Lasers Coming of Age: 21 Years of Enlightenment

Changing the Patient laser experience

Using the *Solea Isotropic CO₂ Hard & Soft Tissue Laser in Pediatric Dentistry: A 6 month report

ALD Annual meeting
Scottsdale Arizona 2014

Lawrence Kotlow DDS
Kiddsteeth.com
Practice limited to pediatric dentistry

Manufactured by Convergent Dental
2/5/14

Disclosure and Acknowledgements

I have assisted in the development of a variety of laser products, including Innovative optics (laser glasses) T4M (videos and webinars), Schick (Serona digital radiography). I am an investor in the development of the Solea CO₂ laser and as such I am also on their professional advisory board. For all of these, I have been a beta tester of new products. I receive honoraria or supplies for my participation.

Objectives of today’s presentation

1. How I became involved with Convergent Dental & the development and use of the Solea hard & soft tissue laser.
2. Introduction to the CO₂ laser @ 9300nm
3. Identify key features of this laser that change much of what we have know about hard tissue lasers.
4. How this lasers compares and differs from erbium lasers.
5. Example of hard and soft tissue procedures using CO₂ @ 9300nm

There are two types of dental lasers

Hot Lasers

- Combination Hard and Soft tissue lasers

- The Erbium Family of Lasers
  - Carbon Dioxide @ 9.250 nm

Cold Lasers

- Soft Tissue lasers

- Diodes CO₂, Nd:YAG

PDT
Aiming Beams
Caries-Detection
Fluorescence
Photobiostimulation
Is everything we hear over the internet true: Examining the facts

I have been a member of the Academy and using Laser since 2000

Lasers I have used and owned
1. Hoya DElight Erbium Laser (Fully upgraded)
2. Hoya VersaWave Erbium Laser
3. Fotona PowerLase AT Erbium & Nd:YAG Laser
4. Fotona LightWalker Erbium Laser
5. Hoya 810 Diode Laser
6. Hoya 980 Laser
7. Xlase 1064 Diode Laser
8. 5 different Low Level Photbiomodulating lasers

Creating the perfect dental laser

One laser for both soft and hard tissue procedures
1. Excises or incises tissue rapidly
2. Reduction for the use of local anesthetics
3. Allowed tissue to heal rapidly
4. Produces little post-surgical swelling or discomfort
5. Excellent hemostasis
6. Is able to produce precise surgical incisions
7. Provides easy use to access any area of the oral cavity
8. Precise controllable surgery
9. Easy to use
10. Reliable

The perfect dental laser

One laser for both soft and hard tissue procedures
1. Reduce or eliminate the need for local anesthesia
2. Removes dental hard tissue rapidly
3. Minimizes need for conventional dental handpieces
4. Easy access any area of the tooth and oral cavity
5. Precise removal of dental hard tissues
6. Provides a mechanism to reduce enamel solubility
7. Make existing enamel or dentin less permeable, blocking out or slow down decalcified tissues
8. Easy to use
9. Reliable
10. Reliable
**Carbon Dioxide Laser @ 9300 nm**

The Solea Laser introduced in August 2013 uses a CO$_2$ beam super pulsed laser @ 9300nm for the removal of hard and soft tissues of the oral cavity.

Variable foot pedal is also computer driven and determines the speed.

**Isotropc CO$_2$ (Hard Tissue ablation (removal))**

- 9300nm wavelength has the highest energy transfer, 9600nm has highest absorption in dental hard tissues. (Hydroxyapatite)
- Heats up the dental hard tissue to very high temperatures by directly heating the mineral (carbonized hydroxyapatite)within the hard tissue.
- Both the temperature and depth of penetration are controlled by “pulse duration”, tissue properties & Percentage of Power.
- Phase transitions in the dental enamel change the mineral composition and liberates and ejects the molten surface layer.

**Approximate Net Absorption Curves Of Key Target Tissues**

- "Soft" tissue lasers
- "ALL" tissue lasers
- "Soft" tissue laser

**Solea CO$_2$ : Know your laser**

- Articulated arm
- Emergency Stop
- Touch-screen monitor
- Galvanometer
- Water reservoir
- Locked front wheels
- Variable Foot pedal

*Courtesy of Don Coluzzi enhanced version*
**Start-up**

- Turn on rear switch
- Once front light goes on amber press to turn green
- After self testing the screen will ask for pin code
- Choose tissue type for treatment
  - For hard tissue message will warn the priming will occur: OK
- Once water is exiting handpiece press OK
- Test fire into water

**Preparing your laser for treatment:** Understanding the start-up screen

1. **Choose Tissue Type**
   - Enamel, Dentin, Soft tissue
2. **Spot size**
   - 0.25, 0.5, 0.75, 1.0 mm
3. **Pulse Duration**
   - 1-500 usec
4. **Choose water spray**
   - In most instances stays at 100%
5. **Set percentage of power** "Fluence" or J/cm²
   - Usually leave 100% unless you have specific reason to lower
6. **Easily place a limit on % of power**

**CO₂ compared to Erbium**

<table>
<thead>
<tr>
<th>CO₂ hard tissue</th>
<th>Erbium Hard tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDA approved for both soft and hard tissue</td>
<td>FDA approved for both soft and hard tissue</td>
</tr>
<tr>
<td>Foot pedal - computerized variable power</td>
<td>Foot pedal - either on or off</td>
</tr>
<tr>
<td>Future software upgrades</td>
<td>Future software upgrades?</td>
</tr>
<tr>
<td>Beam size .25, 0.5, 0.75, 1 mm</td>
<td>Fixed beam size @ .5 0r .9 mm Tips @ range (.5-1.5)</td>
</tr>
<tr>
<td>Ablation controlled by changing pulse durations and total percent of power</td>
<td>Ablation controlled by altering HZ and MJ</td>
</tr>
</tbody>
</table>

**CAP computerized foot pedal.** Varies the Hz, eliminates the need to focus or defocusing

- Unique "Accelerator" pedal
- Variable speed power control

**Galvanometers (Galvos):**
- Computerized motors move up to 10K times/sec
- Manipulate beam for precision cutting
- User selectable spot sizes
- Optimized patterns and pulsing for each tissue type
### CO₂ compared to Erbium

#### CO₂ hard tissue vs. Erbium Hard tissue

<table>
<thead>
<tr>
<th><strong>CO₂</strong></th>
<th><strong>Erbium</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lasing medium molecule of isotopic CO₂ gas which has expected life of 32k hours (about 60 years @ 10 hrs/week)</td>
<td>Lasing medium YAG crystal doped with periodic table Erbium</td>
</tr>
<tr>
<td>Pulse duration can be varied from 1-500μsec</td>
<td>Maximum of 5 set pulse durations (Fotona): 50, 100, 300, 600, 1000μsec, Biolase 60, &amp; 700μsec</td>
</tr>
<tr>
<td>Green aiming beam (532nm)</td>
<td>Green aiming beam</td>
</tr>
<tr>
<td>Battery back-up for laser screen</td>
<td>Reboot laser when power interrupted</td>
</tr>
<tr>
<td>Internet diagnosis and software updates</td>
<td>No internet diagnostics</td>
</tr>
</tbody>
</table>

**Ejected material molten tissue particles**

<table>
<thead>
<tr>
<th><strong>CO₂</strong></th>
<th><strong>Erbium</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ - the absorption of laser light in the ejected tissue (Plume)</td>
<td>Absorption of further light energy is negligible in Erbium ablation since the water is transformed to a vapor.</td>
</tr>
<tr>
<td>The plume from CO₂ laser light is not scattered, but may continue to heat the expanding plume, resulting in loss of energy for tissue ablation and ablation efficiency.</td>
<td>The plume of ejected material may scatter the Erbium beam but further radiation is not absorbed by the ejected material.</td>
</tr>
</tbody>
</table>

The combination of the use of uniform aluminum material and ultra-high vacuum long life indium seals keeps the gas cool and leads to extended life. All aluminum CO₂ gas lasers are virtually sealed for life with a Mean Time Between Failures, MTBF, being 30,000 hours or 3.5 years running the laser 24/7/365. For a typical dental installation the 30,000 hours equates to 19.5 years.

Photonic energy result of Flash Lamp stimulation of dopant with in a solid Quartz crystal

### CO₂ compared to Erbium

#### CO₂ hard tissue vs. Erbium Hard tissue

<table>
<thead>
<tr>
<th><strong>CO₂</strong></th>
<th><strong>Erbium</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater absorption in Hydroxyapatite</td>
<td>Absorption is primarily in water (OH)</td>
</tr>
<tr>
<td>Absorption in enamel is 10x that of erbium, 93% of enamel</td>
<td>Absorbed in water, 4% of enamel</td>
</tr>
<tr>
<td>Due to peak absorption in enamel vaporizes it through photothermal effect</td>
<td>Photoacoustic explosion of water</td>
</tr>
<tr>
<td>Vaporized enamel rather than chipping effect</td>
<td>Explosion of water results in chipping effect</td>
</tr>
<tr>
<td>Computer assisted beam control &amp; galvos</td>
<td>Single beam</td>
</tr>
</tbody>
</table>

**Primarily end cutting, but allows for easy widening of cavity preparation**

- The CO₂ beam remains collimated and in focus for a long distance
- End cutting and requires perpendicular cutting to enamel rods
- Repetition rate 1-10,000 pulses (Hz) per second, quieter (avg 2400)
- When ablation hard tissue usually in the area of 12-15 Hz (louder)

**Requires acid etching for sealant or composite placement**

- Numerous papers have been published indicating increased enamel resistance to solubility
- Hydroxyapatite Ca₁₀(HA)
- No increase in caries protection

Position paper March 2007  ALD *

Low microsecond-pulsed carbon dioxide lasers with a 9.3- or 9.6-µm wavelength have great potential for efficient and effective ablation of sound and pathological hard tissues, as well as modification of the mineral to increase resistance to caries attack.

Inhibition of caries progression of from 40% to 85% was achieved over the range of laser conditions tested. At 9.3 and 9.6 µm, 25 pulses at absorbed fluences of 1 to 3 J/cm² produced inhibition on the order of 70% with minimal subsurface temperature elevation (< 1°C at 2 mm depth), comparable with inhibition produced in this model with daily fluoride dentifrice treatments.

The laser treatment produced 46% demineralization inhibition for the 4-week and a marked 87% inhibition for the 12-week arm. This study shows, for the first time in vivo, that the short-pulsed 9.6 µm CO2-laser irradiation successfully inhibits demineralization of tooth enamel in humans.


In-vivo occlusal caries prevention by pulsed CO2-laser and fluoride varnish treatment: A clinical pilot study.

Using your lasers on hard tissues with Children

1. Sealants
2. Photobiostimulating analgesic effect
3. Preventive resin restorations
4. Class I restorations
5. Class II restorations
6. Class III restorations
7. Class IV restorations
8. Class V restorations
9. Direct and Indirect pulpcaps
10. Crown preps
11. Removal or cutting of bone
12. Can you remove composites and alloy?
Reduction in the need for local anesthesia

1. Complete multiple restorative quadrants without the need to have to consider local anesthetic dosages.
2. Effective is due to Photobiomodulation or Low level laser ability

Appears to be almost 100% in primary teeth

Changing the Patient experience using the CO₂ laser @ 9300nm

Typical initial settings 75-90 pulse duration, water off. Use the variable power foot control 0 to 30-40%. Limit power (Hz) setting to 30-40 %, .25 spot size.

Soft tissue settings less than 70 pulse duration tissue is not heated adequately and may not prevent bleeding.

Tooth analgesia CO₂ @9300nm

Typical initial settings Dentin Tissue Choice, 100-125 pulse duration, 15-45 seconds, water on, air on, Power 100%, spot size .5 mm. Use the variable power foot control to adjust percentage of power from 50-100%. Keep all parameters at subablative power.

Sealants CO₂ @9300nm

Typical initial settings Dentin Tissue Choice, 75-125 pulse duration, water on, air on, Power 100%, spot size .25-.5mm. Use the variable power foot control to adjust percentage of power from 50-100%. Maintain power control to just etch enamel surfaces.
Typical initial settings: Dentin Tissue Choice, 75-200 pulse duration, water on, air on, Power 100%. Initially .5 spot size, finish using .25. Use the variable power foot control to adjust percentage of power from 50-100%.

Lawrence Kotlow DDS

Class I Restoration CO2 @9300nm

Typical initial settings: Dentin Tissue Choice, 75-250 pulse duration, water on, air on, Power 100%. Initially .5 spot size, finish using .25. Use the variable power foot control to adjust percentage of power from 50-100%.

Lawrence Kotlow DDS

Class II II restorations CO2 @9300nm

Tooth # K

Typical initial settings: Dentin Tissue Choice, 75-200 pulse duration, water on, air on, Power 100%. Initially .5 spot size, finish using .25. Use the variable power foot control to adjust percentage of power from 50-100%.

Lawrence Kotlow DDS

Class IIb restorations CO2 @9300nm

Tooth # T

Typical initial settings: Dentin Tissue Choice, 75-200 pulse duration, water on, air on, Power 100%. Initially .5 spot size, finish using .25. Use the variable power foot control to adjust percentage of power from 50-100%.

Lawrence Kotlow DDS
Tooth # 30

Typical initial settings: Dentin Tissue Choice, 100-222 pulse duration, water on, air on, Power 100%. .25 -.5 Spot size. Use the variable power foot control to adjust percentage of power from 50-100%.

Teeth F,G

Typical initial settings: Dentin Tissue Choice, 75-150 pulse duration, water on, air on, Power 100%. .25 -.5 Spot size. Use the variable power foot control to adjust percentage of power from 50-100%.

Tooth # H

Typical initial settings: Dentin Tissue Choice, 75-150 pulse duration, water on, air on, Power 100% . .25 -.5 Spot size. Use the variable power foot control to adjust percentage of power from 50-100%.
Permanent Anterior tooth Class V Preparation
CO2 @9300nm

Typical initial settings 100-140 pulse duration, water 100%, air on. Use the variable power foot control to adjust percentage of power from 50-100%. Spot size varies from .25-.5 as needed.

Lawrence Kotlow DDS

Permanent Anterior tooth Class III Preparation
CO2 @9300nm

Typical initial settings 90-140 pulse duration, water 100%, air on. Use the variable power foot control to adjust percentage of power from 50-100%. Spot size .25

Lawrence Kotlow DDS

Posterior Primary Stainless Steel Crown Preparation CO2 @9300nm

Typical initial settings as high as 350 pulse duration, water 100%, air on. Use the variable power foot control to adjust percentage of power from 50-100%. Spot size varies from .25-1mm as needed.

Lawrence Kotlow DDS

Maxillary Frenectomy CO2 @9300nm

Typical initial settings 75 pulse duration, water off. Use the variable power foot control 0 to 30-40%. Limit power (Hz) setting to 30-40 %. .25 spot size. Soft tissue settings less than 70 pulse duration tissue is not heated adequately and may not prevent bleeding.

Lawrence Kotlow DDS
Lingual Frenectomy CO₂ @9300nm

Typical initial settings 75-90 pulse duration, water off. Use the variable power
foot control 0 to 30-40%. Limit power (Hz) setting to 30-40 %, .25 spot size.

Soft tissue settings less than 70 pulse duration tissue is not heated adequately and
may not prevent bleeding.

Breastfeeding infant with lingual frenum and lip tie
BD:11/10/13

Surgery 12/30/13
Post surgery exam 1/7/14

CO₂ @9300nm Pulse duration 77/40%/ .25 spot size

Toddler with lingual frenum and lip-tie
BD: 12/21/12

Surgery 12/16/13
Post surgery 12/16/13

CO₂ @9300nm Pulse duration 77/40%/ .25 spot size

Maxillary Frenum lip revision

Surgery 12/30/13
Post surgery exam 1/7/14

BD 1/17/08
Presurgery 12/30/13

Lingual frenum revision

Surgery 12/12/13
Post 12/20/13

CO₂ @9300nm Pulse duration 77/40%/ .25 spot size
Exposure of tooth under soft tissue CO2 @9300nm

1 week post surgery

Typical initial settings 75-90 pulse duration, water off. Use the variable power foot control 0 to 30-40%. Limit power (Hz) setting to 30-40%, .25 spot size.

Soft tissue settings less than 70 pulse duration tissue is not heated adequately and may not prevent bleeding.

Lawrence Kotlow DDS

Biopsy CO2 @9300nm

6 days post surgery

Typical initial settings 75-90 pulse duration, water off. Use the variable power foot control 0 to 30-40%. Limit power (Hz) setting to 30-40%, .25 spot size.

McGarry

Lawrence Kotlow DDS

Thank you for your attention