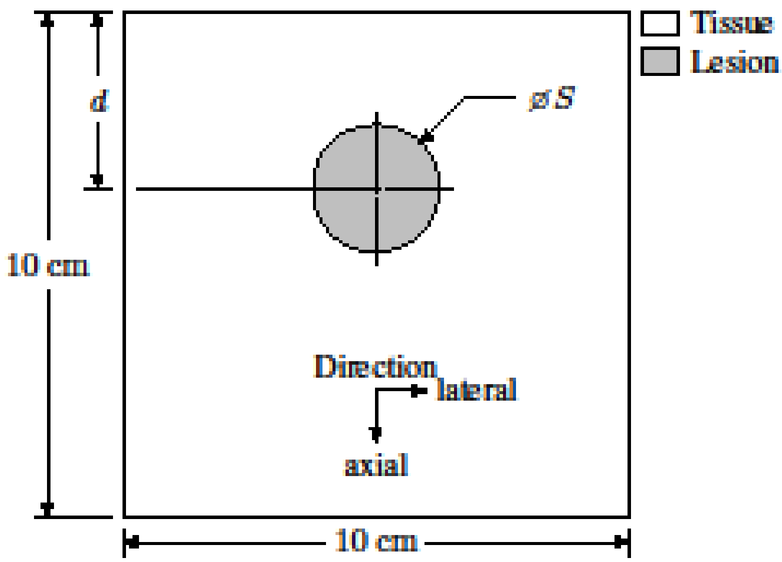
Abstract

Deep tissue injuries are subcutaneous regions of extreme tissue breakdown generally induced by the application of significant mechanical pressure over extended periods of time through the biological mechanisms of ischemia and cell deformation causing rupture. These wounds are commonly suffered as a secondary wound or disease, often formed due to extended periods of motionless such as stationary sitting in spinal cord injured patients or those undergoing surgery.



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Comment [K2]: Abstract should be <= 150 words and give decent summary of everything

Acknowledgements

Thanks!

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Chapter I: Introduction

In this introduction to the research, the main objectives and base motivations for the work are presented. The methodology used to investigate our objective is introduced and the remainder of the thesis is laid out.

I.1: Objective

The broad objective of this work was to numerically characterize the use of ultrasound elastography to detect and monitor formative and progressive deep tissue injuries. When the effect of numerous interrogation parameters is understood, the technology may be evaluated on its feasibility and usefulness to detect deep tissue injuries, with the ultimate goal that ultrasound elastography be implemented clinically for detecting deep tissue injuries.

Ultrasound elastography is a relatively new imaging modality which utilizes traditional ultrasound waveforms to interrogate tissue stiffness rather than tissue echogenicity as is done in classic ultrasound imaging. By examining displacement characteristics of tissue under load, its relative stiffness may be ascertained. However, before this modality can be used clinically with any degree of certainty, the effect of important parameters such as interrogation depth and probing frequencies must be understood and characterized.

I.2: Motivation

According to the National Pressure Ulcer Advisory Board, deep tissue injuries are classified as a sub-category of pressure ulcers [1]. Pressure ulcers and subsequently deep tissue injuries are commonly suffered by people with limited mobility, such as those undergoing lengthy surgical procedures, the elderly, and those with spinal cord injuries [2] with up to

80% of people with spinal cord injuries developing at least one pressure ulcer in their lifetime [3]. While traditional pressure ulcers form in a "top-to-bottom" pattern [??], deep tissue injuries form in a "bottom-to-top" pattern, whereby the injury starts deep below the skin surface – often at the bone-muscle interface [4]. This nature of not being externally visible until the wound has severely progressed makes deep tissue injuries exceedingly difficult to not only diagnose but also to prevent and treat. As of the time of writing, there is no clinically feasible method of detecting deep tissue injuries until they begin to damage the skin – even the National Pressure Ulcer Advisory Panel's description of them is largely based on their appearance after the fact [5]. With our inability to detect these forming injuries and subsequently implement deep tissue injury prevention and mitigation protocols, the injuries may eventually progress to form large subcutaneous cavities which eventually break through the surface and reveal themselves as stage III or IV pressure ulcers [6, 7].

I.3: Methodology

In order to investigate the use of ultrasound elastography for the detection of deep tissue injuries, the technology must be characterised. While traditional experimentation provides an opportunity to work with physical subjects

I.4: Thesis Outline

Chapter II: Literature Review

II.1: Introduction

II.2: Deep Tissue Injuries

II.2.1: Aetiology

II.2.2: Treatment

II.2.3: Detection

II.3: Ultrasound Elastography

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II.3.3: Shear Wave Speed Quantification

II.4: Numerical Characterisation / Finite Element Modelling

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III.1: Introduction

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III.2.1.1: Governing Equations

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III.2.2: Implementation of Tissue Strain Estimation Algorithm

III.3: Results

III.3.1: Lesion Depth Characterisation

III.3.2: Lesion Size Characterisation

III.3.3: Lesion Stiffness Characterisation

Chapter IV: Numerical Characterisation of Acoustic Radiation Force Impulse Imaging

IV.1: Introduction

IV.2: Methods

IV.2.1: Numerical Model

IV.2.1.1: Governing Equations

The governing equations used for this model were the set of coupled first-order partial differential equations given in equations **Error! Reference source not found. – Error! Reference source not found.**.

$$\frac{\partial \vec{u}}{\partial t} = -\frac{1}{\rho_0} p \qquad (4.2.1)$$

$$\frac{\partial p}{\partial t} = -\rho_0 \nabla \cdot \vec{u} \qquad (4.2.2)$$

$$p = c_0^2 p \qquad (4.2.3)$$

IV.2.1.2: Boundary and Initial Conditions

IV.3: Results

Chapter V: Numerical Characterisation of Shear Wave Speed Quantification

Chapter VI: Discussion

Chapter VII: Conclusion

VII.1: Clinical Need for DTI Detection

VII.2: USE Provides Potential Diagnosis Capability

VII.3: Future Work

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Appendix A: Source Code Listings

A.1: Quasi2DUltrasound

Appendix B: