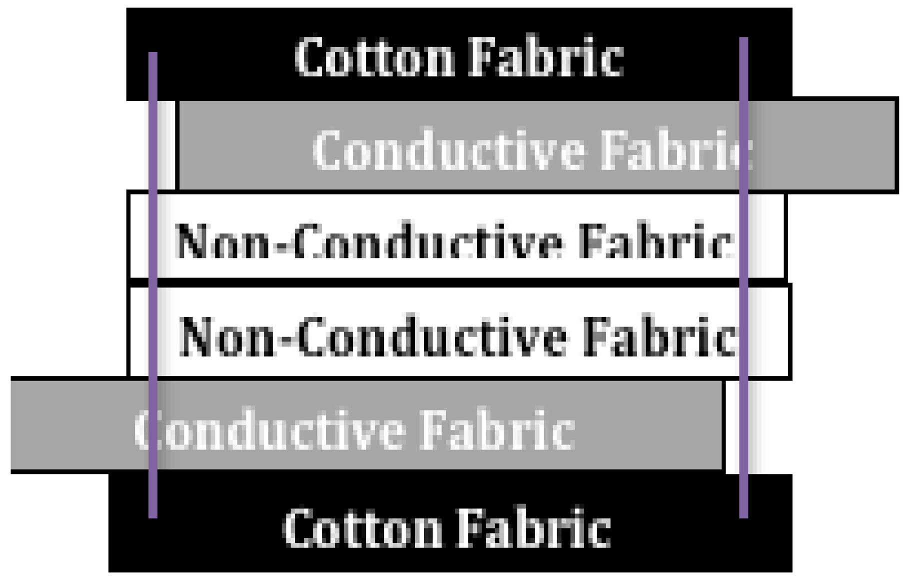

Figure 4: Pad design for current model.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Clemson University Undergraduate Studies Creative Inquiry program for funding. The authors would also like to thank the Steadman-Hawkins Clinic of the Carolinas and Proaxis Therapy for imaging and clinical support.

RESULTS & DISCUSSION

The probe attachment, designed via SolidWorks, allows for reading of pressure values without obstructing the ultrasound field of view. The bench top test for the original one-layer ex-static pad design produced a negative linear trendline of the voltage readings for the unsaturated range of weights. This trend was consistent for 5 pads of the original pad design indicating that there would not be a need to find a calibration line for each individual pad when using the pads in clinical applications. However, the range of unsaturated values (0-125Pa) was too low for the force that a clinician would use during an examination (~kPa-MPa pressures).

The bench top test for the 2 layer ex-static pad design displays a negative linear trend with shifted unsaturated range to a higher force range that could be applicable to clinical usage. Adding an additional layer of ex-static conductive fabric to our original design created a greater distance between the two stretch conductive fabric layers which resulted in a pad that would not saturate at very low pressures.

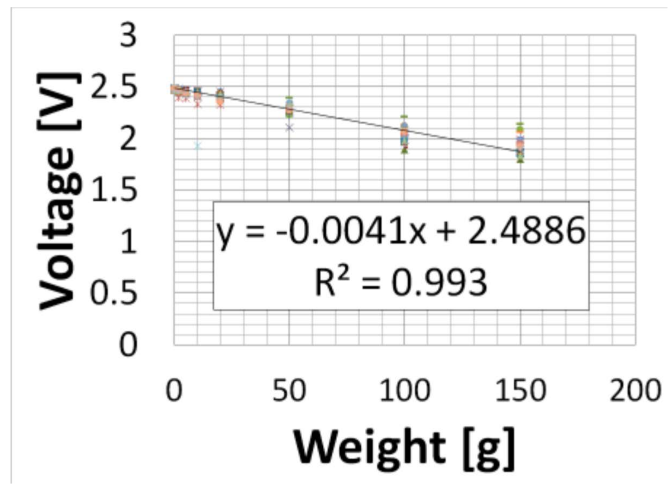

Figure 5: Output voltage vs. applied weight from a single pad over 25 trials showing a consistent linear trend.

CONCLUSION

With better rotator cuff tear diagnosis techniques, preventing injury and maintaining homeostatic function of the shoulder will be within reach. Small tear detection will become easier, and more obtainable for the patient in comparison to the stress, cost, and time of an MRI. These improvements will directly affect majority of the population since over 90% of adults experience rotator cuff tears in their life.

REFERENCES

Board, A.D.A.M Editorial. "Causes, Incidence, and Risk Factors." *Rotator Cuff Problems.* U.S. National Library of Medicine, 06 July 2011. http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001474/.

Chan, KM, Tong, CWC, "Rotator Cuff Disease and Shoulder Impingement Syndrome: Consensus and Controversies" ISAKOS. <http://www.isakos.com/innovations/shoulder.aspx> 14 Feb 2012.

Mora, Steve. A, "Introduction to Rotator Cuff Injuries" La Veta Orthopaedic Associates. <http://www.myorthodoc.com/patient-education/71-your-shoulder/236-introduction-to-rotator-cuff-injuries.html> 14 Feb 2012.