Numerical model of laser tissue ablation and thermal injury

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1. Introduction

- Laser tissue ablation (LTA), is used in a variety of medical and cosmetic applications.
- These include skin rejuvenation, laser assisted drug delivery (LADD), treatment of acne scars and Rhinophyma, and coagulating scalpels.
- However, it is hard to predict crater depth and thermal injury to surrounding tissue.
- We use numerical models to help predict ablation depth and thermal

2. Numerical model

- Our numerical model has three portions

2.1 Monte Carlo radiation transport (MCRT)

- MCRT is a technique that allows the modelling of light transport through turbid media.
- Based upon interaction probabilities and random numbers.
- MCRT is used to calculate heat deposition due to the laser.

2.2 Numerical heat model

- We numerically solve the non-linear heat equation using a finite difference method, with MCRT providing the heat source.

2.3 Numerical damage model

- Arrhenius damage integral & physical damage model.
- Arrhenius damage integral calculates thermal damage to tissue as degree of burn.
- Physical damage model physically changes tissue, i.e ablation of tissue, boiling of water, and changes to optical and thermal properties.

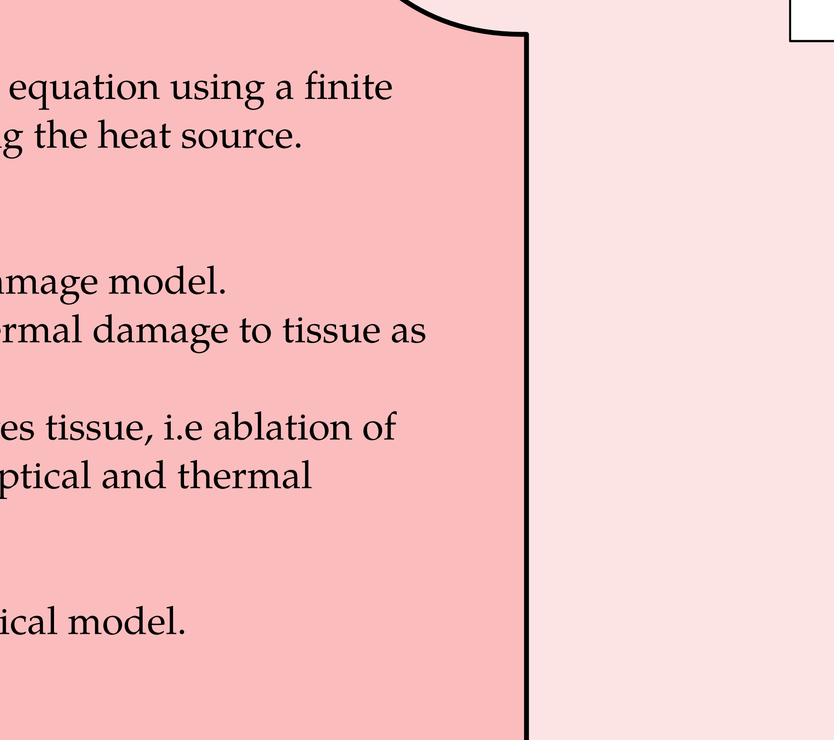
- Background illustrates the overall numerical model.

A) Incident laser light.
B) MCRT.
C) Normal tissue.
D) Thermally damaged tissue.

3. Experiments

- Validate simulation against experimental data.
- Experiment on porcine tissue ex-vivo using Pixel CO_2 laser.
- Ablation craters measured with Optical Coherence Tomography (OCT).
- Numerical model run with same parameters as experiment.

Figure 1)



4. Results

- Figure 1) Illustrates the thermal damage around one ablation crater.
- Figure 2) Shows a full numerical simulation of the experiment carried out on porcine tissue.

a) Side on view.
b) Top down view.
c) OCT image of ablated porcine tissue.

- Figure 3) Gives a comparison of ablation depth as a function of energy for the numerical data and experimental data.

Figure 2)

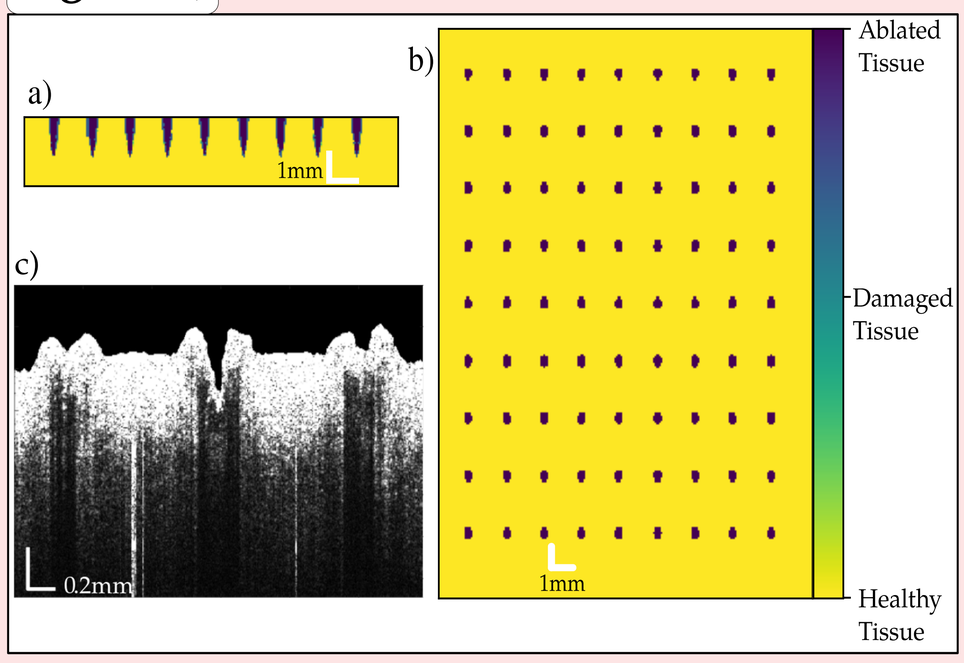
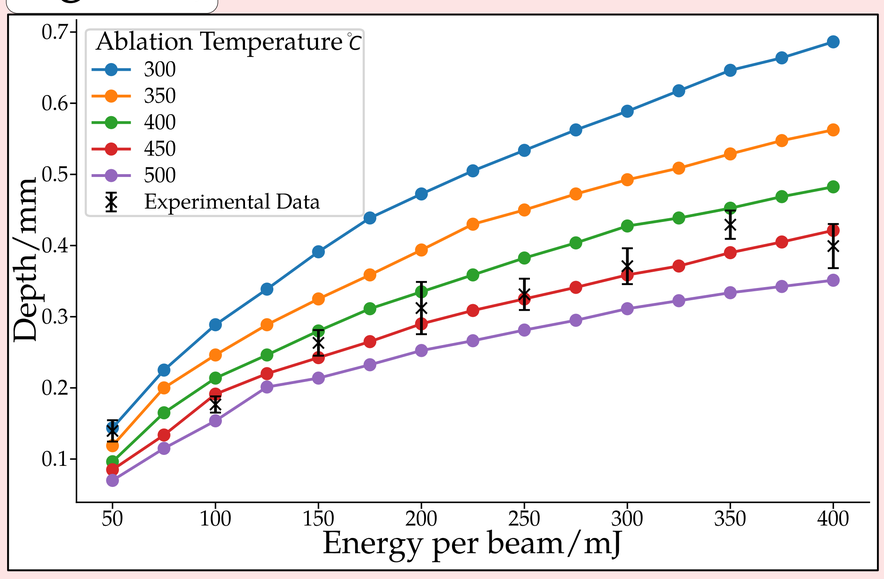


Figure 3)



5. Conclusion

- Have shown that numerical model matches experimental results for a determined ablation temperature.
- In future the model could be used to help predict/optimise treatment outcomes for a variety of cosmetic and medical procedures.

6. Acknowledgments

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