Laser Applications in Laryngeal Surgery

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General Laser Principles

- Laser Effects on Tissue
  - Photothermal
  - Photochemical
  - Photomechanical

- Laser Therapeutic Goal
  - Direct These Energies to Pathological Targets
  - Spare Adjacent Normal Tissues

Lasers Useful in Laryngology

- CO₂ (10,600 nm)
  - Microspot Technology
  - Defocused Applications
  - Wave-Guiding System

- Thulium 2-micron (2013 nm)
  - Cut/Coagulate (CO₂ + YAG)
  - Bendable Fiber Delivery

- Photoangiolytic Lasers
  - Pulsed Dye Laser (585 nm)
  - KTP Continuous Wave and Pulsed (532 nm)

CO₂ Laser Applications

- Precision Cutting
  - Limited Hemostasis
  - Focused Thermal Effect on Surface
  - Pulsed to Limit Char

- Precision Ablation
  - Defocused Laser
  - Limited Depth
  - Ablation w Sparing Lamina Propria
OmniGuide Photonic Bandgap Fiber Technology

- Addresses CO2 Laser Limitation
  - Enhanced Exposure Via Flexible Fiber
  - Improved Cutting Ability for Resections
- Wave-guiding System
  - Reflective Dielectric Mirrors
  - Cladding
  - Hollow Core

Versatility/Mechanical Advantage Fiber Delivery Approach

- In-Office Application via Flexible Scope
- In O.R. w 30° Telescope
- 70 y.o. With Hx SCC
  - Recurrent AC Leukoplakia
  - Unable to Exposure AC w Laryngoscope

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  - Nd:YAG & Holmium Features
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Thulium Laser Verrucous Ca

- 2013nm > Absorbed/Water
- Cutting-Ablation Like CO2
- Cutting-Hemostasis Like Nd:YAG w Less Penetration
- Advantages in Large Resections
  - Excellent Hemostasis
  - Flexible Fiber for Tangential Cuts
  - Contact Mode Efficiency
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  - Microspot Technology
  - Defocused Applications
  - Wave-Guiding System
- **Thulium 2-micron** (2013 nm)
  - CO2, Nd:YAG, & Holmium Features
- **Photoangiolytic Lasers**
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Angiolytic Lasers
Prototype: 585-nm Pulsed Dye Laser

- **Selective Absorption**
  - OxyHgb → Intra-luminal Energy Delivery
    - Hemostasis
    - Vascular Lesions & Vascular-Dependant Neoplasms
- **Epithelial Effects**
  - Alters Epithelial Cell
  - Cleaves From BMZ
- **ECM, Collagen Effects**
  - Scar Sulcus Vocalis
  - Reinke’s Edema

PDL Mechanism of Action on Vascular Lesions (eg. RRP)

- Direct Energy to Lesion
  - Intravascular Coagulation >"Photoangiolysis" of Subepithelial Microvasculature (Blanching)
  - 585nm PDL -Oxyhemoglobin is Chromophore
- Spares Adjacent Tissue (Pulsed Delivery Allows Adequate Thermal Relaxation Time & Recovery Non-Target Tissues)
  - Epithelial Surface Sparing (eg. Ant. Commissure)
  - Prevents Scarring of Lamina Propria
  - Selective Ablation Vascular Lesion (x=Angiogenesis)

Vascular Ectasia & Varicities
Vascular Lesions at Anterior Commissure (RRP)


Theory: More Efficient Selective Vascular Ablation (Photoangiolyis) Will Limit Vessel Rupture & Extravasation

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PDL Clinical Effect on Dysplastic Epithelium

- 59 y.o. SCCa L TVF at 2 yrs. s/p RT
- c/o Progressive Hoarseness
- In Office Biopsy: Mild-Dysplasia
- Compliant Patient for Careful f/u

Pre- & 4-Wks Post in-Office PDL

PDL Lyses BMZ Linking Proteins

Clinical Leukoplakia


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Use of PDL in Treatment of VF Scar

• N = 11 Scarred VFs s/p Radiation 
  Hemilaryngectomy, or Phonosurgery
• Favorable Results w PDL at 6 Months
  – 10/11 Subjectively Better, 1 Same
  – VHI Improved From 48 to 36 (p < 0.05)
  – Improvement in:
    • Phonatory Flow Rate, Jitter, Shimmer, HNR
    • Stroboscopic Exam (Trained, Blinded Judges)

PDL Mechanism of Action on 
Scar/Collagen, BMZ, Epithelium, ECM

PDL: Addresses Vocal Fold Pathology w 
Preservation of ECM Structure & Function

• Stimulates Collagen Remodeling (Dermatology Reports: Keloids, Hypertrophic scars, Striae)
• Theories:
  – PDL-Induced Tissue Hypoxia > Collagenesis from Decreased Microvascular Perfusion
  – Thermal Effect > Dissociation Disulfide Bonds > Collagen Realignment
  – Induced Mast Cell Response > Interleukins & Other Immune Factors Altering Collagen Metabolism

PDL-Induced Inflammatory Response in VFs.
Lin Y, et al. Lasers In Surgery & Medicine, 2009

• Studied PDL Effect on Normal in vivo & 
  Cultured VF Fibroblasts (rat model)
  – Altered Inflammatory Cytokine and 
    Procollagen/Collagenase Expression
    • Relevant to Management of Scar and SV
  – Induced Inflammatory Repair Process in vivo
    While Preserving Normal Tissue Morphology
    • Relevant to Application in Reinke’s Edema
PDL Single Treatment Reike’s Edema

Pre-operative Exam        2-months Post-operative

Combining PDL and Thulium

Summary

USEFUL LASERS
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• Thulium 2-micron (2013nm)
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USES OF LASERS
• Direct Effects
  – Incision/Excision
  – Ablation
  – Hemostasis
• Indirect Effects on Lesions
  – Angiolyis
    • Vascular Lesions
    • Vascular-Dependent Lesions
  – Epithelial
    • Leukoplakia > Dysplasia
    • SCC
  – Extracellular Matrix
    • Reinke’s
    • Collagen
    • Scar
    • Sulcus vocalis