ADVANCED LASER SURGERY IN DENTISTRY

GEORGIOS E. ROMANOS

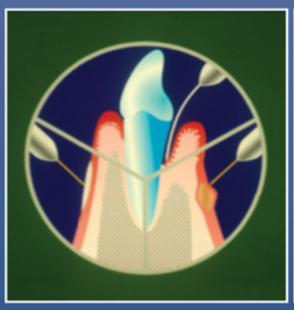








Table of Contents

<u>Cover</u>
<u>Title Page</u>
<u>Copyright Page</u>
<u>Dedication Page</u>
About the Author
<u>List of Contributors</u>
<u>Preface</u>
Acknowledgement
1 Laser Fundamental Principles
1.1 Historical Background
1.2 Energy Levels and Stimulated Emission
1.3 Properties of the Laser Light
1.4 The Laser Cavity
1.5 Laser Application Modes
1.6 Delivery Systems
<u>1.7 Applicators</u>
1.8 Laser Types Based on the Active Medium
1.9 Laser and Biological Tissue Interactions
<u>References</u>
2 Lasers and Wound Healing
2.1 Introduction
2.2 Wound Healing and Low Power Lasers
2.3 Wound Healing and High-Power Lasers
2.4 Lasers and Bone Healing
<u>References</u>

3 Lasers in Oral Surgery
3.1 Introduction
3.2 Basic Principles
3.3 Excision Biopsies
3.4 Removal of Benign Soft Tissue Tumors
3.5 Removal of Drug-Induced Gingival Hyperplasias
and Epulides
3.6 Removal of Soft Tissue Cysts
3.7 Frenectomies and Vestibuloplasties
3.8 Removal of Precancerous Lesions (Leukoplakia)
3.9 Surgical Removal of Malignant Soft Tissue
<u>Tumors</u>
3.10 Laser Coagulation
3.11 Lasers in Vascular and Pigmented Lesions
3.12 Exposure of Impacted, Unerupted Teeth
3.13 Removal of Sialoliths Using the Laser
References
4 Lasers and Bone Surgery
4.1 Introduction
<u>4.2 CO₂ Laser</u>
4.3 Excimer Laser
4.4 Er:YAG and Ho:YAG Lasers
4.5 Laser Systems for Clinical Dentistry
References
<u>5 Lasers in Periodontology</u>
5.1 Introduction
5.2 Laser-Assisted Bacteria Reduction in
Periodontal Tissues
<u>5.3 Removal of Subgingival Calculus</u>

5.4 Removal of Pocket Epithelium
5.5 Retardation of the Epithelial Downgrowth
5.6 Laser Application in Gingivectomy and Gingivoplasty
5.7 Laser-Assisted Hemostasis in Periodontics
5.8 Photodynamic Therapy in Periodontology
5.9 Gingival Troughing for Prosthetic Restorations
5.10 Fractional Photothermolysis in Periodontology
5.11 Education and Future of Lasers in Periodontal Therapy
References
6 Lasers and Implants
6.1 Introduction
6.2 Laser-Assisted Surgery Before Implant Placement and Implant Exposure
6.3 Laser Application During Function
6.4 Laser Applications in Peri-implantitis Treatment
6.5 Recent Laser Research on Implants
6.6 Implant Removal
6.7 Laser-Assisted Implant Placement
6.8 Future of Laser Dentistry in Oral Implantology
References
7 Photodynamic Therapy in Periodontal and Peri- Implant Treatment
7.1 Biological Rationale
7.2 Use of PDT as an Alternative to Systemic or Local Antibiotics
7.3 Conclusions
References

8 Understanding Laser Safety in Dentistry
<u>8.1 Laser Safety</u>
8.2 International Laser Standards
8.3 Regulatory Agencies and Nongovernmental
<u>Organizations</u>
8.4 State Regulations
8.5 Nongovernmental Controls and Professional Organizations
8.6 The Joint Commission (TJC)
8.7 Standards and Practice
8.8 Hazard Evaluation and Control Measures
8.9 Administrative Controls
8.10 Procedural and Equipment Controls
8.11 Laser Treatment Controlled Area
8.12 Maintenance and Service
8.13 Beam Hazards
8.14 Laser Safety and Training Programs
8.15 Medical Surveillance
8.16 Nonbeam Hazards
8.17 Electrical Hazards
8.18 Smoke Plume
8.19 Fire and Explosion Hazards
8.20 Shared Airway Procedures
8.21 Conclusion
<u>References</u>
<u>Appendix A</u>
<u>Suggested Reading</u>
<u>Appendix B</u>
<u>Physical Units</u>

Laser Parameters

Physical Parameters

<u>Important Formulas</u>

<u>Index</u>

End User License Agreement

List of Tables

Chapter 1

<u>Table 1.1 Thermal relaxation times for different chromophores of various size...</u>

<u>Table 1.2 Laser systems with applications in</u> medicine.

<u>Table 1.3 Optical output characteristics and heat</u> <u>generation efficiency on th...</u>

<u>Table 1.4 Biological effects in soft tissues based on temperature increase (a...</u>

<u>Table 1.5 Biological effects in hard tissues based on temperature increase (a...</u>

Chapter 2

<u>Table 2.1 Wound healing effects of the low-power lasers.</u>

<u>Table 2.2 Wound healing effects of the high-power lasers.</u>

<u>Table 2.3 Wound healing in the rat skin, four weeks after Nd:YAG laser irradi...</u>

Chapter 3

Table 3.1 Operation mode and clinical procedure.

<u>Table 3.2 Chronological order in laser surgical procedures.</u>

<u>Table 3.3 Tissue color and relationship to laser</u> wavelengths and power settin...

<u>Table 3.4 Studies on leukoplakia removal and recurrence rate.</u>

Chapter 4

<u>Table 4.1 Bone healing in the osteotomies using</u> <u>different laser systems compa...</u>

Chapter 5

<u>Table 5.1 Bactericidal effect of laser irradiation in</u> vitro.

<u>Table 5.2 Temperature increase during laser irradiation in vitro.</u>

<u>Table 5.3 Root surface changes due to laser irradiation in vitro.</u>

<u>Table 5.4 Suggested laser parameters for periodontal procedures.</u>

Chapter 8

Table 8.1 Related links.

List of Illustrations

Chapter 1

<u>Figure 1.1 Electromagnetic spectrum and the different wavelengths.</u>

Figure 1.2 OCT device for clinical and diagnostic applications.

<u>Figure 1.3 Spontaneous and stimulated emission principles.</u>

<u>Figure 1.4 Collimated light of the laser versus non-collimated light of the ...</u>

<u>Figure 1.5 Schematic demonstration of a laser device.</u>

Figure 1.6 Continuous (CW) and pulsed (chopped, gated) laser application mod...

<u>Figure 1.7 Transverse electromagnetic modes with</u> regular, high concentrated ...

<u>Figure 1.8 Articulated arm for a CO₂ laser</u> <u>application in the modern CO₂ las...</u>

<u>Figure 1.9 Hollow guide of a CO₂ laser presenting</u> the flexible delivery syst...

<u>Figure 1.10 Flexible optical fibers for medical and</u> dental applications.

<u>Figure 1.11 Irradiation of soft tissues in the lamb</u> <u>vestibule using a cerami...</u>

<u>Figures 1.12-1.14 Special tips for direct connection</u> with the hand piece (le...

<u>Figures 1.15 and 1.16 Diode laser irradiation</u> <u>during frenectomy and partial ...</u>

<u>Figure 1.17 Special tools to remove plastic coating around glass fiber witho...</u>

Figure 1.18 Innovative all metal-tube compared to the classic old glass tube...

Figure 1.19 Development of CO₂ lasers over time by LightScalpel, Inc. demons...

<u>Figure 1.20 Argon laser device (Premier, Irvine, CA).</u>

<u>Figure 1.21 Classic Nd:YAG laser (Pulsemaster 1000; American Dental Technolo...</u>

<u>Figure 1.22 Nd:YAG laser device (American Dental Technologies, Southfield, M...</u>

<u>Figures 1.23 and 1.24 Representative Er:YAG laser devices for dental clinica...</u>

<u>Figures 1.25–1.27 Different Er,Cr:YSGG laser</u> devices developed in the last 2...

Figure 1.28 Various diode lasers for oral applications (from left to right):...

Figure 1.29 Water absorption spectrum in the wavelengths of 980, 810, and 10...

<u>Figure 1.30 Blue-light laser (SIROLaser Blue, Dentsply Sirona, Charlotte, NC...</u>

<u>Figure 1.31 Incisions using blue laser light (445 nm) and average power of 2...</u>

Figure 1.32 Comparative incisions using blue laser light (left), pulsed CO₂ ...

Figure 1.33 Basic concept of a fiber laser.

<u>Figure 1.34 Absorption spectrum of water and blood.</u>

<u>Figure 1.35 Ytterbium high-power laser developed</u> <u>by IPG Photonics Co.</u>

<u>Figure 1.36 Superpulse diode laser (Alta-ST, Surgical Laser System, IPG Phot...</u>

<u>Figure 1.37 Physical properties of the light in</u> contact with matter or biolo...

Figure 1.38 The absorption spectrum of water, (oxy)hemoglobin, and melanin d...

Figure 1.39 Absorption areas of the visible and near infrared (a), mid-infra...

Figure 1.40 Use of flat reflectors can produce direct reflections having haz...

Figure 1.41 Concept of the photodynamic therapy of tumors (from Niemz 2019)....

Figure 1.42 Effects of temperature distribution in the tissues (from Niemz 2...

Figure 1.43 Photothermal effects of a 3 W-CO₂ laser on soft tissues (chicken...

<u>Figure 1.44 Photothermal effects of lasers on soft tissues (chicken breast) ...</u>

<u>Figure 1.45 Schematic drawing of the penetration depth of different laser wa...</u>

<u>Figure 1.46 Laser-tissue effects based on the wavelength and the application...</u>

Figure 1.47 Principle of the fractional photothermolysis in the soft tissue....

<u>Figure 1.48 Histological demonstration of the coagulation zones in the soft ...</u>

Figure 1.49 Concept of the Laser patterned microcoagulation (LPM) for impro...

<u>Figure 1.50 Principle of plasma cleaning process of a metal.</u>

Chapter 2

Figure 2.1 Incision quality during laser irradiation of the bovine mucosa sh...

<u>Figure 2.2 Temperature changes of the tissue</u> during laser irradiation. The l...

Figure 2.3 Wound healing after scalpel incision (a); 1.75 W power Nd:YAG (b)...

Figure 2.4 Wound healing after scalpel incision (a); 1.75 W power Nd:YAG (b)...

Figure 2.5 Wound healing after scalpel incision (a); 1.75 W power Nd:YAG (b)...

<u>Figure 2.6 Incision area three days after 5W diode laser (980 nm) incision p...</u>

<u>Figure 2.7 Incision area 14 days after 10W diode</u> <u>laser (980 nm) presenting c...</u>

<u>Figure 2.8 Incision area 14 days after 15W diode</u> (980 nm) laser presenting m...

Chapter 3

<u>Figure 3.1 Differences in penetration depths</u> between CO₂ laser and Nd:YAG la...

<u>Figure 3.2 Perpendicular irradiation using a focused CO₂ laser (noncontact) ...</u>

<u>Figure 3.3 Superficial irradiation of the tissue after excision to create a ...</u>

<u>Figure 3.4 Hyperkeratosis of the mandible (a); the pathological tissue was e...</u>

<u>Figure 3.5 Necessary instruments for conventional laser-assisted surgical pr...</u>

<u>Figure 3.6 Intraoperative burn of the lower lip of a patient during laser-as...</u>

Figure 3.7 Coagulation of the blood vessel tumor in the papilla #6-7 (a) usi...

<u>Figure 3.8 Scar tissue formation due to the use of high-power diode laser (9...</u>

Figure 3.9 Excision of a soft tissue tumor in the maxilla (a) using a contin...

<u>Figure 3.10 Removal of a soft tissue tumor in the vestibule of the anterior ...</u>

<u>Figure 3.11 Irritation fibroma in the vestibular fold before the laser surge...</u>

Figure 3.12 Lingual fibroma (a) excised with a focused non-contact CO₂ laser...

Figure 3.13 Fibroma at the buccal mucosa (a) removed with contact pulsed Nd:...

<u>Figure 3.14 Excision of a fibroma in the tongue (a) using an Er:YAG laser (b...</u>

<u>Figure 3.15 Soft tissue tumor of the alveolar ridge</u> (a); excision with the C...

<u>Figure 3.16 Soft tissue tumor in the palate (a). The surgical excision occur...</u>

<u>Figure 3.17 Palatal soft tissue lesion (a); using an ablative mode, the lesi...</u>

<u>Figure 3.18 Excision of soft tissue tumor (a) with a scalpel and a CO₂ laser...</u>

<u>Figure 3.19 Clinical diagnosis of symmetric fibromas (a). The surgical proce...</u>

<u>Figure 3.20 Pyogenic granuloma of the lower lip</u> (a). The tumor was excised w...

Figure 3.21 Fibroma in the buccal mucosa (a). The excision was performed usi...

Figure 3.22 Fibroma of the buccal mucosa (a) excised with a CO₂ laser with a...

<u>Figure 3.23 Surgical excision of the hyperplastic gingiva underneath the bar...</u>

<u>Figure 3.24 Hyperplastic and inflamed peri-implant</u> mucosa with bleeding on p...

Figure 3.25 Clinical and radiographical examination of a patient with an oss...

<u>Figure 3.26 Soft tissue tumor of the gingiva</u> <u>associated with some bleeding (...</u>

<u>Figure 3.27 Soft tissue tumor of the lip (a) removed using an 810 nm diode l...</u>

Figure 3.28 Small tumor of the upper lip (a). An Nd:YAG laser with contact f...

<u>Figure 3.29 Soft tissue tumor of the buccal mucosa</u> without symptoms (a). The...

<u>Figure 3.30 Soft tissue asymptomatic tumor of the tongue (a). Clinical exami...</u>

<u>Figure 3.31 Soft tissue tumor of the gingiva (a);</u> excision of the tumor usin...

Figure 3.32 Soft tissue tumor in the mouth floor (a); a sialolith was not de...

Figure 3.33 Epulis in the interdental area #2-3 (a). A gingivectomy was carr...

<u>Figure 3.34 A gingival tumor in a buccal aspect and occlusal view (a, b). Di...</u>

Figure 3.35 Mucocele of the low lip (a); a half-moon-shaped incision was per...

<u>Figure 3.36 Mucus retention cyst of the lower lip</u> (a). After topical anesthe...

Figure 3.37 Extravasation cyst of the sublingual gland (a). A plastic cathet...

Figure 3.38 Swelling of the cheek (a) and sensitivity to palpation for at le...

Figure 3.39 Excision of the lingual frenum (a) with a CO₂ laser (4 W; contin...

<u>Figure 3.40 The excisions of the two frenula (a, b)</u> in the maxilla and the m...

Figure 3.41 Tight frenum in the anterior maxilla (a). Excision with the CO_2 ...

<u>Figure 3.42 Hypertrophic papilla creating esthetic</u> <u>problems for the patient ...</u>

Figure 3.43 Excision of the labial frenulum (a) with a focused 810 nm diode ...

<u>Figure 3.44 Excision of the labial frenum (a) using a focused 810 nm diode l...</u>

<u>Figure 3.45 Insufficient vestibule in the maxilla (a)</u> associated with lack o...

<u>Figure 3.46 Lack of vestibule depth before surgery</u> (a); the incision was per...

Figure 3.47 Insufficient depth of the vestibule in the mandible (a). The muc...

<u>Figure 3.48 A frenectomy (a) was performed using a pulsed Nd:YAG laser (2.0...</u>

<u>Figure 3.49 Vestibuloplasty with an Er:YAG laser.</u>
<u>Observe the insufficient b...</u>

<u>Figure 3.50 Insufficient vestibule depth in the maxilla including soft tissu...</u>

<u>Figure 3.51 Insufficient vestibule depth in the mandible due to the presence...</u>

<u>Figure 3.52 Similar to the previous clinical case,</u> the soft tissue tumor was...

<u>Figure 3.53 Oral leukoplakia in the alveolar ridge of</u> the maxilla before exc...

Figure 3.54 Oral leukoplakia of the tongue (a) and mouth floor (b); charring...

<u>Figure 3.55 Leukoplakia of the gingiva (a); removal of the lesion using a CO</u>

<u>Figure 3.56 Leukoplakia of the gingiva (a);</u> coagulation after laser excision...

Figure 3.57 Oral leukoplakia in the interdental papilla (a); excision with a...

Figure 3.58 Oral leukoplakia at the right side of the tongue (a); excision u...

<u>Figure 3.59 Soft tissue tumor in a patient with von Willebrand disease befor...</u>

<u>Figure 3.60 Schematic illustration of the ice cube technique in conjunction ...</u>

<u>Figure 3.61 Vascular lesion of the buccal mucosa</u> (a); coagulation using the ...

<u>Figure 3.62 Hemangiomas of the lower lip (a); the lesions were coagulated us...</u>

Figure 3.63 Multiple telangiectasias on the skin before (a, b) and after (c,...

Figure 3.64 Hemangioma of the lip (a) in a size larger than the width of a t...

<u>Figure 3.65 Conventional method of coagulation of the hemangioma of the tong...</u>

<u>Figure 3.66 Large hemangioma on the tongue (a)</u> <u>coagulated with the intralumi...</u>

<u>Figure 3.67 Hemangioma of the oral mucosa (a)</u> irradiated with the ice cube t...

<u>Figure 3.68 Hemangioma of the lower lip (a, b)</u> removed with a diode laser an...

<u>Figure 3.69 Initial clinical demonstration of a large hemangioma of the oral...</u>

<u>Figure 3.70 Before surgery (a) and laser irradiation</u> (b); three weeks post (...

<u>Figure 3.71 Before, during, and after treatment</u> (five months post-op).

<u>Figure 3.72 Hemangioma of the upper lip</u> <u>associated with esthetic concerns (a...</u>

<u>Figure 3.73 Amalgam tattoo removal (a) using a pulsed Nd:YAG laser (b); the ...</u>

Figure 3.74 Removal of a nevus in the upper lip (a) using an Nd:YAG laser (b...

<u>Figure 3.75 Pericoronitis around tooth#17 (a);</u> excision of the mucosa with a...

<u>Figure 3.76 Unerupted tooth (a) exposed with a CO₂ laser (b) after placement...</u>

<u>Figure 3.77 CO2 laser-assisted surgical exposure of an impacted tooth for or...</u>

Figure 3.78 Surgical exposure of an impacted tooth for orthodontic reasons u...

<u>Figure 3.79 Surgical exposure of an impacted tooth</u> <u>for orthodontic reasons u...</u>

<u>Figure 3.80 A deeply localized salivary stone was palpated in the submandibu...</u>

Chapter 4

<u>Figure 4.1 Comparison of the osteotomies</u> <u>performed by Lindemann bur, piezosu...</u>

<u>Figure 4.2 Electron microscopic analysis of an osteotomy using Er:YAG laser ...</u>

<u>Figure 4.3 Electron microscopic analysis of an osteotomy using Er,Cr:YSGG la...</u>

<u>Figure 4.4a Bone removal using an Er:YAG laser (Hoya, Japan).</u>

<u>Figure 4.4b Osteotomy site presenting a smooth</u> <u>surface after exostosis remov...</u>

<u>Figure 4.4c Bone specimen removed with the Er:YAG laser presenting areas of ...</u>

<u>Figure 4.5a Preparation of an exostosis (tori mandibularis) after elevation ...</u>

<u>Figure 4.5b Osteotomy procedure for removal of a lingual exostosis using an ...</u>

Figure 4.6 Crown lengthening using an Er:YAG laser for osseous reduction and...

Figure 4.7 Window preparation for sinus augmentation using an Er,Cr:YSGG las...

<u>Figure 4.8 Preparation of the cortical layer of the alveolar ridge using an ...</u>

<u>Figure 4.9 Minimal invasive removal of an implant using an Er:YAG laser (Hoy...</u>

<u>Figure 4.10 Block section using an Er:YAG laser</u> (<u>Hoya Conbio, Versawave, Tok...</u>

<u>Figure 4.11 Bone splitting using the Er,Cr:YSGG laser (Waterlase® MD) w...</u>

Chapter 5

<u>Figure 5.1 Removal of calculus in vitro using a new laser with wavelength of...</u>

<u>Figure 5.2 Calculus removal using the Er:YAG laser on an extracted tooth....</u>

<u>Figure 5.3 Removal of the long junctional</u> <u>epithelium in ex vivo conditions i...</u>

<u>Figure 5.4 Mean PPD over time and mean CAL over time. Clinical parameters af...</u>

<u>Figure 5.5 Schematic illustration of the laser fiber</u> movement within the poc...

<u>Figure 5.6 Schematic illustration of the periodontal</u> wound healing after las...

Figure 5.7 CO_2 laser irradiation in the pocket as well as deepithelializatio...

<u>Figure 5.8 Schematic illustration of the laser tip</u> within the pocket for rem...

<u>Figure 5.9 Removal of the oral epithelium after CO₂ laser irradiation (a) us...</u>

<u>Figure 5.10 Laser-assisted guided tissue</u> regeneration (LA-GTR) for pocket re...

Figure 5.11 Deep periodontal pocket of 7 mm (a), which was treated with this...

Figure 5.12 Advanced gingiva hyperplasia caused by a hydantoin medication (a...

<u>Figure 5.13 Gingival hyperplasia associated with cyclosporin-A (CyS-A) and n...</u>

<u>Figure 5.14 Periodontal nonsurgical therapy in a patient with stage 1 period...</u>

Figure 5.15 Donor site of a free keratinized gingival graft (a) and adequate...

<u>Figure 5.16 Pulsed diode laser 2 W for laserassisted SRP (a); noncontact di...</u>

<u>Figure 5.17 Insufficient vestibule depth (a);</u> <u>frenectomy performed with a CO</u>

Figure 5.18 Gingival tumor in a pregnant patient (a); the diode laser excise...

Figure 5.19 Crown lengthening procedure (a) with the pulsed Nd:YAG laser (b)...

<u>Figure 5.20 Diastema in the anterior maxilla before treatment (a, b); soft t...</u>

Figure 5.21a and b Periodontal condition before treatment and probing of the...

Figure 5.21c and d Probing and soft tissue coagulation after osseous reconto...

<u>Figure 5.21e Clinical outcome four months after</u> <u>surgery demonstrating excell...</u>

<u>Figure 5.22a and b Pre-op clinical condition (a) and marking of the exact le...</u>

<u>Figure 5.22c and d Gingivectomy using the guide</u> (c) and submarginal laser-as...

<u>Figure 5.22e and f Gingival margin after</u> gingivectomy (e); laser-assisted os...

Figure 5.22g Laser-assisted frenectomy.

<u>Figure 5.22h Two-month postoperative clinical photo.</u>

<u>Figure 5.22i Six-month postoperative clinical photo.</u>
<u>An implant at #10 was p...</u>

Figure 5.23a and b Mandibular teeth pre-op.

<u>Figure 5.23c and d Laser-assisted gingivectomy using the guide.</u>

<u>Figure 5.23e and f Laser-assisted gingivectomy and osseous recontouring usin...</u>

<u>Figure 5.23g and h Osseous recontouring using the Er:YAG laser tip and gingi...</u>

<u>Figure 5.23i Probing depths of 3 mm establish</u> <u>proper supra-crestal soft tiss...</u>

Figure 5.23j Final result 4 months after surgery.

<u>Figure 5.24 Pre-op clinical condition (a); surgical guide determining the ex...</u>

Figure 5.25 Clinical periodontal condition before digital impression (a); th...

<u>Figure 5.26 Fractional photothermolysis using glass fiber of a 980 nm diode ...</u>

Figure 5.27 Diode laser-assisted pocket debridement (a) and fractional photo...

<u>Figure 5.28a-f Preoperative clinical (a-c) and radiological condition (d) wi...</u>

<u>Figure 5.28g and h Preoperative radiological</u> <u>condition (#9) with severe bone...</u>

<u>Figure 5.28i and j Preoperative radiological</u> condition (#10) with severe bon...

<u>Figure 5.29 Preoperative condition with severe attachment loss (a), with las...</u>

Figure 5.30a and b 8 mm initial probing depth on the mesial aspect of the ri...

<u>Figure 5.30c Cause-related laser-assisted</u> <u>nonsurgical periodontal therapy wa...</u>

Figure 5.30d and e Clinical aspect of the case at one year follow-up recall ...

<u>Figure 5.30f and g At eight-year follow-up recall</u> <u>appointment, the probing r...</u>

<u>Figure 5.30h and i Comparative clinical images one year (h) and eight years ...</u>

Figure 5.30j and k Comparative periapical radiographs, made at baseline (j) ...

Figure 5.31a and b Clinical aspect pre- (a) and six years post- (b) from cau...

Figure 5.31c and d Clinical aspect pre- (c) and six years post- (d) from cau...

Figure 5.31e and f Comparative periapical radiographs taken at baseline (e) ...

<u>Figure 5.31g-i Cause-related laser-assisted</u> <u>nonsurgical periodontal therapy ...</u>

<u>Figure 5.31j and k The treatment in each site takes</u> 30 seconds, preceded and...

Figure 5.32a Initial clinical aspect.

Figure 5.32b Full mouth radiological status, executed immediately after the ...

<u>Figure 5.32c On the lingual appearance of the mandibular incisors, abundant ...</u>

Figure 5.32d At the first visit, the biometric periodontal indexes are colle...

<u>Figure 5.32e On the distal aspect of the mandibular right lateral incisor, a...</u>

<u>Figure 5.32f The periodontal probe, kept oblique to</u> the vertical axis of the...

<u>Figure 5.32g Clinical aspect of the case following comprehensive nonsurgical...</u>

Figure 5.32h With only one professional oral hygiene session, it was possibl...

Figure 5.32i On the distal aspect of the right maxillary first molar, 7 mm p...

Figure 5.32j In the periapical radiograph, a calculus spicola on the mesial ...

Figure 5.32k Considering the probing depth ≥ 6mm, the use of a diode laser i...

<u>Figure 5.32l Nonsurgical periodontal</u> <u>instrumentation with universal curette ...</u>

<u>Figure 5.32m Ultrasonic instrumentation (Combi, Mectron S.p.A., Ge, Italy) i...</u>

<u>Figure 5.32n Etiological therapy essentially consists of two main phases: no...</u>

Figure 5.320 At a recall appointment, one year after the initial cause-relat...

<u>Figure 5.32p A periapical radiograph is taken to confirm a condition of clin...</u>

<u>Figure 5.32q Initial periapical radiograph at the left maxillary molars. A l...</u>

Figure 5.32r The periodontal probe detects 7mm on the distal aspect of the l...

Figure 5.32s Also, in this site, as in the contralateral site (see figure 5....

<u>Figure 5.32t Nonsurgical periodontal</u> <u>instrumentation remains absolutely esse...</u>

<u>Figure 5.32u A universal curette (Universal curette ENACARE, Micerium, Avegn...</u>

<u>Figure 5.32v Periapical radiograph of, taken one year after Figure 5-32r rad...</u>

Figure 5.32w At a recall appointment one year after the cause-related laser ...

Figure 5.33 Advanced periodontal necrosis due to severe overheating using th...

<u>Figure 5.34 Effects of different laser wavelengths</u> on the tissues.

Figure 5.35 Laser wavelengths and tissue effects.

Chapter 6

<u>Figure 6.1 Scanning electron microscopic analysis</u> of sandblasted implant sur...

<u>Figure 6.2 Extensive melting, porosity alterations, cracks, and ruptures of ...</u>

<u>Figure 6.3 Morphological studies on implant</u> <u>surface analysis after laser irr...</u>

<u>Figure 6.4 Lingual frenum, which does not allow optimal stability of the pro...</u>

<u>Figure 6.5 Bacterial reduction after CO₂ laser</u> <u>irradiation. Left slide: test...</u>

<u>Figure 6.6 Bacterial growth after the CO₂ laser irradiation presents reducti...</u>

<u>Figure 6.7 Ligature-induced peri-implant defects in dog irradiated with the ...</u>

Figure 6.8 New bone formation in contact with the implant surface after CO_2 ...

<u>Figure 6.9 Soft tissue incision with a CO₂ laser for implant uncovering; an ...</u>

<u>Figure 6.10a Clinical condition of a submerged implant system before uncover...</u>

<u>Figure 6.10b Second stage surgery with a focused beam of a CO₂ laser (4 W, C...</u>

<u>Figure 6.10c One week after implant uncovering</u> <u>presents an excellent peri-im...</u>

Figure 6.11 Peri-implant hyperplasia before surgery (a); using noncontact fo...

Figure 6.12a Peri-implant hyperplastic mucosa demonstrating difficulties in ...

Figure 6.12b Removal of the peri-implant hyperplastic tissues with a 980 nm ...

<u>Figure 6.13a Peri-implant hyperplasia underneath a</u> bar-retained implant supp...

<u>Figure 6.13b Hyperplastic tissues before laser</u> excision after removal of the...

<u>Figure 6.13c Excision and sufficient coagulation</u> <u>after CO₂ laser irradiation...</u>

<u>Figure 6.13d Two weeks postoperative clinical</u> <u>condition presents an improvem...</u>

Figure 6.14 Peri-implant lesions in the area #19-21 after removal of the res...

Figure 6.15 Peri-implantitis diagnosed immediately before delivery of the fi...

<u>Figure 6.16 Advanced peri-implant bony defect with symptoms of peri-implanti...</u>

<u>Figure 6.17 Peri-implant bone loss associated with pain and suppuration (a);...</u>

<u>Figure 6.18 Peri-implant infrabony defects at #19–20 (a, b); meticulous degr...</u>

Figure 6.19 Advanced peri-implant bony defect around splinted implants #13 a...

Figure 6.20 Bar chart of means of coronal (continuous) by group over time.

Figure 6.21 Bar chart of means of apical (continuous) by group over time.

Figure 6.22 Bar chart of means of coronal (pulsed mode) by group over time....

Figure 6.23 Bar chart of means of apical (pulsed mode) by group over time.

Figure 6.24 Average temperature change at the coronal level (t = 30 seconds)...

Figure 6.25 Average temperature change at the apical level (t = 30 seconds)....

Figure 6.26 Average time to reach critical threshold $(\Delta 10^{\circ}\text{C})$ in the coronal ...

<u>Figure 6.27 Measurement of heat transfer using</u> <u>noninitiated (a) and initiate...</u>

Figure 6.28 Experimental setting to evaluate temperature changes of implants...

<u>Figure 6.29 Temperature increase during laser irradiation of an implant with...</u>

<u>Figure 6.30 Ossseointegrated blade implant</u> removal using an Er:YAG laser (Ve...

Chapter 7

<u>Figure 7.1 Application of the phenothiazine</u> chloride dye following subgingiv...

<u>Figure 7.2 Application of the low level-laser light into the pocket.</u>

Chapter 8

Figure 8.1 ANSI Z535.2 new laser signs.

Figure 8.2 ANSI Z535.2 new sign example.

Figure 8.3 ANSI Z136.12014 grandfathered sign.

<u>Figure 8.4 Example of occlusive tested laser</u> window covers.

Figure 8.5 Example of occlusive tested laser covers.

<u>Figure 8.6 Appropriate eye protection (goggles)</u> <u>specific for different wavel...</u>

Figure 8.7 Laser protective eyewear (LPE).

<u>Figure 8.8 Example of laser wavelength and O.D. imprinted on eyewear.</u>

<u>Figure 8.9 Example of occlusive metal laser</u> <u>eyewear.</u>

<u>Figure 8.10 Example of adhesive laser protective eyewear.</u>

<u>Figure 8.11 Example of corneoscleral patient eye</u> <u>shields.</u>

<u>Figure 8.12 Example of portable plume evacuator</u> with support clamp.

Advanced Laser Surgery in Dentistry

Georgios E. Romanos

D.D.S., Ph.D., PROF. DR. MED. DENT. Stony Brook University School of Dental Medicine Stony Brook, NY, USA and Johann Wolfgang Goethe University School of Dentistry - Carolinum Frankfurt, Germany

WILEY Blackwell

This edition first published 2021 © 2021 John Wiley & Sons, Inc.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at http://www.wiley.com/go/permissions.

The right of Georgios E. Romanos to be identified as the author of this work has been asserted in accordance with law.

Registered Office

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

Editorial Office

111 River Street, Hoboken, NJ 07030, USA

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-ondemand. Some content that appears in standard print versions of this book may not be available in other formats.

Limit of Liability/Disclaimer of Warranty

The contents of this work are intended to further general scientific research, understanding, and discussion only and are not intended and should not be relied upon as recommending or promoting scientific method, diagnosis, or treatment by physicians for any particular patient. In view of ongoing research, equipment modifications, changes in governmental regulations, and the constant flow of information relating to the use of medicines, equipment, and devices, the reader is urged to review and evaluate the information provided in the package insert or instructions for each medicine, equipment, or device for, among other things, any changes in the instructions or indication of usage and for added warnings and precautions. While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials or promotional statements for this work. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for your situation. You should consult with a specialist where appropriate. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read. Neither

the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

Library of Congress Cataloging-in-Publication Data

Names: Romanos, Georgios, author.

Title: Advanced Laser Surgery in Dentistry / Georgios E. Romanos.

 $Description:\ First\ edition.\ |\ Hoboken,\ NJ:\ Wiley-Blackwell,\ 2021.\ |\ Includes$

bibliographical references and index.

Identifiers: LCCN 2020028457 (print) | LCCN 2020028458 (ebook) | ISBN 9781119583301 (hardback) | ISBN 9781119583356 (adobe pdf) | ISBN 9781119583349 (epub)

Subjects: MESH: Oral Surgical Procedures | Laser Therapy

Classification: LCC RK501 (print) | LCC RK501 (ebook) | NLM WU 600 | DDC 617.6/05 dc23

LC record available at https://lccn.loc.gov/2020028457

LC ebook record available at https://lccn.loc.gov/2020028458

Cover Design: Wiley

Cover Images: Courtesy of Georgios E. Romanos, © MIKHAIL

GRACHIKOV/Shutterstock