Ultrasound Transducer Holder

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Abstract

Advancements in ultrasound imaging software have made its use more prevalent in a clinical setting. Echometrix, a Madison-based startup company, recently developed innovative ultrasound video software involved in musculoskeletal diagnostics and rehabilitation. The software, however, requires the use of three hands in order to operate. A simple ultrasound transducer holder would eliminate this complication. The holder needs to be secured to the surface of the body and allow the transducer to be arranged over a location of interest (ie: shoulder, leg, arm, etc.) and then locked in place. Two designs are proposed, fabricated, and tested proving that the concept is plausible. The design alternatives are critiqued and compared in order to determine the best possible design for the future. Effectiveness, structural integrity and ease of use are some of the factors taken into account when assessing the designs.

Background

Ultrasound
- Transmittal and Reception of high frequency sound
- Acoustics of material change with load
- Mechanical properties can be obtained based on relationship

Echometrix Software (*echoSoft*)
- Dynamic Ultrasound imaging
- Tensile loading of tendon
- Track pixels to develop stiffness/strain relationships
- Healthy tissues vs injured tissues

Operation
- Three hands needed
  - › Hold transducer
  - › Apply load
  - › Turn on and operate software

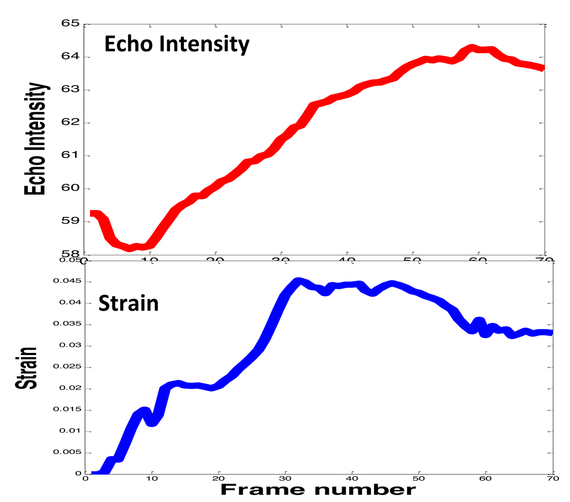

Fig 1: Acoustics of materials have been shown to change as a load is applied.

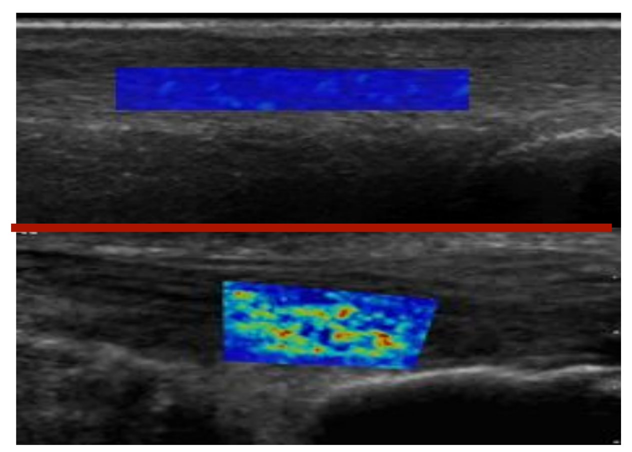

Fig 2: *EchoSoft* comparison of healthy and injured tendon's response to tensile loading.

Motivation

Efficiency
- Eliminates the need for a third hand
- Improves quality of tendon analysis

Tendon Analysis
- Tendons involved in skeletal movement
- Noninvasive
- Prognosis of injury
  - › Mechanical
  - › Structural
- Track progression of treatment

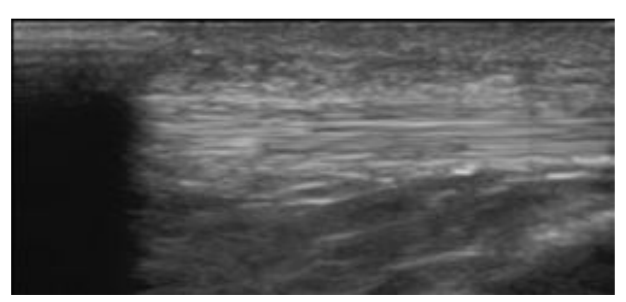

Fig 3: Shadow seen on image due to detachment of transducer from image during data collection.

Fig 4: Applying an ultrasound transducer to analyze the achilles tendon.

Final Design

Design 1 (Screw and Spring)

Components
- Fabricated rails and carriages
- Foam padding
- Velcro transducer connection
  - › Freedom of transducer orientation
- Z-direction Adjustment
  - › Screw
  - › Spring
  - › Sleeve
- 4 Velcro straps for body attachment
- Outer dimensions 19.7 cm x 18 cm

Assessment
- Securely and comfortably straps to the body
- Tightly holds transducer
  - › Longitudinal
  - › Cross-sectional
- Fabricated rails and carriages do not lock
- Precise square movements
- Capable of small movements in z-direction
- Small and lightweight
- Confined to area inside base
- With extended use readjustments of screws are needed
- Constrained access of on-site injection
- Structural strength – FOS = 24.8

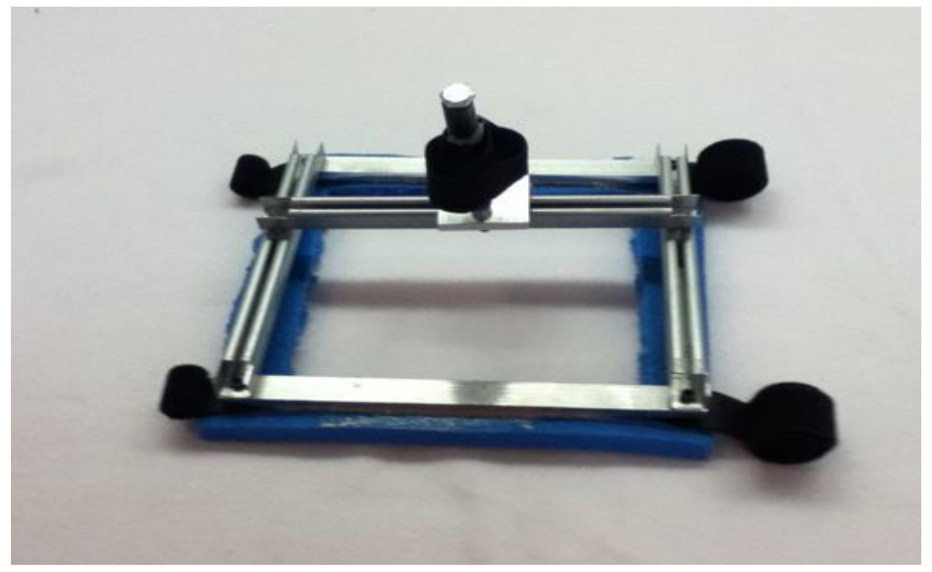

Fig 5: Picture of first design utilizing the screw and spring mechanism.

Flaws
- No rotation
- Limited z-direction adjustment does not allow close contact between transducer and skin surface
- Absence of locking feature
- Inconsistent frame integrity
  - › Forward tilt
  - › Screws loosen with use
- Crevices in rails are deep and hard to clean with 70% ethanol
- Insecure transducer connection
- Not able to view some joints (ie: knee, shoulder) due to confined area

Fig 6: Picture of second design attached to patient with leg extended (left) and with leg in flexed position (right).

Design 2 (Ball and Socket)

Components
- Manufactured rails and carriages
  - › Locks in place with screw
- Foam padding
- Manufactured transducer connection
- Two ball and socket joints
  - › 6 Degrees of freedom
- 4 Velcro straps for body attachment
- Outer dimensions 19.7 cm x 19.7 cm

Assessment
- Addresses and remedies major flaws in first design
- Securely and comfortably straps to the body
- Carriages firmly and easily locked in place
- Intuitive adjustment of transducer location
  - › Natural coarse adjustments
  - › Radius limits fine adjustments
- Allows for full rotation
- Able to extend outside of base area to reach joints and open injection access
- Structural strength: FOS = 3.66

Flaws
- Tedious locking mechanism
- Transducer connection not conducive to variable sizes
- Radius of motion limits adjustments
- Larger and heavier than original design
- Injection inside base

Design Criteria

- Securely straps on to surface of body over location of interest
- Allows translation, rotation
- 6 Degrees of Freedom
- Easily locks into desired position
- Holder can be cleaned with 70% alcohol
- Allow for needle injection therapy
- Develop and compare multiple designs in order to prove concepts

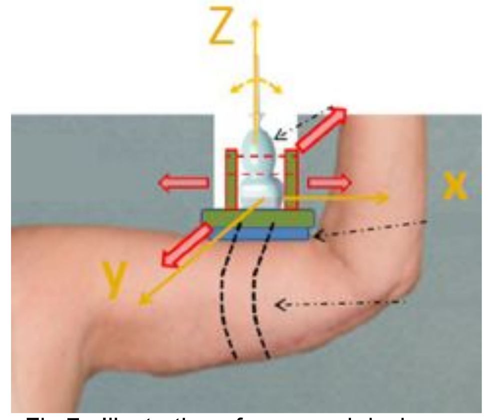

Fig 7: Illustration of proposed design concept.

Future Work

Size Reduction
- Reshaping support beams and rails
  - › No overhang
  - › Curve/Adjust to individual body topography
- Create space for easier injections
  - › Eliminate second support beam
  - › Support beam can be opened/removed
- Reduce weight

Ball and Socket
- More elegant movement
- Arm should be shorter
- Easier locking (button or switch)

Gripping System
- More versatile for odd shaped transducer

Locking Mechanism
- Easier to access
- Less user involvement

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