



University of Southern Queensland  
Faculty of Engineering and Surveying

# **Welding of Skin using Nd:YAG Laser with Bipolar Contact Applicators**

A dissertation submitted by  
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In fulfilment of the requirements of

**Master of Engineering**

## **Certification of Dissertation**

I certify that the ideas, designs and experimental work, results, analysis and conclusions set out in this dissertation are entirely my own efforts except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution.

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Date

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Professor John Grant-Thomson (Supervisor)

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Date

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## Chapter Headings

<b>1</b>	<b>GENERAL INTRODUCTION.....</b>	<b>1</b>
<b>2</b>	<b>LASERS – OVERVIEW AND USE IN MEDICINE.....</b>	<b>5</b>
<b>3</b>	<b>TISSUE WELDING LITERATURE REVIEW.....</b>	<b>35</b>
<b>4</b>	<b>NEODYMIUM: YTTRIUM ALUMINIUM GARNET (ND:YAG) LASER.....</b>	<b>44</b>
<b>5</b>	<b>METHODOLOGY.....</b>	<b>58</b>
<b>6</b>	<b>ANALYSIS AND DISCUSSION OF RESULTS.....</b>	<b>81</b>
<b>7</b>	<b>CONCLUSION.....</b>	<b>133</b>
	<b>APPENDIX A BASIC COMPONENTS AND OPERATION OF A LASER.....</b>	<b>141</b>
	<b>APPENDIX B CLASSIFICATION OF LASERS AND LASER SAFETY.....</b>	<b>148</b>
	<b>APPENDIX C TYPES OF LASERS USED IN MEDICINE.....</b>	<b>162</b>
	<b>APPENDIX D APPLICATIONS OF LASERS IN MEDICINE.....</b>	<b>176</b>
	<b>APPENDIX E LASER DELIVERY METHODS.....</b>	<b>202</b>
	<b>APPENDIX F OPTICAL PARAMETERS OF LASER TISSUE INTERACTION.....</b>	<b>204</b>
	<b>APPENDIX G ETHICS GUIDELINES AND APPROVALS.....</b>	<b>209</b>
	<b>APPENDIX H CERTIFICATE OF EQUIPMENT CALIBRATION.....</b>	<b>223</b>
	<b>GLOSSARY OF TERMS.....</b>	<b>224</b>
	<b>REFERENCES.....</b>	<b>231</b>

## Contents

<b>1</b>	<b>GENERAL INTRODUCTION .....</b>	<b>1</b>
1.1	BACKGROUND.....	1
1.2	PROJECT OBJECTIVES.....	2
1.3	THESIS ORGANISATION .....	4
<b>2</b>	<b>LASERS – OVERVIEW AND USE IN MEDICINE .....</b>	<b>5</b>
2.1	BASIC LASER OPERATION .....	5
2.2	BRIEF HISTORY OF THE LASER .....	6
2.3	HISTORY OF MEDICAL LASERS .....	10
2.4	CLASSIFICATION OF LASERS.....	11
2.5	LASER SAFETY .....	13
2.6	LASERS AND MEDICINE.....	15
2.7	DELIVERY SYSTEMS AND LASER TISSUE INTERACTION .....	19
2.7.1	<i>Interaction Parameters</i> .....	20
2.7.2	<i>Photothermal mechanisms</i> .....	24
2.7.3	<i>Photochemical interaction</i> .....	30
2.7.4	<i>Photodisruption (Photoacoustical) interactions</i> .....	31
2.7.5	<i>Photoablative interactions</i> .....	32
<b>3</b>	<b>TISSUE WELDING LITERATURE REVIEW .....</b>	<b>35</b>
3.1	ANASTOMOSIS .....	38
3.2	TISSUE WELDING (SKIN).....	40
3.3	MECHANISMS OF TISSUE WELDING.....	43
<b>4</b>	<b>NEODYMIUM: YTTRIUM ALUMINIUM GARNET (Nd:YAG) LASER.....</b>	<b>44</b>
4.1	Nd:YAG OPERATION .....	44
4.2	HISTORY .....	44
4.3	EFFECT OF Nd:YAG LASER LIGHT ON TISSUE .....	47
4.4	NONCONTACT DELIVERY SYSTEMS .....	49
4.5	CONTACT DELIVERY SYSTEMS .....	50
4.6	PARAMETERS RELEVANT TO TISSUE WELDING USING Nd:YAG CONTACT PROBES.....	55

<b>5</b>	<b>METHODOLOGY .....</b>	<b>58</b>
5.1	ETHICS .....	59
5.2	EXPERIMENTAL DESIGN.....	59
5.2.1	<i>Number of Animals</i> .....	59
5.2.2	<i>Justification of animal usage</i> .....	60
5.3	GENERAL CARE OF EXPERIMENTAL ANIMALS .....	64
5.4	TENSILE TESTING OF RAT SKIN .....	65
5.4.1	<i>Test Equipment</i> .....	65
5.4.2	<i>Test Procedures</i> .....	68
5.5	LASER WELDING VERSUS SUTURING.....	73
5.5.1	<i>Suturing</i> .....	74
5.5.2	<i>Laser welding</i> .....	75
<b>6</b>	<b>ANALYSIS AND DISCUSSION OF RESULTS.....</b>	<b>81</b>
6.1	TENSILE TESTING.....	81
6.1.1	<i>Yield Force – Female</i> .....	88
6.1.2	<i>Elongation – Female</i> .....	97
6.1.3	<i>Yield force - Male</i> .....	100
6.2	STATISTICAL MODEL FOR BASELINE STRENGTH .....	106
6.3	LASER POWER SETTINGS .....	107
6.4	LASER VS SUTURING HEALING .....	109
6.5	STATISTICAL MODEL FOR LASER WELDED AND SUTURE HEALING .....	118
6.5.1	<i>Laser Welded Wounds</i> .....	118
6.5.2	<i>Sutured Wounds</i> .....	119
6.6	A COMPARISON OF LASER AND SUTURE STRENGTHS .....	120
6.7	HISTOLOGY .....	122
<b>7</b>	<b>CONCLUSION.....</b>	<b>133</b>

## Appendices

<b>APPENDIX A BASIC COMPONENTS AND OPERATION OF A LASER.....</b>	<b>141</b>
BASIC COMPONENTS OF A LASER.....	141
BASIC OPERATION OF A LASER .....	142
MODES OF OPERATION .....	143
TERMS TO DESCRIBE THE LASER BEAM.....	145
<i>Focal Length</i> .....	145
<i>Wavelength</i> .....	145
<i>Transverse Electromagnetic Mode</i> .....	145
<i>Energy</i> .....	146
<b>APPENDIX B CLASSIFICATION OF LASERS AND LASER SAFETY .....</b>	<b>148</b>
CLASS I .....	148
CLASS IIA AND CLASS II .....	149
CLASS IIIA AND CLASS IIIB.....	149
CLASS IV .....	150
LASER SAFETY .....	151
<i>Eye</i> .....	154
<i>Skin</i> .....	159
<i>Smoke Plume</i> .....	160
<b>APPENDIX C TYPES OF LASERS USED IN MEDICINE.....</b>	<b>162</b>
GAS .....	162
<i>Helium-neon</i> .....	162
<i>Argon</i> .....	163
<i>Carbon Dioxide (CO<sub>2</sub>)</i> .....	165
<i>Metal vapour</i> .....	169
<i>Excimer</i> .....	169
LIQUID .....	171
<i>Dye lasers</i> .....	171
SOLID STATE .....	172
<i>Ruby</i> .....	173
<i>Nd:YAG (Neodymium: Yttrium Aluminium Garnet)</i> .....	173
<i>KTP</i> .....	174
<i>Er:YAG (Erbium: Yttrium Aluminum Garnet)</i> .....	174
<i>Ho:YAG (Holmium: Yttrium Aluminum Garnet)</i> .....	175
SEMICONDUCTOR .....	175

<b>APPENDIX D APPLICATIONS OF LASERS IN MEDICINE.....</b>	<b>176</b>
GENERAL SURGERY .....	178
DERMATOLOGY.....	178
<i>Vascular lesions</i> .....	180
<i>Cutaneous lesions</i> .....	184
COSMETIC SURGERY AND PLASTIC SURGERY .....	185
<i>Tattoo removal</i> .....	185
OTORHINOLARYNGOLOGY .....	186
GASTROENTEROLOGY .....	188
GYNAECOLOGY .....	189
OPHTHALMOLOGY.....	190
<i>Photocoagulation</i> .....	191
<i>Photodisruption</i> .....	191
UROLOGY.....	194
LASER ANGIOPLASTY .....	194
NEUROSURGERY.....	195
ORTHOPAEDICS .....	196
DENTISTRY AND ORAL SURGERY .....	198
PHOTOMEDICINE (INCLUDING BIOSTIMULATION AND PHOTODYNAMIC THERAPY) .....	200
<b>APPENDIX E LASER DELIVERY METHODS.....</b>	<b>202</b>
<b>APPENDIX F OPTICAL PARAMETERS OF LASER TISSUE INTERACTION.....</b>	<b>204</b>
REFLECTION .....	204
SCATTERING.....	206
TRANSMISSION .....	206
ABSORPTION .....	206
<b>APPENDIX G ETHICS GUIDELINES AND APPROVALS .....</b>	<b>209</b>
1. USQ GUIDELINES FOR THE PREPARATION OF APPLICATIONS FOR ETHICS CLEARANCE.....	209
2. ETHICS APPLICATION .....	211
3. ETHICS COMMITTEE APPROVAL .....	220
4. QUEENSLAND GOVERNMENT APPROVAL .....	221
5. ST ANDREW’S HOSPITAL APPROVAL.....	222
<b>APPENDIX H CERTIFICATE OF EQUIPMENT CALIBRATION.....</b>	<b>223</b>
<b>GLOSSARY OF TERMS.....</b>	<b>224</b>
<b>REFERENCES.....</b>	<b>231</b>



## List of Tables

Table 2-1 Current uses of lasers .....	6
Table 2-2 History of development of the laser.....	9
Table 2-3 Development of medical laser technology.....	11
Table 2-4 Laser classification overview .....	12
Table 2-5 Summary of laser hazards .....	13
Table 2-6 Summary of clinical use of lasers in medicine.....	17
Table 2-7 Summary of laser wavelengths commonly used in medicine.....	18
Table 2-8 Laser delivery systems.....	19
Table 2-9 Parameters influencing interaction mechanisms .....	20
Table 2-10 Depth of penetration into tissue for varying wavelengths .....	26
Table 2-11 Thermal effects of laser radiation.....	26
Table 2-12 Summary table of laser tissue interactions.....	34
Table 3-1 Summary of tissue welding research and clinical procedures.....	37
Table 3-2 Summary of types of lasers used for tissue welding.....	39
Table 3-3 Brief summary of cutaneous tissue welding .....	42
Table 4-1 History of development of Nd:YAG medical laser .....	47
Table 4-2 Comparison of contact and non-contact power .....	52
Table 4-3 Comparison of laser features with Nd:YAG contact and non-contact modes .....	53
Table 4-4 Characteristics of contact and noncontact Nd:YAG.....	54
Table 5-1 Summary of experimental stages.....	58
Table 5-2 Specifications for mechanical clamps (HT50) .....	66
Table 5-3 Specifications for Houndsfield Universal Testing Machine.....	67
Table 6-1 Number of samples tested from each test position- Female rats.....	82
Table 6-2 Number of samples tested from each test position- Male rats.....	82
Table 6-3 Model summary for baseline strength .....	106
Table 6-4 ANOVA table of yield strength.....	107
Table 6-5 Comparison of laser settings and skin temperature .....	109
Table 6-6 Laser and Suture - notes of wounds .....	111
Table 6-7 Model summary for laser welded wounds .....	119
Table 6-8 Model summary for sutured wounds .....	119

Table B-1 Laser classification overview .....	148
Table B-2 Selected occupational exposure limits (MPE's) for medical lasers .....	151
Table B-3 Laser safety standards reference.....	152
Table B-4 Laser safety requirements.....	153
Table B-5 Laser class with major hazards.....	154
Table B-6 Laser wavelength and eye damage .....	158
Table B-7 Summary of possible skin damage by laser radiation .....	160
Table C-1 Use of argon lasers in medicine (including experimental work).....	165
Table C-2 Various types of medical dye lasers and uses.....	172
Table D-1 Laser usage in major area of medicine .....	177
Table D-2 Laser type and effect on tattoo dye .....	186
Table D-3 Gastrointestinal endoscopic applications of the Nd:YAG laser.....	189
Table D-4 Uses of lasers in neurosurgery .....	196
Table D-5 Summary of laser uses in standard orthopaedic procedures.....	198
Table D-6 Lasers in dentistry research .....	199
Table D-7 Biostimulative effects of Helium-Neon laser .....	201

## List of Figures

Figure 1-1 Laser sales 2000-2001 .....	3
Figure 2-1 Map of laser tissue interactions .....	22
Figure 2-2 Absorption coefficients for several biological structures .....	23
Figure 2-3 Absorption coefficient of the constituents of skin .....	24
Figure 2-4 Flowchart of parameters for thermal interactions .....	25
Figure 2-5 Location of thermal effects .....	27
Figure 2-6 Critical temperature for the occurrence of cell necrosis .....	29
Figure 4-1 Nd:YAG laser energy distribution in tissue and loss through backscatter .....	52
Figure 4-2 Radiation from bipolar probes .....	55
Figure 4-3 Depth of tissue necrosis as a function of laser power .....	57
Figure 4-4 Laser power relationship for smoke production and blood loss .....	57
Figure 5-1 (a) Initial plan for tensile testing (b) Final plan for testing .....	62
Figure 5-2 Microtensile test die manufactured to ASTM D-1708 standards .....	66
Figure 5-3 Blunt dissection process .....	69
Figure 5-4 Test position layout .....	70
Figure 5-5 Test specimen showing "shrink back " .....	71
Figure 5-6 Mounting of test sample in clamps .....	72
Figure 5-7 Position of incisions .....	74
Figure 5-8 (a) Preparation of wound site (b) incision on rat .....	74
Figure 5-9 Suturing of rats .....	75
Figure 5-10 Initial welding technique (a and b) .....	76
Figure 5-11 Final welding technique .....	77
Figure 5-12 Tissue welding using bipolar Nd:YAG laser and appropriate safety glasses .....	78
Figure 5-13 Welding process – Clockwise from top left (a) welding dermis with bipolar probes (b) welding top layers of skin (c) thermal relaxation of skin (d) wound at 1 day .....	78
Figure 5-14 Suture and laser wound at 1 day .....	79
Figure 5-15 Test samples taken from wound area .....	80
Figure 5-16 Wound position on test specimen (a) correct position (b) incorrect placement .....	80
Figure 5-17 Lasered test sample on sand paper prior to mounting in clamps .....	80
Figure 6-1 Limits of break site on test specimens .....	83
Figure 6-2 Approximate locations of specimen failures .....	83
Figure 6-3 Typical tensile test response of complete skin failure - Male .....	85
Figure 6-4 Typical tensile test response of connective tissue – male .....	85

Figure 6-5 Typical tensile test response for complete skin failure – Female.....	86
Figure 6-6 Typical tensile test response of connective tissue - Female.....	86
Figure 6-7 Typical tensile test response indicating slippage.....	87
Figure 6-8 Test specimen in clamps of testing machine.....	87
Figure 6-9 Female mean tensile strength.....	90
Figure 6-10 Significance of age and position on tensile strength.....	91
Figure 6-11 Normalised standard deviations for related positions for female rats.....	91
Figure 6-12 Female tail break force data.....	93
Figure 6-13 Female head break force data.....	95
Figure 6-14 Female midline break force data.....	96
Figure 6-15 Average elongation for each position for female rats.....	98
Figure 6-16 Normalised standard deviations of elongation for each position.....	98
Figure 6-17 Elongation for head line - Female.....	99
Figure 6-18 Elongation for midline - Female.....	99
Figure 6-19 Elongation for tail line - Female.....	100
Figure 6-20 Male mean tensile strength.....	101
Figure 6-21 Tensile strength data from individual male rats.....	102
Figure 6-22 Male head break force data.....	103
Figure 6-23 Male midline break force data.....	103
Figure 6-24 Male tail break force data.....	104
Figure 6-25 Female mean tensile strength by position.....	105
Figure 6-26 Male mean tensile strength by position.....	105
Figure 6-27 Completed wound closure with laser.....	108
Figure 6-29 Sample numbering for healing rate tests.....	110
Figure 6-30 Severe irritation of wound.....	112
Figure 6-31 Irritation caused by stitches.....	112
Figure 6-32 Laser wound showing normal healing - day 2.....	113
Figure 6-33 Normal healing of sutures, stitches undone by rats grooming.....	113
Figure 6-34 Normal healing of wounds - Laser.....	114
Figure 6-35 Normal healing of wounds - Suture.....	115
Figure 6-36 Rat 3-4 at 7 days (a) epidermis (b) dermis.....	115
Figure 6-37 Tensile test of suture wound showing healing rates.....	117
Figure 6-38 Tensile test of laser welded wound showing healing rates.....	118
Figure 6-39 Laser and sutured healing rates.....	121

Figure 6-40 Samples for histological analysis.....	123
Figure 6-41 Cross-section of normal skin .....	124
Figure 6-42 Low magnification showing scar tissue.....	125
Figure 6-43 Hair follicle in area of healing.....	126
Figure 6-44 Subcutaneous tissues at high magnification.....	127
Figure 6-45 Fibroblastic scar tissue at low magnification.....	128
Figure 6-46 Dense fibroblastic scar tissue .....	129
Figure 6-47 High magnification showing cellular nature of scar. ....	130
Figure 6-48 Low magnification of scar tissue .....	131
Figure 6-49 Tissue at epidermal-dermal junction .....	132
Figure A-1 Electromagnetic spectrum.....	141
Figure A-2 Basic components of a laser .....	142
Figure A-3 Population inversion and pumping of atoms.....	142
Figure A-4 Laser system.....	143
Figure A-5 Modes of operation .....	144
Figure A-6 Variation of power density with beam area.....	147
Figure B-1 Anatomical diagram of the eye.....	155
Figure B-2 Damage to eye from laser wavelengths.....	156
Figure C-1 Spot size and tissue effect .....	167
Figure C-2 Modes of operation of CO <sub>2</sub> laser.....	168
Figure F-1 Optical properties.....	204
Figure F-2 Reflection .....	205
Figure F-3 Absorption coefficients of selected tissues .....	207
Figure F-4 Absorption coefficient of water .....	208
Figure F-5 Temperature variance with mode of laser operation.....	208

# 1 General Introduction

This thesis investigates the feasibility of closing wounds in skin tissue by laser welding as a substitute for suturing. Such a process would provide advantages in some surgical procedures. The investigation revised available theory on the action of lasers on skin tissue as a basis for the experimental program. The results of experiments using rat skin are then reported.

## 1.1 Background

Laser systems permit very high-energy radiation of a single wavelength to be focused on a tiny spot, and have found application in many areas of engineering. They are also currently used in many branches of medicine including ophthalmology, gynaecology, dermatology, otolaryngology, and gastroenterology. These medical applications employ argon, YAG, and carbon dioxide type lasers. In many cases, lasers have been found to be more effective than conventional treatment methods with advantages including reduced blood loss, more accurate removal of unwanted tissue, shorter operating times and less postoperative pain and care (Gibson and Kernohan, 1993).

Today the cost of medical care and surgery is an increasing concern to governments and society. Research efforts are focusing on equipment, treatment and techniques that result in faster healing times and shorter hospital stays. Patients also prefer techniques that result in less pain and scarring.

Tissue welding using laser energy represents a small but growing area of medical research and is largely focused on anastomosis<sup>1</sup>. This thesis investigates, using a specific experimental program, the feasibility of the bipolar contact Nd:YAG laser to weld **cutaneous**

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<sup>1</sup> Words in **courier new** font are defined in Glossary.

tissue. No similar published research has been identified in this area. The available literature focuses on non-contact lasers of various types and settings and mainly in the area of anastomosis. The experimental methodology and the specific technique for the bipolar contact laser is developed, tested and evaluated as part of this project

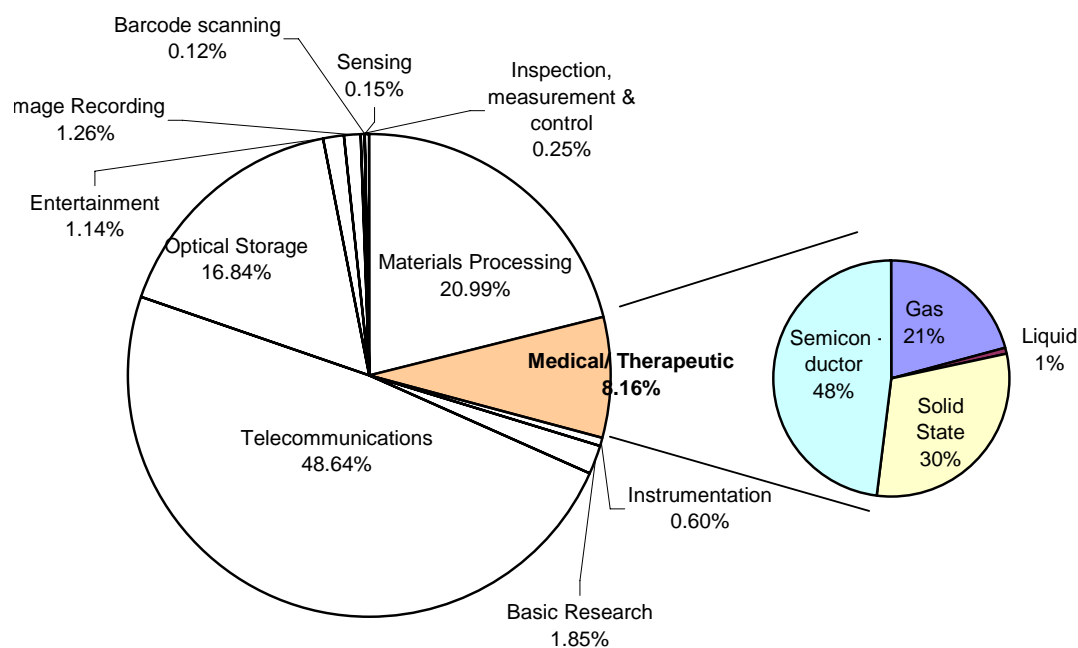
## **1.2 Project Objectives**

The main project objective is to experimentally investigate the feasibility of using a laser for welding cutaneous tissue. The feasibility of the process will be quantified by comparisons of welded cutaneous rat skin and sutured skin with uninjured rat skin.

In order to achieve this objective, several major aims were identified:

- To investigate the current uses of lasers in medicine.
- To assess the types of lasers suited to laser-tissue interaction and to determine a suitable type for use in this project.
- To evaluate known theory and published experimental work on the effects of laser energy on cutaneous tissue.
- To design and undertake an experimental program to test the effectiveness of laser welding skin in promoting healing.
- To compare the healing process of skin following laser welding with that of suturing.

The first three of these aims require an overview of the major medical fields as well as the enormous range of currently available commercial lasers. Figure 1.1 indicates the current range of lasers in commercial use and the proportion of these in medical use. They form the fourth largest section of sales in the industry.



**Figure 1-1 Laser sales 2000-2001**

The approach used in this thesis is to define the major areas of medicine covering all areas where the use of lasers is well established (e.g. Ophthalmology and Dermatology) through to areas where the use of lasers is just emerging. The details of medical procedures are outside the scope of this thesis and so the discussion is limited to the type of laser used and the resulting effect on tissue.

Tissue welding is included in the major review of lasers in medicine. It meets the second and third aims of the thesis and concludes that a Nd:YAG bipolar contact laser has potential for welding cutaneous tissue. An experimental program is described for the testing of weld strength and healing time for 20 female inbred Wistar rats matched in age and general health. The rats received two scalpel skin wounds, one of which was conventionally sutured while the second was laser welded using a technique developed specifically for this project. Tensile tests were used to



determine the baseline tensile strength of uninjured skin to compare sutured and laser welded skin healing times.

### **1.3 Thesis Organisation**

This thesis spans two disciplines of engineering and medical science.

Background information relating to lasers, including brief history of development, laser classification, safety issues and laser-tissue interaction are covered in Chapter 2.

Chapter 3 contains a literature review on Tissue Welding. It indicates that although significant work has been done on anastomosis, there has been little experimental work done on welding of cutaneous tissue. In particular a bipolar contact laser had never been used to undertake this kind of work.

Chapter 4 investigates the history of Nd:YAG bipolar contact laser as well as the effect of this particular wavelength on tissue with contact and non contact delivery methods.

Experimental methodology, results and analysis, discussion and conclusion pertaining to the second objective are contained in Chapters 5, 6, and 7 respectively.