APPLICATIONS MANUAL

Er:YAG and Nd:YAG Lasers in Dermatology and Aesthetic Medicine

94797 CE ENG 15
Please note that while every effort has been made to ensure that the data given in this manual is accurate, the information, figures, illustrations, tables, screenshots, specifications, and schematics contained herein are subject to change without notice.

Copyright © Fotona d.o.o., all rights reserved.
The contents of this publication may not be reproduced in any form without the explicit permission of Fotona d.o.o.
Foreword

Dear customer,

Thank you for purchasing a Fotona laser system and placing your trust in our brand. We are certain that your Fotona system will be an asset to your practice and will provide you with substantial advantages in many different areas of your daily work. With over 50 years of experience in the laser industry, we have a deep understanding of the modern physician's needs and aim to provide laser-based solutions that excel in quality and reliability.

Fotona medical laser systems have been developed and are manufactured according to the most stringent international quality and safety requirements and standards. All Fotona laser systems are authorized to carry the CE mark.

The purpose of this Applications Manual is to provide general information and guidelines that can be helpful to establish your own treatment procedures and protocols. We strongly recommend carefully reading and studying its entire content as well as the system's Operator Manual before attempting to operate the device. Please take note of the various warnings and notes that are provided to ensure the maximum life-span of your device and to ensure your safety and the safety of the patient and any medical personnel assisting you.

Should you have any questions or comments regarding your Fotona laser system, we invite you to contact us by email at info@fotona.com. You may also use our other contact details provided on the cover page.

To ensure that we can be of optimal service to you, we kindly recommend registering your Fotona device online at www.fotona.com.

We hope you will enjoy your Fotona laser system and the added value and advantages it will bring to your work.

The Fotona Team
CONTENTS

1. INDICATIONS FOR USE AND APPLICABLE DEVICES ........................................................................7
   1.1 APPLICABLE DEVICES ........................................................................................................... 7
   1.2 INDICATIONS, CONTRA-INDICATIONS AND SIDE EFFECTS .............................................. 8

2. INTRODUCTION TO LASERS IN MEDICINE ........................................................................... 12
   2.1 L.A.S.E.R ................................................................................................................................. 12
   2.1.1 The Unique Properties of Laser Light .................................................................................. 12
   2.1.2 Main Components of a Medical Laser .................................................................................. 12
   2.2 LASER – TISSUE INTERACTION ........................................................................................... 13
   2.3 LASER TYPES AND APPLICATIONS ....................................................................................... 13
   2.4 LASER PARAMETERS ............................................................................................................... 14
       2.4.1 Wavelength (nm) ............................................................................................................... 14
       2.4.2 Power (W) ......................................................................................................................... 14
       2.4.3 Repetition Rate - Frequency (Hz) ..................................................................................... 14
       2.4.4 Pulse Duration (µs or ms) ................................................................................................ 14
       2.4.5 Pulse Energy (J) ................................................................................................................. 15
       2.4.6 Peak Power (W) ................................................................................................................ 15
       2.4.7 Spot Size (mm) .................................................................................................................. 15
       2.4.8 Fluence (J/cm²) ................................................................................................................ 15
   2.5 OPTICAL AND THERMAL TISSUE PARAMETERS ................................................................. 15
       2.5.1 Absorption Coefficient & Penetration Depth ..................................................................... 15
       2.5.2 Thermal Relaxation Time ................................................................................................ 16
   2.6 FOTONA VSP TECHNOLOGY ................................................................................................ 17
   2.7 SPATIAL BEAM DELIVERY PATTERNS ................................................................................. 17
       2.7.1 Handpieces ....................................................................................................................... 17
   2.8 SAFETY PRECAUTIONS ........................................................................................................... 18

3. PROCEDURES IN DERMATOLOGY AND AESTHETICS .......................................................... 20
   3.1 INTRODUCING LASER TREATMENTS TO YOUR PATIENT .................................................. 20
   3.2 PRE-TREATMENT SKIN PREPARATION GUIDELINES ............................................................... 22
   3.3 PRE-TREATMENT SAFETY PRECAUTIONS ............................................................................ 23
   3.4 GENERAL OPERATIVE GUIDELINES ...................................................................................... 23
   3.5 COLD AIR COOLING DURING FOTONA LASER TREATMENTS ............................................... 24
   3.6 POST-OPERATIVE CARE GUIDELINES .................................................................................... 25

4. ER:YAG TECHNOLOGY IN DERMATOLOGY AND AESTHETICS ............................................. 26
   4.1 INTRODUCTION ....................................................................................................................... 26
       4.1.1 Advantages of Fotona VSP-shaped Er:YAG laser Technology ........................................... 26
   4.2 ER:YAG LASER OPERATIVE GUIDELINES ........................................................................... 28
       4.2.1 Administering Anesthesia ................................................................................................ 29
       4.2.2 Post-Operative Care ......................................................................................................... 30
   4.3 ADDITIONAL CONSIDERATIONS AND TECHNOLOGIES IN ER:YAG SKIN REJUVENATION ............................................................................................................................. 31
       4.3.1 The Effect of Fluence and Pulse Width in Er:YAG Skin Rejuvenation ............................... 31
       4.3.2 SMOOTH Mode in Skin Rejuvenation ............................................................................. 32
       4.3.3 Turbo Mode in Skin Resurfacing ..................................................................................... 33
       4.3.4 Wide Area Skin Resurfacing using Fotona Er:YAG Scanner Technology ..................... 34
       4.3.5 Full Field and Patterned Treatments ............................................................................... 34
       4.3.6 Stamping and Scanning Fractional Treatments ................................................................. 36

5. ER:YAG TREATMENT GUIDELINES & PARAMETERS ............................................................... 39
   5.1 SKIN RESURFACING .............................................................................................................. 39
       5.1.1 Light Peel Skin Resurfacing ............................................................................................ 40
       5.1.2 Medium Peel Skin Resurfacing ....................................................................................... 41
       5.1.3 Deep Peel Skin Resurfacing ............................................................................................ 43
   5.2 FRACTIONAL ABLATIVE SKIN RESURFACING .................................................................... 46
5.2.1 Light Fractional Skin Resurfacing ................................................................. 47
5.2.2 Medium Fractional Skin Resurfacing .......................................................... 47
5.2.3 Deep Fractional Skin Resurfacing ............................................................... 48
5.3 SPECIFIC TREATMENT PROTOCOL – PERI-Ocular AND PERI-ORAL REGIONS ................................................................. 49
5.4 SMOOTH MODE REJUVENATION TREATMENTS ........................................ 51
5.5 BENIGN SKIN LESIONS REMOVAL ................................................................. 53
5.6 GENERAL SURGERY .......................................................................................... 57

6. ND:YAG LASERS IN DERMATOLOGY AND AESTHETICS .............................................. 59

6.1 INTRODUCTION ................................................................................................. 59
6.1.1 Nd:YAG Wavelength Considerations ........................................................ 59
6.1.2 Pulse width Considerations ........................................................................ 63
6.1.3 Variable Square Pulse Technology ........................................................... 64
6.1.4 Pulse Energy and Fluence Considerations ................................................ 66
6.1.5 Spot Size Considerations ........................................................................... 67
6.2 COLD AIR COOLING DURING FOTONA ND:YAG TREATMENTS ....................... 68

7. ND:YAG TREATMENT GUIDELINES & PARAMETERS ................................................... 69

7.1 LASER HAIR REMOVAL .................................................................................... 69
7.1.1 Treatment Principle .................................................................................... 69
7.1.2 Hair Biology ............................................................................................... 70
7.1.3 Hair Growth Cycle ..................................................................................... 71
7.1.4 Treatment Results and Patient Expectations ............................................. 71
7.1.5 Suggested Hair Removal Parameters ....................................................... 73
7.1.6 Laser Hair Removal Treatment Schedule ............................................... 76
7.1.7 Suggested Eyebrow Hair Removal Protocol ............................................. 76
7.1.8 Miscellaneous Considerations in Hair Removal ....................................... 77

7.2 VASCULAR LESION TREATMENTS .................................................................. 78
7.2.1 Treatment Principles ................................................................................ 79
7.2.2 Classification of Cutaneous Vascular Lesions ......................................... 79
7.2.3 Suggested Vascular Treatment Parameters ............................................ 80

7.3 NON-ABLATIVE, ND:YAG SKIN REJUVENATION .............................................. 86
7.3.1 Suggested Treatment Parameters ........................................................... 86

7.4 TREATMENT OF MILD-TO-MODERATE INFLAMMATORY ACNE VULGARIS ......................... 89
7.4.1 Suggested Treatment Parameters ........................................................... 90
7.4.2 Post Treatment Guidelines ...................................................................... 91

7.5 ND:YAG LASER IN PODIATRY ......................................................................... 92
7.5.1 Wart Treatment ......................................................................................... 92
7.5.2 Temporary increase of clear nail in patients with onychomycosis .............. 92

8. ND:YAG LASERS IN GENERAL SURGERY .............................................................. 94

8.1 ND:YAG LASERS IN ENDOVENOUS LASER THERAPY ...................................... 94
8.1.1 Introduction .............................................................................................. 94
8.1.2 Varicose Veins Treatment ........................................................................ 97

8.2 ND:YAG LASERS IN LASER LIPOLOGY AND LASER-ASSISTED LIPOSUCTION ................................................................. 106
8.2.1 Introduction ............................................................................................. 106
8.2.2 Laser Lipolysis and Laser Assisted Liposuction Treatment ....................... 107

8.3 ND:YAG LASERS IN LASER ASSISTED REDUCTION OF AXILLARY HYPERhidrosis ................................................................. 115
8.3.1 Introduction ............................................................................................. 115
8.3.2 Laser Assisted Reduction of Axillary Hyperhidrosis Treatment ................ 115

8.4 INCISION AND EXCISION, REMOVAL OF POST-SURGICAL GRANULATIONS ................................................................. 118
8.5 BIOPSIES ........................................................................................................ 119
8.6 FIBROMA REMOVAL ...................................................................................... 119
8.7 HEMOSTASIS ................................................................................................. 120

9. COMBINED TREATMENT GUIDELINES & PARAMETERS .............................................. 121

9.1 INTRODUCTION ............................................................................................... 121
9.2 TWINLIGHT® REJUVENATION ....................................................................... 121
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.2.1</td>
<td>Suggested Treatment Parameters</td>
<td>122</td>
</tr>
<tr>
<td>9.3</td>
<td>FOTONA 3D™ AND FOTONA 4D™ REJUVENATION</td>
<td>124</td>
</tr>
<tr>
<td>9.3.1</td>
<td>Suggested Treatment Parameters</td>
<td>124</td>
</tr>
<tr>
<td>9.4</td>
<td>FOTONA TIGHTSCULPTING™ REJUVENATION</td>
<td>127</td>
</tr>
<tr>
<td>9.4.1</td>
<td>Suggested Treatment Parameters</td>
<td>127</td>
</tr>
<tr>
<td>10.</td>
<td>CONTRIBUTORS</td>
<td>130</td>
</tr>
</tbody>
</table>
1. **INDICATIONS FOR USE AND APPLICABLE DEVICES**

1.1 **Applicable Devices**

This Applications Manual is intended to be used in the field of dermatology, aesthetic medicine and surgery with the following Fotona laser systems:

**XS Dynamis (including FotonaSmooth XS variant), Dualis XS; M002-2A:**
- Er:YAG laser with a wavelength of 2940 nm

**SP Dynamis (including FotonaSmooth SP variant), SP Spectro, Fotona SP Plus; M021-4AF/3:**
- Er:YAG laser, with a wavelength of 2940 nm
- Nd:YAG laser, with a wavelength of 1064 nm

**XP Dynamis, XP Spectro, Dualis XP Plus, Dualis XP; M001-12F:**
- Nd:YAG laser with a wavelength of 1064 nm

The Applications Manual that follows is cleared to be used in the territory of the EU. Before attempting to use this Applications Manual, carefully read the appropriate Operator Manuals for the above laser systems and accompanying accessories.

**NOTE**

The practitioner should be aware that the skin structure differs from person to person, so treatment parameters and protocols will differ from case to case. Suggested parameter ranges in this Applications Manual as well as pre-sets in Fotona laser systems should be taken only as guidelines. The practitioner should adjust the laser treatment procedure and selection of treatment parameters from case to case based on the intended clinical end-point.

**WARNING!**

Do not treat any suspicious lesion; always biopsy (multiple biopsies) any suspicious lesions.

Consult a specialist for cancer screening before initiating ablative laser therapy.

**WARNING!**

Do NOT attempt any laser treatments if the patient shows clear signs of having hyper-sensitive or abnormally sensitive skin.
1.2 Indications, Contra-indications and Side effects

The indications for use of the devices defined in section 1.1 (Applicable devices), which are the subject of this Applications Manual, are listed in this section below.

Er:YAG Laser

Indications in Dermatology and Aesthetic

Indications in Dermatology

- Epidermal nevi
- Actinic cheilitis
- Keloids
- Verrucae
- Skin tags
- Anal tags
- Keratoses
- Scar revision
- Skin resurfacing
- Skin rejuvenation

Dermatological procedures requiring coagulation, resurfacing and ablation of soft tissue with the Fractionated Handpieces

Ophtalmology Indications:

- Soft tissue surrounding the eye and orbit

Podiatry Indications:

- Warts
- Plantar verrucae
- Large mosaic verrucae
- Matrixectomy

Indications in Surgery

ENT Surgery Indications:

- ENT lesions
- Cysts
- Polyps
- Hyperkeratosis
- Oral leukoplaikia

General Surgery Indications:

- Surgical incision/excision, vaporization and coagulation of soft tissue during any general surgery application where skin incision, tissue dissection, excision of lesions, complete or partial resection of internal organs, lesions, tissue ablation and vessel coagulation is necessary

Oral /Maxillofacial Indications:

- Oral and glossal lesions
- Gingivectomy
Nd:YAG Laser

**Indications in Dermatology and Aesthetic**

- Permanent reduction of unwanted hair in Fitzpatrick skin types I-VI
- Skin rejuvenation
- Non-ablative wrinkle reduction
- Treatment of mild to moderate inflammatory acne vulgaris
- Photocoagulation and hemostasis of pigmented and vascular lesions; including but not limited to nevus flammeus (port wine stain), hemangioma, warts, telangiectasia, rosacea, venus lake, leg veins, spider veins, reticular veins and cherry (senile) angiomma
- Verrucae and warts
- Temporary increase of clear nail in patients with onychomycosis (e.g. dermatophytes, Trichophyton rubrum and T. mentagrophytes, and/or yeast Candida albicans, etc.)

**Indications in Surgery**

**Endovenous Laser Therapy**

- Endovenous laser therapy of superficial incompetent tributary veins associated with varicose veins and varicosities

**Laser-Assisted lipolysis**

- Laser-assisted axillary hyperhidrosis reduction
- Treatment of Aphthous Ulcers
- Excision and Vaporization of Herpex Simplex I and II lesions
- Laser assisted uvulopaletoplasty (LAUP)

**General surgery**

- Surgical incision/excision, Vaporization and coagulation of soft tissue. All soft tissue is included, striated and smooth tissue, muscle, cartilage, meniscus, mucous membrane, lymph vessels and nodes, organs and glands
- Laser-assisted axillary hyperhidrosis reduction
- Treatment of Aphthous Ulcers
- Excision and Vaporization of Herpex Simplex I and II lesions
- Laser assisted uvulopaletoplasty (LAUP)

**Contra-indications (relative and absolute):**

**General laser contra-indications**

**Absolute (Er:YAG and Nd:YAG)**

- History of a histologically demonstrated malignant disease in the area to be treated
- Clinical findings indicative of malignant disease
- Hyperthyrosis if the neck region is to be treated
- Epilepsy
- Pregnancy
- Active systemic infection
- Previous treatment with ionizing radiation in the area to be treated
Relative (Er:YAG and Nd:YAG)

- History of a histologically demonstrated malignant disease
- History of wound healing disorders, including but not limited to post inflammatory hyperpigmentation, abormal scarring and keloid scarring
- Infection of the treatment area, including but not limited to viral, bacterial or fungal infections of tissues
- Inflammation of the treatment area, including but not limited to infection or autoimmune diseases
- Fever
- Systemic or local autoimmune disorders
- Neurological disorders
- Laser treatment of the testicular area
- History of photosensitivity disorder
- Use of medications, which promote photosensitivity in the last 6 months, including but not limited to tetracyclines, fluoroquinolones, thiazide diuretics, phenothiazine, sulfonamides and vitamin A derivates
- Type 1 diabetes
- Type 2 diabetes
- Use of anti-platelet medications, including but not limited to COX inhibitors, ADP inhibitors or thromboxane inhibitors
- Use of anticoagulation medications, including but not limited to coumarins, heparins or factor Xa inhibitors
- Use of vasodilators
- Conditions or diseases, which limit blood coagulation
- Conditions or diseases, which limit platelet function
- Conditions or diseases, which limit blood oxygen capacity, including but not limited to heavy blood loss
- Connective tissue disorders
- Gold therapy

Additional relative contra-indications in Aesthetics and Dermatology (Er:YAG and Nd:YAG):

- Recent excessive sun exposure, tanned skin
- Any tissue in the proximity or on top of any kind of implants

Additional relative contra-indications for Temporary increase of clear nail in patients with onychomycosis (e.g. dermatophytes, Trichophyton rubrum and T. mentagrophytes, and/or yeast Candida albicans, etc.):

- Permanent or semi-permanent discoloration of the nail plate
- Concomitant nail disorders, including but not limited to psoriasis of nail plate and lichen planus
- Subungual pigment formation or hemorrhage
- Other undiagnosed lesions of nail plate and periungual area

Additional relative contra-indications in Surgical indications (Er:YAG and Nd:YAG):

- History of cardiovascular disease
- History of pulmonary disease
- Endocrine disorders
- Morbid obesity
- Any tissue in the proximity or on top of any kind of implants
Possible side effects

General laser treatment related side effects:

- Discomfort during and/or after the treatment
- Mild to moderate pain during and/or after the treatment
- Tissue erythema
- Tissue oedema
- Delayed healing
- Bleeding
- Haematoma
- Tissue burns
- Blistering
- Soreness
- Tenderness of the treated area
- Non specific tissue inflammation
- Tissue infection
- Tissue hyperpigmentation
- Tissue hypopigmentation
- Paresthesia
- Hemosiderin staining
- Tissue necrosis
- Ulcerations
- Scarring including hypertrophic and atrophic scarring

Additional possible side effects in Aesthetics and Dermatology (Er:YAG and Nd:YAG):

Additional possible side effects in permanent reduction of unwanted hair in Fitzpatrick skin types I-VI

- Hair removal by lasers can cause paradoxial increased hair growth in some individuals. Based upon currently available data, the highest risk groups for this response are females of Mediterranean, Middle Eastern, and South Asian heritage treated on the face and neck.

Additional possible side effects in Surgical indications (Er:YAG and Nd:YAG):

- Embolism
- Friction burns
- Irregular contour deformities

An informed consent from the patient is recommended.
2. INTRODUCTION TO LASERS IN MEDICINE

2.1 L.A.S.E.R

The acronym LASER stands for Light Amplification by Stimulated Emission of Radiation.

2.1.1 The Unique Properties of Laser Light

Natural, or incoherent, light is composed of electromagnetic waves traveling in a disoriented fashion. Laser light has three unique properties that distinguish it from natural light.

Laser light is collimated: it travels in a single direction with very little divergence. Ordinary light waves spread and lose intensity quickly. This property allows laser light to be transmitted with very little power loss in comparison with ordinary light.

Laser light is monochromatic: it consists of one color or a narrow range of colors. Ordinary light has a much wider range of wavelengths or colors. This property allows laser light to have very specific effects on tissues.

Laser light is coherent: all of the light waves move in phase in both time and space. Ordinary, incoherent light from a light bulb is composed of a mixture of waves with different frequencies, traveling in different directions. This property allows laser energy to be delivered in an extremely precise and controlled manner.

2.1.2 Main Components of a Medical Laser

Laser energy is generated within the laser cavity. The laser cavity has three main components.

The first component is the active medium; it can be solid, liquid, or gas. A solid active medium consists of a cylindrical laser crystal. Popular laser crystals for medical laser applications are Nd:YAG and Er:YAG (neodimium:yttrium-aluminum-garnet and erbium:yttrium-aluminum-garnet). The active medium determines the specific wavelength of light at which the laser operates (e.g. 1064 nm for Nd:YAG and 2940 nm for Er:YAG).

The second component is an incident energy source used to stimulate the atoms of the active medium. A pulsed low pressure xenon flashlamp is often used.

The third component is the optical resonator - two highly polished mirrors placed at either end of the laser cavity, which redirect the escaping incoherent light of the active medium, producing bright, unidirectional, and monochromatic light.

Laser light travels through a beam delivery system, either an articulated arm or optical fiber, and then through a handpiece to reach the target tissue.

A reliable, high-performance power supply is needed to generate laser light. The laser parameters are controlled by the practitioner using an interface.
2.2 Laser – Tissue Interaction

Laser treatments are defined by the laser beam parameters, the target surface area, the light contact pattern and the speed at which the beam moves across the tissue.

The wavelength and power density of a laser beam determine its effect on tissue. Laser light is absorbed, transmitted, reflected, and scattered by tissue; the relative proportions of these phenomenon depend on the optical characteristics of the tissue. Only absorption produces significant tissue effects. Absorption can result in photochemical, photothermal, and photomechanical interactions between the beam and the tissue.

In general: more energy equals more effect. The energy and power of the laser beam can be controlled directly. The speed at which the beam moves across tissue also affects how much energy is absorbed by the tissue. Slower beam movement across an area will result in more energy delivered to that area.

Sometimes the pattern of the light is important. The pattern can be controlled manually or by an automated scanner.

Chemicals that absorb light are called chromophores. The most important chromophores in aesthetic laser therapy are water (which absorbs at 2940 nm), melanin, oxyhemoglobin and desoxyhemoglobin (which absorbs at 1064 nm).

2.3 Laser Types and Applications

A wide range of lasers are available for medical applications. In general, medical lasers can be divided into four groups: gas lasers (CO$_2$, Argon, HeNe, etc.), solid state lasers (Er:YAG, Nd:YAG, KTP, etc.), liquid (dye) lasers, and diode lasers.
### Table 2.1 Laser Types vs. Applications

<table>
<thead>
<tr>
<th>Laser Type</th>
<th>Wavelength (nm)</th>
<th>Active Medium</th>
<th>Absorbing Chromophores</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Er:YAG</td>
<td>2940</td>
<td>Erbium in yttrium-aluminum-garnet (Er:YAG)</td>
<td>Water</td>
<td>photo-rejuvenation, skin resurfacing, benign lesions, surgery</td>
</tr>
<tr>
<td>Nd:YAG and Q-switched Nd:YAG</td>
<td>1064</td>
<td>Neodymium in yttrium-aluminum-garnet (Nd:YAG)</td>
<td>Slight absorption in melanin and hemoglobin. Q-switched Nd:YAG has strong absorption in darker tattoo ink pigment.</td>
<td>hair removal, blood vessel treatment, tattoo removal, photo-rejuvenation, acne treatments, surgery</td>
</tr>
<tr>
<td>Ruby</td>
<td>694</td>
<td>Chromium ions in aluminum oxide</td>
<td>Strong absorption in melanin and black, dark blue ink pigment</td>
<td>tattoo removal, pigmented lesions, hair removal</td>
</tr>
<tr>
<td>KTP (frequency doubled Nd:YAG)</td>
<td>532</td>
<td>Potassium-Titanyl-Phosphate (KTP) crystal (Nd:YAG)</td>
<td>Melanin, hemoglobin</td>
<td>vascular lesions, pigmented lesions</td>
</tr>
<tr>
<td>Ho:YAG</td>
<td>2140</td>
<td>Holmium in yttrium-aluminum-garnet</td>
<td>Water</td>
<td>surgery</td>
</tr>
<tr>
<td>CO₂</td>
<td>10600</td>
<td>CO₂, N₂, He gas mixture</td>
<td>Water</td>
<td>skin resurfacing, benign lesions, surgery</td>
</tr>
<tr>
<td>Diode</td>
<td>810, 940, 980, 1440</td>
<td>(semiconductor) diodes</td>
<td>Melanin, hemoglobin</td>
<td>hair removal, blood vessel treatment, photo-rejuvenation, surgery</td>
</tr>
<tr>
<td>Dye</td>
<td>400-800</td>
<td>Organic compound in solution</td>
<td>Melanin, hemoglobin</td>
<td>vascular lesions, non-ablative rejuvenation</td>
</tr>
<tr>
<td>Excimer</td>
<td>190-350</td>
<td>XeF, XeCl, KrF, ArF</td>
<td>Proteins and water</td>
<td>psoriasis, ophthalmology</td>
</tr>
</tbody>
</table>

### 2.4 Laser Parameters

#### 2.4.1 Wavelength (nm)

Laser light can be represented as periodic waves of energy traveling through space. Wavelength refers to the physical distance between crests of successive waves in the laser beam. Typical medical laser wavelengths are: 1064 nm (near-infrared), 2940 nm (mid-infrared), etc. Only laser wavelengths between 400 nm and 700 nm are visible to the human eye.

#### 2.4.2 Power (W)

Laser power refers to the rate at which energy is generated by the laser. Laser power of 1 Watt means that 1 Joule of energy is emitted in 1 second.

#### 2.4.3 Repetition Rate - Frequency (Hz)

Medical lasers are usually operated in a repetitive pulse mode. Laser pulses are emitted periodically at a pulse repetition rate, for example 10 pulses per second. Hertz (Hz) is the most commonly used unit for pulses per second.

#### 2.4.4 Pulse Duration (µs or ms)

Pulse duration and pulse width are synonymous terms, which refer to the temporal length of the laser pulse; that is, the time during which the laser actually emits energy.
2.4.5 Pulse Energy (J)

The radiant energy in a laser pulse. The Pulse Energy, unlike the Laser Power, is independent of frequency and repetition rate, because of this Pulse Energy is sometimes used in preference to Laser Power to specify treatment parameters.

2.4.6 Peak Power (W)

Peak power refers to the power level during an individual laser pulse.

\[ \text{Peak power} = \frac{\text{Pulse energy}}{\text{Pulse duration}} \]

For a laser operating in Pulsed Mode with energy of 1 Joule and pulse duration of 100 µs, peak power can be calculated as 10kW.

2.4.7 Spot Size (mm)

Laser beam spot size refers to the diameter of the laser beam on the target. By changing the laser beam spot size while keeping the laser pulse energy constant, the energy fluence can be changed substantially and thus the basic mechanism of laser beam interaction with the tissue (heating, ablation, vaporization) influenced.

2.4.8 Fluence (J/cm²)

Fluence refers to the amount of laser energy delivered per unit area. It is also called ‘dose of energy’ or ‘energy density’.

\[ \text{Fluence} = \frac{\text{Energy}}{\text{Area}} \]

Fluence becomes larger as the spot size becomes smaller if all other parameters are held constant. Fluence is independent of spot size, frequency, and even the time of the treatment. This makes it useful for specifying general treatment characteristics. Other parameters must also be properly adjusted to efficaciously and safely apply laser treatment.

2.5 Optical and Thermal Tissue Parameters

2.5.1 Absorption Coefficient & Penetration Depth

One of the most important optical features of a target tissue is its ability to absorb laser light. The light absorption coefficient is usually referred to as the \( \mu_a \) coefficient and is expressed in units of 1/cm or cm⁻¹.

If laser light falls on tissue without scattering, then the fluence delivered to each layer of tissue decreases exponentially with depth. Assuming the fluence of the incident light is \( F_0 \) and the absorption coefficient of the tissue is \( \mu_a \), then the fluence, \( F \), delivered to the tissue at depth \( z \) can be modeled by:

\[ F = F_0 \times e^{-\mu_a z} \]

At a depth of \( 1/\mu_a \), the fluence decreases to roughly 1/3 of the initial fluence (\( F = F_0 \times e^{-1} = 0.367 \times F_0 \)).
The value of the absorption coefficient depends upon the laser wavelength and tissue type.

![Absorption coefficient at various wavelengths. Nd:YAG laser light has virtually no absorption in water, so it penetrates further into tissue than Er:YAG. This makes it possible for Nd:YAG laser light to target structures deeper in the skin. Er:YAG light is used for superficial treatments.](image)

**Figure 2.1.** Absorption coefficient at various wavelengths. Nd:YAG laser light has virtually no absorption in water, so it penetrates further into tissue than Er:YAG. This makes it possible for Nd:YAG laser light to target structures deeper in the skin. Er:YAG light is used for superficial treatments.

### 2.5.2 Thermal Relaxation Time

The TRT (Thermal Relaxation Time) is defined as the time it takes for a target mass to dissipate approximately 63% of its thermal energy. Smaller objects of similar shape and composition have smaller TRTs. The TRT of a target tissue is an important parameter in laser therapy; it often determines which parameters are necessary to achieve the appropriate clinical effect.

The rapid development of concentrated heat energy in small volumes of target tissue is necessary for effective laser treatment. The concentrated heat energy causes secondary effects in the tissue: the killing of hair follicles, the ablation of skin, etc. Heat energy is directly proportional to temperature. To achieve the aforementioned effects, the heat energy, or temperature, must exceed some threshold value; below this value there will be no efficacious secondary effects and instead the tissue will merely 'heat up'. Objects with low TRT will not be able to retain heat energy above a clinically relevant threshold (i.e. they will cool too quickly for the laser to heat them up, cooling too much even during the duration of one pulse). Often the tissue structures targeted by laser treatment have low TRT values, so short, high-energy laser pulses – which heat very rapidly – are necessary to perform effective treatments.

Sometimes, heating the tissue is the object of the treatment. In these cases longer pulse widths should be used.
### 2.6 Fotona VSP Technology

Fotona’s Variable Square Pulse (VSP) technology – a unique, patented and proprietary laser solution – provides rectangular pulses with variable pulse width.

![Figure 2.2. Comparison of standard laser technology pulses and Fotona VSP shaped pulses.](image)

Many tissue effects occur only above certain temperature thresholds. Heating the skin below these thresholds may cause undesirable effects or damage. VSP technology enables the laser to affect a stable temperature above these thresholds throughout an entire pulse’s duration.

Within a laser pulse the energy rises, reaches a maximum, and then decays. Without VSP technology control, during the rise and decay of the pulse, the energy delivery is insufficient to develop a temperature above a clinically effective threshold. VSP technology virtually eliminates the rise and decay period of laser pulses, resulting in a stable delivery of laser energy across the entire pulse duration.

### 2.7 Spatial Beam Delivery Patterns

The way in which laser light is delivered across a treatment area can have a significant impact on the efficacy and efficiency of the treatment. Fotona’s laser systems, scanners, and handpieces have features that help to control the spatial pattern of the laser treatment.

#### 2.7.1 Handpieces

The simplest way to control the spatial distribution of the laser is to operate with a basic handpiece and move the handpiece beam between pulses. This method is good for small area treatments and procedures that require high levels of precision.

Fotona’s handpieces allow the laser beam spot size to be easily adjusted to suit particular treatments. Spot size adjustments can provide additional precision, can make it easier to work on larger areas and can even influence the laser-tissue interaction in some treatments. In skin resurfacing, Fotona’s Pixel Screen Technology (PST) handpieces pixelate the original laser beam, without altering its basic properties, to enable fractional treatments that are less invasive and offer quicker recovery times than full ablative treatments.
**Scanners**

The use of handpieces to deliver the laser beam to the treatment area is certainly the most basic and common delivery modality. Yet procedures over larger areas with handpieces, as in skin resurfacing or hair removal, are prone to error and become tedious for both the patient and the practitioner.

Fotona's scanners efficiently execute complex, broad patterns for large-area treatments. Scanners are available for both Nd:YAG and Er:YAG laser treatments. More details of scanner operation can be found in the relevant Operator Manuals and the section in this Applications Manual. Alternatively, you can contact your local Fotona representative for more information or visit the Fotona website at www.fotona.com.

Three scanning patterns are common to all Fotona scanners:

The **SE or SEquential** scanning sequence performs a single, uninterrupted, line-by-line scan across the entire scan area, which can be defined by the practitioner. This scanning sequence can be particularly useful in situations when the practitioner wants to cover a smaller scan area than the entire scan area, without having to change the scanning area size during the treatment. In this case the practitioner would simply stop the scan mid-sequence.

The **OP or OPtimal** scanning sequence performs a scan across the entire scan area chosen by the practitioner in which neighboring, successive spot deposition is avoided. The complete scanning sequence is completed in four passes across the entire scan area. The OP scanning sequence is recommended for performing scanner treatments that require high fluence levels to be delivered to the skin at high repetition rates.

The **PR or PaRtial** scanning sequence is based on the same non-successive spot deposition principles as the OP scanning sequence, with the addition of an Autorepeat time between successive passes. The Autorepeat time is a variable, configurable pause that can be set by the practitioner. The Autorepeat time pauses provide additional cooling in the treatment site, which make the PR scanning sequence particularly useful when treating patients with a low pain threshold.

### 2.8 Safety Precautions

Safety warnings, methods of adherence to regulatory standards and system safety features are extensively covered in the system Operator Manual. Read the entire manual to ensure your safety and the safety of the patient and any assisting personnel.

**WARNING!**

Fotona laser systems should only be used by persons trained in the operation of laser devices.

**WARNING!**

The recommended parameters should be used according to practitioner skills. Laser systems with the highest average power and/or maximum energy per pulse are recommended to be used by experienced practitioners. Use of maximal parameters by unexperienced practitioner can result in tissue injury.
WARNING!
Appropriate protective eyewear must be worn by the patient and all operating personnel to prevent inadvertent exposure to the eyes.

CAUTION!
Connect the laser system to a properly grounded mains electrical supply outlet. Install the system in a location that meets IEC requirements.

WARNING!
Only service personnel with authorization from Fotona should install, maintain, repair and calibrate the laser system.

WARNING!
Place warning lights in prominent places at all entrances to the treatment room to alert all personnel that they are entering a controlled area.

WARNING!
Do not use the laser system in the presence of flammables or explosives, such as volatile anesthetics, alcohol, certain surgical preparation solutions, and other such substances.

Do not use the laser system before ensuring that surgical drapes and gowns made of flame-retardant material and towels or gauze sponges moistened with sterile saline solution or sterile water are available in the operating field.

WARNING!
Instruments that are introduced in the operating field and potentially in the laser beam path should be non-reflective. Note that materials that do not reflect light will be heated by the laser beam.
3. PROCEDURES IN DERMATOLOGY AND AESTHETICS

3.1 Introducing Laser Treatments to Your Patient

Before developing a treatment plan and setting treatment goals with your patient, ensure that your patient understands the laser treatment and that your patient has no characteristics which disqualify them from laser treatment. A partial list of important points to discuss is provided below:

- Introduce and discuss the Fotona laser treatment modality and procedure with the patient.
- Disqualify any patients, who have clearly been exposed to the sun and/or artificial tanning methods in the 3 weeks prior to treatment.
- Obtain a detailed anamnesis, including previously undergone treatments, and determine the suitability of the patient for the suggested treatment.
- Determine and evaluate the patient's expectations, and explain potential limitations and the need for multiple treatment sessions.
- Discuss pre- and post-operative procedures with the patient.
- Stress that facial tattooing, such as permanent lip or eyeliner, may be partially removed due to certain treatments.
- Explain that some discomfort may be experienced during the treatment and that transient erythema or edema may appear post-operatively.
- Discuss the patient's upcoming social events, vacation and/or business plans that could be compromised by potential side effects of the treatment.
- Explain the risk of adverse reactions to the treatment, such as changes in texture and pigmentation of the skin.
- Patients with a history of Herpes Simplex should be prescribed an oral antiviral drug beginning the day before laser treatment. Reactivation of Herpes Simplex has been reported after laser treatments; pre-treatment with an antiviral drug is therefore especially important when performing laser treatments around the upper lip area.

- Evaluate the patient's skin type (ref. Fitzpatrick skin type classification), taking into account ethnicity.

<table>
<thead>
<tr>
<th>Fitzpatrick Skin Type Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I: White, Always Burn, Never Tan</td>
</tr>
<tr>
<td>Type II: White, Usually Burn, Difficult Tan</td>
</tr>
<tr>
<td>Type III: White, Sometimes Burn, Average Tan</td>
</tr>
<tr>
<td>Type IV: Moderate Brown, Rare Burn, Tan with Ease</td>
</tr>
<tr>
<td>Type V: Dark Brown, Very Rare Burn, Tan Very Easily</td>
</tr>
<tr>
<td>Type VI: Black, No Burn, Tan Very Easily</td>
</tr>
</tbody>
</table>

Source: Fitzpatrick, TB. ARCH DERMA, 1998

Table 3.1. Fitzpatrick Skin Type Classification
- A conservative laser treatment approach is recommended for patients with impaired blood flow to the face (e.g. smoking, previous cosmetic surgery – skin flaps).

- Warn patients taking medication of photosensitive reactions that can cause skin sloughing and scarring (see Table 2.2 – photosensitivity causing drugs).

- Oral isotretinoin (accutane) damages the normal functions in skin appendages and impairs the skin’s ability to re-epithelize. Evidence of using oral isotretinoin is an absolute contra-indication to laser therapy.

- Encourage questions from the patient.

**NOTE**

*Test the laser treatment on a small skin surface area before performing the full treatment. If confluent edema, hypo- or hyperpigmentation appears, fluence/energy settings should be reduced.*
## Drugs that may cause Photosensitivity

<table>
<thead>
<tr>
<th>Acne medications:</th>
<th>Perphenazine (Triلافon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotretinoin (Accutane)</td>
<td>Prochlorperazine (Compazine; and others)</td>
</tr>
<tr>
<td>Tretinoin (Retin-A)</td>
<td>Promethazine (Phenergan; and others)</td>
</tr>
<tr>
<td>Anticancer Drugs:</td>
<td>Thiordinazine (Mellaril)</td>
</tr>
<tr>
<td>Decarbazine (DTIC-Dome)</td>
<td>Triluperazine (Stelazine; and others)</td>
</tr>
<tr>
<td>Fluorouracil (Fluoroplex; and others)</td>
<td>Triflupromazine (Vesprin)</td>
</tr>
<tr>
<td>Capetotabine (Xeloda; and others)</td>
<td></td>
</tr>
<tr>
<td>Methotrexate (Mexitate; and others)</td>
<td></td>
</tr>
<tr>
<td>Vinblastine (Veiban)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Antidepressants:</td>
<td></td>
</tr>
<tr>
<td>Amipritryline (Elavil; and others)</td>
<td></td>
</tr>
<tr>
<td>Desipramine (Norpramine; Petroban)</td>
<td></td>
</tr>
<tr>
<td>Doxepin (Adapin; Sinequan)</td>
<td></td>
</tr>
<tr>
<td>Imipramine (Tofranil; and others)</td>
<td></td>
</tr>
<tr>
<td>Nortriptyl (Aventyl; Pamelor)</td>
<td></td>
</tr>
<tr>
<td>Protriptyline (Vivactil)</td>
<td></td>
</tr>
<tr>
<td>Trimipramine (Surmontil)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Diuretics:</td>
<td></td>
</tr>
<tr>
<td>Bendroflumaril (Naturetin; and others)</td>
<td></td>
</tr>
<tr>
<td>Benztiazide (Exna; and others)</td>
<td></td>
</tr>
<tr>
<td>Chloretiazide (Diuril; and others)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypoglycemics:</td>
<td></td>
</tr>
<tr>
<td>Griseofulvin (Falvicin – U/F; and others)</td>
<td></td>
</tr>
<tr>
<td>Methacycline (rondomycin)</td>
<td></td>
</tr>
<tr>
<td>Nalidixlid acid (NegGram; and others)</td>
<td></td>
</tr>
<tr>
<td>Oxytetracyclines (Terramycin; and others)</td>
<td></td>
</tr>
<tr>
<td>Sulfacynine (Renoxquid)</td>
<td></td>
</tr>
<tr>
<td>Sulfamathazine (Neotrizon; and others)</td>
<td></td>
</tr>
<tr>
<td>Sulfamethizole (Thiosulf; and others)</td>
<td></td>
</tr>
<tr>
<td>Sulfamethoxazole (Gantanol; and others)</td>
<td></td>
</tr>
<tr>
<td>Sulfamethoxazole-trimethoprim (Bactrim; Septra)</td>
<td></td>
</tr>
<tr>
<td>Sulfasalazine (Azulfidin; and others)</td>
<td></td>
</tr>
<tr>
<td>Sulphathiazole</td>
<td></td>
</tr>
<tr>
<td>Sulfisoxazole (Gantrisin; and others)</td>
<td></td>
</tr>
<tr>
<td>Tetracyclines (Achromyslin; minocin)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Herbal/Organic:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Antipsychotic drugs:</td>
<td></td>
</tr>
<tr>
<td>Chlorpromazine (Thorazine; and others)</td>
<td></td>
</tr>
<tr>
<td>Fluphenazine (Permitil; Prolin)</td>
<td></td>
</tr>
<tr>
<td>Haloperidol (Haldol)</td>
<td></td>
</tr>
<tr>
<td>These medications may cause hyperpigmentation, dermatitis, hypersensitivity to light or other effects. Test the treatment on a small area before performing the full treatment.</td>
<td></td>
</tr>
</tbody>
</table>

| Table 3.2. Drugs That May Cause Photosensitivity |

### 3.2 Pre-Treatment Skin Preparation Guidelines

- Before treatment, cleanse the skin surface with soap and water. Remove any makeup, lotions, perfumes or deodorants. The skin surface must be completely clean and dry before beginning laser treatment.
WARNING!
Do not cleanse the skin with ethanol. Ethanol or ethanol fumes may pose a fire threat when using the laser.

- Any hair-bearing areas should be close shaven; hair should not be longer than 1 – 2 mm.
- During the treatment, larger hair-bearing areas can be protected or dampened with wet sponges, to avoid the odor of burned hair.

3.3 Pre-Treatment Safety Precautions

- Protective eyewear must be worn by the patient and all operating personnel.
- Do not use the laser on or near the patient's eyes. Be aware that using the laser anywhere inside the orbit may potentially cause direct eye injury.
- For treatments in the perilabial area, protect the teeth with moist cotton wool tampons or a dental laser shield to avoid damage to tooth enamel.
- Reducing fluence settings or lowering the number of pulses on sensitive areas may be necessary.

![Figure 3.1. Protective eyewear and smoke evacuator.](image1)
![Figure 3.2. Protective Eyewear.](image2)

3.4 General Operative Guidelines

When treating clients it is always important to be aware that skin is a living tissue with characteristics that differ from person to person and from body area to body area. It is therefore advisable to start laser treatments with lower treatment parameter settings and to adjust them depending on the clinical outcome. It is important to realize that changes in individual parameter settings (e.g. fluence, cooling time, spot size, number of laser passes) effect and interact with other treatment parameters and ultimately affect the treatment outcome. It is therefore advisable to treat each case individually and build a database of different case experiences.
The intended clinical end-point and the requirements of the patient should serve as the basis for the laser procedure and treatment parameter selection.

If combining different treatment options, there should be enough time given between treatments in order to avoid side effects as a result of laser energy accumulation.

**NOTE!**
Use additional caution when treating body areas with delicate skin (e.g. face and neck, atrophic scars etc.).
Always perform a test on a smaller area of skin near the treatment area before administering the full treatment.

**NOTE!**
The suggested parameters in this Applications Manual are to be taken as guidelines but will invariably differ from case to case.

### 3.5 Cold Air Cooling During Fotona Laser Treatments

The use of dermal cooling before, during and after Fotona Laser treatment is recommended only with non-ablative applications. Cooling with cold air is one way to provide an effective means of dermal cooling. Use a cold air device intended for the minimization of pain and thermal injury before, during and after laser treatment, such as the Cryo v6.0 from Zimmer, to accomplish cooling. Follow the instructions given for the device to properly perform cooling.

Cold air cooling devices apply cold air to the skin at a temperature between -20°C and -30°C, in adjustable quantities. The advantage of cold air is that it easily diffuses over the entire target surface area.

**NOTE!**
When using an external cooling system, make sure you follow the cooling system manufacturer’s instructions and treatment recommendations carefully. Ensure any pre-cooling procedure has been completed, which may take several minutes depending on the particular make of cooling system used, and that the level of cooling selected is sufficient for the treatment. If necessary, test the patient’s response to the treatment and cooling using an appropriate test area.

Applying cold air cooling to the treatment site:

- Aim the cold air flow before and after the laser treatment at the treatment area and adjust the cooling intensity as appropriate
- Maximum patient comfort can be reached when the surface skin temperature has reached 20°C. According to the Zimmer Cryo 6 manufacturer this can be achieved by setting the cooling intensity to 5 and aiming the cold air flow at the treatment site for approximately 8 seconds. For long duration PIANO sculpting treatments the recommended cooling intensity setting is 2-3, and the cold air flow is to be delivered to the treatment area for the whole duration of the treatment.
3.6 Post-operative Care Guidelines

- Topical vaseline can be used. If there are any signs of epidermal damage, the patient should use an antibiotic ointment.
- Carefully applying ice treatments can relieve any discomfort and can reduce swelling.
- Care should be taken to prevent trauma to the treated area for five days following treatment.
- Sun block must be used and exposure to direct sunlight avoided during the healing period.
- Makeup can be applied as long as the skin is not broken. Makeup will also serve as an additional sun block.
- After hair removal, the patient should return after 4 weeks for a check-up of the treated area and a possible additional treatment session.
  After vascular treatments, we recommend a check-up within 2–4 weeks post-operatively.

WARNING!
Do not treat any suspicious lesion; always biopsy (multiple biopsies) any suspicious lesions.
Consult a specialist for cancer screening before initiating ablative laser therapy.

WARNING!
Do NOT attempt any laser treatments if the patient shows clear signs of having hyper-sensitive or abnormally sensitive skin.
4. **ER:YAG TECHNOLOGY IN DERMATOLOGY AND AESTHETICS**

4.1 **Introduction**

Fotona’s Er:YAG-based laser systems represent a new generation of aesthetic laser systems that allow the practitioner to easily select the ideal combination of treatment parameters (i.e. energy/fluence, repetition rate, pulse width, spot size) to achieve the optimal clinical outcome.

4.1.1 **Advantages of Fotona VSP-shaped Er:YAG laser Technology**

Standard Er:YAG laser systems operate at a fixed pulse width of 250 – 350 microseconds. This is a good pulse width to induce a pure ablative effect; but current demands in aesthetic surgery go beyond ablative skin resurfacing. Minimal downtime and immediately visible results are required. Although there are many laser systems available on the market, most of them can fulfill only one of these requirements; often dramatic results imply long healing times.

In order to solve this dilemma, Fotona developed a unique approach to the design of the laser system. Fotona’s Variable Square Pulse (VSP) technology controls the energy and time duration (or pulse width) simultaneously. This unique technological platform offers many treatment alternatives, from pure ablation and cutting to minimally ablative dermal remodeling with deep thermal effects, by switching between VSP modes. VSP technology offers a simple way to control the degree of ablation and/or deep tissue heating.

Fotona VSP-shaped Er:YAG short pulses are shorter than the TRT of skin tissue, and can ablate without significant heat transfer to the tissue, causing a cutting effect. This effect is illustrated as the Light Peel and Deep Cold Peel on Figure.

VSP-shaped Er:YAG long pulses ablate upper skin layers and mediate controlled heating in deep layers. Deep heating affects rejuvenation by stimulating collagen growth. This effect is shown as the Medium Peel, Deep Peel, and Smooth Mode in the figure.
Figure 4.2. Healing time vs. Effect. The range in which VSP modes operate is between the curve and the horizontal line.

With VSP technology the trade-off between efficacy and healing time can be managed very precisely. Ablative procedures can be as gentle as a microdermabrasion or as aggressive as a full ablative skin resurfacing treatment.

At a given power setting, longer pulse width will deliver more energy to the skin and will heat the skin; this heating will increase efficacy in some applications, but will also cause post-operative redness and edema, thereby increasing recovery time.

Cutting with MSP mode
To cut tissue use Micro Short Pulse (MSP) mode with a 0.45 mm spot size. Cuts are as or more precise than those performed with a surgical scalpel. The high repetition rate (up to 50 Hz at 120 mJ) of the laser pulses leads to complete and nearly simultaneous homeostasis of the cut tissue.

Pure ablation with MSP and SP mode
To achieve a pure ablative effect, administer single, high-energy Er:YAG laser pulses in the Micro Short Pulse (MSP) and Short Pulse (SP) mode. Effective ablation with minimal thermal damage to surrounding tissues can be achieved at fluence values above approximately 2 J/cm², depending upon the specific characteristics of the patient’s skin.

Combined ablation and thermal effects with LP and VLP mode
A combination of ablative and thermal effects can be used by operating in Long Pulse (LP) and Very Long Pulse (VLP) mode. There is no sharp limit that defines the regions between which ablation dominates and which thermal effects dominate. In general the range from 0.5 to 2.7 J/cm² can be thought of as the transition region, as the fluence increases ablation effects begin to dominate.

Thermal effects with XLP mode
Skin rejuvenation through thermally mediated dermal remodeling is achieved by applying low energy laser pulses in eXtra Long Pulse mode (XLP). To avoid ablative effects, the fluence values of the individual laser pulses should be kept below the ablation threshold. As the fluence is increased warming effects will give way to ablative effects, this happens around 0.8 J/cm².

Deep thermal effects with SMOOTH mode
To expand the Er:YAG laser’s treatment range, Fotona has developed SMOOTH Mode. Although Er:YAG lasers are predominantly thought of as ablative lasers in aesthetic and surgical treatments, SMOOTH treatments are non-ablative.

The SMOOTH mode modality is based on a burst (train) of Fotona SP mode Er:YAG laser pulses. The cumulative fluence of the burst of pulses can be set and the repetition rate of the burst is adjustable. The predefined laser pulse widths and repetition rate give the SMOOTH mode a larger degree of thermal effect in the skin than conventional Er:YAG laser treatment settings. For the SMOOTH mode, the threshold for ablation is approximately at a 10x higher fluence compared to a standard mode.
4.2 Er:YAG Laser Operative Guidelines

Skin structure differs from person to person, and from body area to body area and so treatment parameters and protocols will differ from case to case. Base the laser treatment procedure and selection of treatment parameters on the intended clinical end-point. Suggested parameter ranges in this Applications Manual is to be taken as guidelines, they will differ from case to case.

In many aesthetic treatments the clinical end-point is determined by the depth reached through Er:YAG laser ablation. The following images provide a general indication of the depth reached in the skin during ablation.

<table>
<thead>
<tr>
<th>Tissue Effect</th>
<th>VSP Technology Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>Micro Short Pulse (MSP)</td>
</tr>
<tr>
<td>Ablation</td>
<td>Micro Short Pulse (MSP)</td>
</tr>
<tr>
<td>Combined ablation and thermal effects</td>
<td>Long Pulse (LP)</td>
</tr>
<tr>
<td>Thermal effects</td>
<td>eXtra Long Pulse (XLP)</td>
</tr>
<tr>
<td>Deep thermal effects without ablation</td>
<td>SMOOTH mode</td>
</tr>
</tbody>
</table>

Table 4.1. Tissue Effect vs. VSP mode

**Visually Assessing Treatment Progress**

**Intra-epidermal treatment**

Whitish coloring of the skin after administering laser pulses generally indicates that the intra-epidermal level has been reached.

**Deep Epidermal Level**

Yellowish coloring of the skin after administering laser pulses generally indicates that the deep epidermal level has been reached.
When the Er:YAG laser treatment is continued to the papillary dermis level, punctate bleeding will become more frequent. Continued treatment deeper than the papillary dermis (illustrated in Figure 4.6) has minimal clinical effects, while the potential for complications and side effects may increase.

4.2.1 Administering Anesthesia

Topical anesthesia, nerve blocks, tumescent anesthesia, oral sedation or pain medication can be used to alleviate discomfort during treatment. One method of administering topical anesthesia is given below.

Perform a minimally ablative resurfacing procedure at very short pulse width settings. Then apply anesthetic cream 3 times in 20 minute intervals. After the last interval is complete, begin the procedure. The minimally ablative treatment opens the epidermis and allows for greater penetration of the anesthetic.

Suggested Treatment Technique

General Resurfacing

To perform resurfacing, pass across the treatment area once with the laser. If necessary make another pass at a 90° angle (perpendicular) to the first pass. During the treatment remove eschar with a sponge moistened in physiologic solution. Asses the depth of ablation throughout the treatment and adjust the settings as necessary. Resurfacing can also be performed with one of the Fotona Er:YAG scanners. The same general guidelines apply.

The face and dorsum of the hands are the easiest areas to resurface, followed by the upper third of the neck. The lower portions of the neck can also be resurfaced, but must be treated with great care.

Wrinkle removal

To perform wrinkle removal, ablate the upper layer of the epidermis: two passes may be required. Next, pass a small spot size laser beam along the wrinkle as shown in Figure A. Additional passes may be required along the edge of the wrinkle depending upon the depth of the wrinkle (see Figure B). Then, use a large spot size laser beam at long pulse width settings to cover the whole area (see Figure C and Figure D).

Sponge off eschar and assess progress throughout the treatment. During repeat passes use a moistened sponge to apply physiological solution to the area; this will enhance ablation. This technique is particularly well-suited for wrinkles in the peri-ocular and peri-oral regions.
**Benign skin lesion removal**

Pass over the lesion with consecutive shots in a straight line, trying to maintain consistent overlap between shots. When the edge of the lesion is reached, move straight down from the last shot to start a new line. The next pass is made in the opposite direction of the previous pass.

![Figure 4.8. Laser firing pattern for broader lesion removal](image)

Sponge off eschar at regular intervals to assess progress. For repeat passes, apply a wet, dampened sponge in physiological solution in order to enhance ablation. The process is repeated until the clinical endpoint has been reached. If capillary bleeding appears, higher pulse width settings may be used to induce coagulation; read further in this application's manual for more information.

**Hypertrophic scarring**

Pass the laser beam over along the top of the scar and repeat until the scar has been planed down level to the adjacent skin. Multiple passes along the outer sides of the scar may be needed to achieve an even, natural-looking effect.

![Figure 4.9. Single line laser pass](image) ![Figure 4.10. Multi-line laser pass](image)

Sponge off eschar at regular intervals to assess progress. For repeat passes, apply a wet, dampened sponge in physiological solution in order to enhance ablation. The process is repeated until the clinical endpoint has been reached. If capillary bleeding appears, higher pulse-width settings may be used to induce coagulation; read further in this applications manual for more information. Repeat passes may also be applied at the edges of the ablated scar to achieve an even result.

### 4.2.2 Post-Operative Care

After treatment keep the area moist. Use petroleum jelly, Aquaphor, Eucerin or some other occlusive dressing for 5 days. After 5 days, the dressing should be applied at night for the next 5 days. Moisturizer can be used from day 5 onwards.
4.3 Additional Considerations and Technologies in Er:YAG Skin Rejuvenation

Fotona’s Er:YAG laser can be used in skin rejuvenation treatments to erase wrinkles and tighten skin in both ablative (resurfacing) and non-ablative modalities. As a general rule, more aggressive treatments produce a greater effect but are associated with longer recovery times and greater risk. Figure 4.11 provides a summary of the skin rejuvenation modalities the Fotona Er:YAG laser can provide.

4.3.1 The Effect of Fluence and Pulse Width in Er:YAG Skin Rejuvenation

Coagulation, ablation, and heating cause clinical effects. The proportion of these effects relative to each other can be controlled by varying the pulse width and the fluence. Fotona’s VSP Technology makes it easy to define and modify these proportions in rejuvenation procedures. Through VSP Technology, nine convenient Er:YAG modalities are defined based on their tissue effects, namely ablation depth and thermal effects (coagulation depth). They are presented in Fig. 4.12. The chart can be read as follows: the uppermost left cell represents a light cold peel; the lowermost right cell represents a deep hot peel. The suggested parameters needed for each modality are presented in Fig. 4.13.
Details on how to use several of the VSP operational modalities are presented in the sections that follow together with case studies.

<table>
<thead>
<tr>
<th>Light Peel</th>
<th>Medium Peel</th>
<th>Deep Peel</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSP 1 - 3 J/cm²</td>
<td>MSP 3 - 10 J/cm²</td>
<td>SP 10 - 50 J/cm²</td>
<td></td>
</tr>
<tr>
<td>SP 1 - 3 J/cm²</td>
<td>LP 3 - 10 J/cm²</td>
<td>VLP 10 - 17 J/cm²</td>
<td>Warm</td>
</tr>
<tr>
<td>VLP, XLP 1 - 3 J/cm²</td>
<td>VLP, XLP 3 - 10 J/cm²</td>
<td>XLP 10 - 17 J/cm²</td>
<td>Hot</td>
</tr>
</tbody>
</table>

Figure 4.13.: Parameters needed for various VSP mode effects.

Two additional factors can modulate Er:YAG skin rejuvenation; the spatial distribution of laser energy across the treatment area and the temporal characteristics with which the laser covers the treatment area. The following sections describe Dynamis/Spectro system features that help to control these factors.

4.3.2 SMOOTH Mode in Skin Rejuvenation

To expand the Er:YAG laser’s treatment range, Fotona has developed SMOOTH Mode. Although Er:YAG lasers are predominantly thought of as ablative lasers in aesthetic and surgical treatments, SMOOTH treatments are non-ablative.

This modality constitutes a more aggressive approach within the non-ablative rejuvenation treatment segment. Its clinical action is more aggressive than a medium depth peel but not as aggressive as a full, deep papillary dermal skin resurfacing treatment. SMOOTH mode treatments provide a non-ablative dermal rejuvenation effect that is uniquely complemented with a minimal ablative skin resurfacing element. The resulting remodeling and stimulation of new collagen provides a tighter and smoother feel to the skin.

In the SMOOTH mode, laser energy is transmitted as heat onto the tissue surface, without any resulting ablation, and is then dissipated into the deeper tissue layers. Laser energy is delivered onto the tissue in a fast sequence of low-fluence laser pulses inside an overall super-long pulse of several hundred milliseconds. Only the cumulative fluence of the sequence of pulses within the SMOOTH mode can be set. The repetition rate of the pulses within the sequence cannot be varied but is fixed to the optimal value for non-ablative skin treatments.
Figure 4.15. Fotona SMOOTH mode delivers Er:YAG optical laser energy in temporally optimally-spaced, short laser pulses in order to prevent temperature build-up at the surface and to achieve homogeneous heating within a several-hundred-micron thick superficial layer of the skin. The skin tissue is treated in a smooth, almost “feather-like” non-ablative manner, without any bleeding and with a precisely controlled temperature deposition that eliminates the risk of tissue necrosis.

When the temporal separation between the pulses is longer than the thermal relaxation time of the surface tissue, the tissue has sufficient time to cool between the pulses by dissipating heat into the deeper tissue layers. Thus, temperatures required for ablation are reached at much higher fluences. And if at the same time, laser energy is delivered over a time period that is shorter than the thermal relaxation time of the total epidermal layer, then the deeper-lying skin layer does not have time to cool off during the laser pulse sequence. The delivered laser energy thus results in an overall non-ablative build-up of heat and creates a temperature increase within the skin up to the optimal temperature range for collagen remodeling and neocollagenesis. Research has also shown that with SMOOTH mode pulses, human tissue is non-ablatively heated to a depth of 100 microns, which is just what is required for a depth-controlled thermal treatment of the skin.

4.3.3 Turbo Mode in Skin Resurfacing

Turbo Mode allows you to rapidly apply a beam multiple times to a single treatment spot, thus increasing the ablation depth of the originally set laser beam. The pulse can be repeated up to six times. Figure 4.16. shows how Turbo Mode can be used with facial rejuvenation.
4.3.4 Wide Area Skin Resurfacing using Fotona Er:YAG Scanner Technology

Fotona’s Er:YAG scanner technology, such as the S-Runner and T-Runner scanners, is designed to provide full coverage across the treatment area. It can be used to perform all of the VSP Er:YAG laser resurfacing treatments.

Because the laser spots are circular they must overlap in order to cover the entire area. Four degrees of overlap are provided, 0%, 13%, 20%, and 30%; the overlap is given as the maximum percentage of the spot diameter covered twice in a pass. 13% Overlap is the minimum needed to cover all area sections at least once (see Fig. 4.17).

4.3.5 Full Field and Patterned Treatments

There are two approaches to superficial tissue treatments: full-field and non-uniform, patterned treatments (See Fig. 4.18).
As opposed to full-field treatments, patterned treatments are based on a concept of producing an array of smaller treatment “islands”.

In full-field treatments, the entire surface area within the laser spot is affected by the laser. The patterned technique is based on a concept of producing an array of smaller treatment “islands” on the tissue surface. The reason to have healthy untouched spots around the heated tissue is to use the capacity of healthy spot tissue and cells for a faster immune response and healing process. Clinical experience also shows that patterned treatment is more comfortable to the patient, allowing practitioners to use higher fluences within the treatment spots.

**Fotona Pixel Screen Technology**

The PS type of Fotona stamping patterned handpieces (such as PS01, PS02, and PS03) employs a special Fotona Pixel Screen (PS) technology to create smaller beam dots on the tissue. With the Pixel Screen technology, the full beam is divided into smaller beams by a special pixel screen (See Fig. 4.19). As a result, the fluence of each individual pixel beam remains comparable to that of the original full beam.

**Fig. 4.19.** Er:YAG laser Pixel Screen technology does not use any focusing optics to create smaller beams. Instead, the full beam is divided into small beams by a special pixel screen. The fluence of each individual beam thus remains unchanged and is equal to that of the full beam.
Figure 4.20. A typical PS01 pixel beam profile.

Figure 4.21. The PS02 pixel pattern with 5 mm laser spot size.

An additional advantage of the PS technology is that it enables the generation of collimated beams that do not considerably change in size with distance relative to the treated tissue. This is particularly important when treating body cavities where the treated surface is not flat or well defined.

4.3.6 **Stamping and Scanning Fractional Treatments**

There are also two types of fractional handpiece technologies, stamping and scanning (Fig. 4.22).
With a stamping fractional handpiece, such as the Fotona FS01, the full laser beam (spot) is divided into many small beams (micro dots or pixels), and the pixel fluence is comparable to the total laser beam fluence. The pixel energy is a fractional part of the total pulse energy.

With scanning fractional handpieces, such as the Fotona F-Runner scanner (F22), the laser beam is concentrated and focused into a very small spot that is scanned over a treated area. The micro dot energy is the same as the full-field pulse energy, which enables higher fluences and deeper treatments. Also, the treatment areas and the dot density can be easily changed via the keyboard.

The fractional treatment regimens are in principle the same as the basic VSP Er:YAG treatment regimens (see Fig. 4.23), but through pixelation they are less invasive and result in shorter downtimes.

Figure 4.23. The fractional treatment regimens are in principle the same as the basic VSP Er:YAG treatment regimens.

**Fotona Scanning Fractional Technology**

The Fotona scanning fractional handpiece F22 (F-Runner) is shown in Fig. 4.25. The F-Runner utilizes a fixed, small spot size and offers a 5% to 20% coverage range. As opposed to the FS01 handpiece, the full beam of the scanning F22 fractional handpiece is focused into a single small spot diameter, and thus much higher fluences and ablative depths can be achieved. A typical scan pattern is shown in Fig. 4.26.

Figure 4.25. The F-22 Scanner

Figure 4.26. A representation of the F-22 Scan Pattern
Fotona Technology with Diffractive Optical Element

The Fotona FS01 is stamping fractionated handpiece (Fig. 4.27) using a special diffractive optical element to create matrix of 9 x 9 spots (microbeams) on the tissue. As a result, the FS01 handpiece produces 81 identical 250 µm microchannel spots in a single laser shot (Fig. 4.28). The microbeam (pixel) energy is a fractional part of the total pulse energy falling on the DOE. The fluence of each micro dot in the 9x9 matrix is the same within the matrix.

Figure 4.27. FS01 handpiece uses a diffractive optical element to create 81 equally spaced micro dots in a 9 x 9 mm square matrix.

Figure 4.28. Standard paper test: FS01 creates 81 exceptionally accurate and sharply defined microspots with each shot.

FS01 handpiece should always be held perpendicularly to the skin when in use. Only in this position will the actual laser spot size meet the predefined spot size value.
5. ER:YAG TREATMENT GUIDELINES & PARAMETERS

The following section describes individual treatment modalities and techniques, and provides guidelines and parameters for these procedures. These guidelines and suggested treatment parameters have been provided by practitioners who use Fotona's laser technology in their practice on a daily basis.

It should be noted that each individual treatment will be different as patients and conditions differ from case to case. Treatment strategy and medical opinion may also differ from practitioner to practitioner. Fotona urges to use common sense, medical training and experience in interpreting these guidelines and parameters.

![Figure 5.1. Treatment groups selection screen for the Er:YAG laser source.](image)

5.1 Skin Resurfacing

The collective desire to stay forever young has created an enormous market for anti-ageing treatments. Recent developments in laser technology are now delivering a longer lasting and scientifically proven method of restoring the natural beauty of the skin. Unlike traditional treatments such as dermabrasion and chemical peels, the unique characteristics of laser skin resurfacing allow more accurate and precise control over the treatment process.

High performance Er:YAG laser with VSP (Variable Square Pulse) technology allow maximal ablation efficiency, which can be accurately tuned from minimal “cold” ablation to deep “hot” ablation depending on clinical outcomes your patients desire.
5.1.1 Light Peel Skin Resurfacing

Light peel skin resurfacing treatments are ideal when the patient requires the recovery period (down-time) to be kept to a minimum, and when a Nd:YAG rejuvenation treatment may not fulfill the patient's expectations. Because of the wide versatility of the Fotona Er:YAG laser, ablative procedures can be performed as minimally as microdermabrasion.

A light peel treatment, with treatment parameters set to create a minimally ablative effect on the superficial skin layers, has a refreshing effect on the skin. Usually the only side effect from this treatment is one day of mild redness. To deposit more heat and obtain a collagen reaction which results in skin tightening, longer pulse width modes can be used at the same power settings. Longer pulse width modes will result in longer periods of post-operative redness. A light peel treatment with the settings below will give one day of redness when using VSP mode, 2 days of redness when using SP mode and 3 days of redness when using LP mode.

Light peel skin resurfacing treatments can be performed with the S-Runner Er:YAG scanner.

- Follow the guidelines set forth in Section 3 of this Applications Manual.
- The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Anesthesia:
  - If deemed necessary, a topical anesthetic cream or regional nerveblocks with 2% xylocaine and 0.5% marcaine, without epinephrine, can be applied.

**Utilized handpieces:** R04-Ti, R11, PS01, PS02, PS03, S-Runner, T-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 – 4</td>
<td>MSP -XLP</td>
<td>3 – 12</td>
<td>2-10</td>
</tr>
</tbody>
</table>

Table 5.1 Practitioner suggested parameters for light skin resurfacing
The face should be covered in one pass. Adjust the treatment settings during operation to obtain the correct effects. The correct treatment settings should give a translucent white appearance to the skin during ablation. For a more aggressive peel, the skin should have a crisp fully white appearance.

“Light Peel” Case Sample

- Topical Betacaine applied for 30 – 60 minutes, no occlusion
- 1 – 2 mg PO xanax
- Laser treatment settings: LP mode, 250 mJ, 6 – 12 Hz, 3 – 7 mm
- 1 – 2 passes, 20 – 30 % overlap, “feathered” edges

Figure 5.4. Light Peel, before (left) and 7 days after (right)
Courtesy of Dr. Zimmerman MD, Las Vegas, Nevada, USA

Post-operative Care

- Apply a sterile ointment.
- Use a Hydrogel mask and netting for the first two days if necessary.

5.1.2 Medium Peel Skin Resurfacing

Medium peel skin resurfacing settings provide a more aggressive ablative skin resurfacing modality than light peel skin resurfacing. The medium peel treatment modality can be reached by altering the energy, VSP mode (or pulse width) and spot size settings from the light peel skin resurfacing settings.

Medium peel treatment parameters will produce a more pronounced clinical effect with longer associated down-time than the light peel. Mild redness can be expected after the peel, and when the redness disappears the skin will have a bronzed appearance. The skin starts peeling between 2 and 5 days after treatment. This treatment modality is widely referred to as the “Las Vegas Peel”.

Medium peel skin resurfacing can be performed with the S-Runner Er:YAG scanner.
Follow the guidelines set forth in Section 3 of this Applications Manual.

The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.

Perform test patches, especially on patients with a history of pigment changes or scarring.

Evenly cover the face for a natural and even-looking clinical outcome.

Anesthesia:
- Topical anesthetic cream or
- Regional nerveblocks with 2% xylocaine and 0.5% marcaine, without epinephrine, if deemed necessary in deep peel treatments.

**Utilized handpieces:** R04-Ti, R11, PS01, PS02, PS03, S-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-12</td>
<td>MSP-XLP</td>
<td>3 – 12</td>
<td>2 – 10</td>
</tr>
</tbody>
</table>

*Table 5.2 Practitioner Suggested Parameters for Medium Peel Skin Resurfacing*

**“Medium Peel” Case Sample**

- Betacaine and regional blocks
- Xanax and lortab, or IM
- Laser treatment settings: LP mod, 250 – 300 mJ, 10 – 20 Hz, 3 – 5 mm
- 2 – 5 passes, 20 – 50 % overlap, “feathered” edges

![Figure 5.6. Medium Peel, Before (left) and 3 weeks After (right)](Image)

*Figure 5.6. Medium Peel, Before (left) and 3 weeks After (right)*

*Courtesy of Dr. Zimmerman MD, Las Vegas, Nevada, USA*

**Post-operative Care**

- Apply a sterile ointment.
- Hydrogel mask and netting for the first and if desired for the second day post-operatively if desired, then open.
- Over the counter pain medication (NSAID’s) or prednisone 20 mg for 5 days is recommended in the case of swelling.
- Apply antibiotic depending on localization of the treatment.
5.1.3 Deep Peel Skin Resurfacing

More dramatic clinical results are achieved by ablating to the papillary dermis in deep peel resurfacing. Ablating beyond the papillary dermis is not recommended as doing so will dramatically increase the risk of adverse side effects. This treatment can be repeated in 3 – 9 months after the first treatment for a greater clinical outcome.

With experience it will be possible to accurately choose treatment settings that will reach the papillary dermis within 2 or 3 passes. This will reduce the risk of side effects, as many are related to multiple passes and excessive heat deposition.

Expect patients to be deep fiery red (tomato red) for up to 10 days. Redness usually begins to improve by the 5th day. Areas that were treated more aggressively – or with more passes – will usually be red for up to 3 months and in rare cases may be red for up to 6 months. Camouflage make-up can be used after day 5.

- Follow the guidelines set forth in Section 3 of this Applications Manual.
- The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Anesthesia:
  - Topical anesthetic cream or
  - Regional nerveblocks with 2% xylocaine and 0.5% marcaine, without epinephrine, if deemed necessary in deep peel treatments.

Utilized handpieces: R04-Ti, R11, PS01, PS02, PS03, S-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14- – 16</td>
<td>SP-XLP</td>
<td>3 – 12</td>
<td>2 – 10</td>
</tr>
</tbody>
</table>

Table 5.3 Practitioner Suggested Parameters for Deep Peel Skin Resurfacing

When using a topical anesthetic cream, wait for at least half an hour after the cream is applied before starting the procedure.

The treatment procedure is similar to that of all resurfacing treatments. Select the desired treatment settings and perform a first set of passes parallel to each other and then a second set of passes at a 90° angle (perpendicular) to the first set. Aim to perform two full-face passes consecutively with a 20 – 50% overlap.

It is often possible to ablate lightly in some areas and deeply in others, where the degree of skin resurfacing is required to be higher for an even clinical outcome. For example, professional drivers will often show a greater degree of sun-damaged skin on the window-side of the face, thus requiring a more aggressive approach on that side. Often 2 passes over the passenger-side of the face and 3 passes over the window-side of the face will provide even-looking results.

For deeper rhytides, opening up the rhytide valley with manual traction perpendicular to the rhytide will be helpful. Once the rhytide is open, adjust the power settings and number of passes to reach the papillary dermis and then adjust the treatment settings to blend the margins as needed.
Skin Resurfacing Case Sample #1:
Lentigo Senilis Treatment with Skin Texture Improvements

<table>
<thead>
<tr>
<th>PS Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS02</td>
<td>2.1</td>
<td>SP</td>
<td>7</td>
<td>2 – 3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5.4 Practitioner Suggested Parameters for Lentigo Senilis

Figure 5.8. Fractional Er:YAG treatment for lentigo senilis and skin texture improvements, before (left) and 1 week after the first treatment (right)
Courtesy of Dr. Volovec, Slovenia

Skin Resurfacing Case Sample #2:
Lentigo Senilis Treatment with Skin Texture Improvements

<table>
<thead>
<tr>
<th>PS Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS02</td>
<td>2.1</td>
<td>SP</td>
<td>7</td>
<td>2 – 3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5.5. Practitioner Suggested Parameters for Lentigo Senilis

Figure 5.9. Fractional Er:YAG treatment for lentigo senilis and skin texture improvements, before (left) and 1 week after the first treatment (right)
Courtesy of Dr. Volovec, Slovenia
Patterned Skin Resurfacing Case Sample #3
Treatment of Moderately Photo-Damaged Skin

Suggested Pre-Treatment Guidelines

- Clean the skin with any antiseptic solution. Dry thoroughly. Ensure adequate patient eye protection (protective eye tape, goggles or corneal shields).
- The use of anesthesia is generally not required. Skin cooling is not used. Two treatment sessions are required, spaced 2 weeks apart.

<table>
<thead>
<tr>
<th>PS Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS01 Pixel level 1</td>
<td>1.00</td>
<td>SP</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5.6. Practitioner Suggested Parameters of Moderately Photo-Damaged Skin

A patient-acceptable result was reached in one session.

Figure 5.10. Fractional Er:YAG treatment for moderately photo-damaged skin, before (left) and 2 weeks after one treatment session (right)
Courtesy of Dr. Pidal, Argentina

Skin Resurfacing Case Sample #4:
Treatment of Photo-Damaged, Aging Skin

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS01 Pixel level 1</td>
<td>1.00</td>
<td>SP</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 5.7. Practitioner Suggested Parameters of Photo-Damaged Skin, Aging Skin

A patient acceptable result was reached in 2 treatment sessions, spread 15 days apart.
5.2 Fractional Ablative Skin Resurfacing

Fractional ablative skin resurfacing treatments are associated with a lesser degree of down-time than their full ablative counterparts, while the clinical effects remain within patients’ acceptable parameters.

This modality is particularly indicated for sun-damaged, aging skin, possibly with acquired pigmented lesions (like lentigo senilis), varying degrees of fine lines and milder wrinkles and scars.

A fractional minimal ablative skin resurfacing treatment, in which treatment parameters are set to create an absolute minimal ablative action within the skin’s superficial layers, has a refreshing effect on the skin. This type of treatment will generally not produce any redness (down-time), or one day of mild redness, at most.

To obtain a collagen reaction, resulting in a skin tightening effect, more heat needs to be deposited into the skin. To achieve this, longer pulse width modes should be used at the same power settings. Longer pulse width modes will result in longer periods of post-operative redness. A fractional minimal ablative skin resurfacing treatment will give one day of redness when using MSP mode, 2 days of redness when using SP mode and 3 days of redness when using LP mode.
Follow the guidelines set forth in Section 3 of this Applications Manual.
The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
Perform test patches, especially on patients with a history of pigment changes or scarring.
Anesthesia:
- If deemed necessary, a topical anesthetic cream or regional nerveblocks with 2% xylocaine and 0.5% marcaine, without epinephrine.

Suggested Treatment Technique

- Begin the procedure with lower fluence settings to evaluate the skin’s response to the treatment settings. Once the response has been assessed increase the fluence to acceptable treatment safety and patient comfort levels.
- The skin surface should be evenly covered with minimal overlapping. To enhance the effect set the coverage to 10 or 20% in F-Runner. With FS01 perform two or three passes each time in different direction.
- 1 to 4 treatment sessions are performed at 2-4 week intervals.

5.2.1 Light Fractional Skin Resurfacing

Utilized handpieces: FS01, F-Runner

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Coverage</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS01</td>
<td>2.2 - 8</td>
<td>MSP-VLP</td>
<td>5%</td>
<td>2-4</td>
<td>1-2</td>
</tr>
<tr>
<td>F22</td>
<td>8</td>
<td>MSP-LP</td>
<td>5%</td>
<td>2-50</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Table 5.8. Suggested Parameters for Light Fractional Skin Resurfacing

5.2.2 Medium Fractional Skin Resurfacing

Utilized handpieces: FS01, F-Runner

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Coverage</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS01</td>
<td>10-16</td>
<td>MSP-VLP</td>
<td>5%</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>F22</td>
<td>10-16</td>
<td>MSP-LP</td>
<td>5%</td>
<td>2-50</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Table 5.9. Suggested Parameters for Medium Fractional Skin Resurfacing
5.2.3 Deep Fractional Skin Resurfacing

Utilized handpieces: FS01, F-Runner

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Coverage</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS01</td>
<td>18-80</td>
<td>MSP-VLP</td>
<td>5%</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td>F22</td>
<td>18-80</td>
<td>MSP-XLP</td>
<td>5%</td>
<td>2-10</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Table 5.10. Suggested Parameters for Deep Fractional Skin Resurfacing

Suggested Post-Treatment Guidelines

- Apply a thin layer of antibiotic ointment immediately after the treatment. Instruct the patient to apply the ointment 2 – 3 times per day for 4 – 7 days.

- Adequate sun protection is needed in between sessions and for at least 1 month after the last treatment.

Figure 5.17. Acne Scar-Revision Treatment: before (left) and after (right)

Figure 5.18. Scar revision: before (left) and after (right)
5.3 **Specific Treatment Protocol – Peri-Ocular and Peri-Oral Regions**

Peri-ocular and peri-oral skin resurfacing procedures are popular among patients who choose not to have a complete facial treatment. Peri-oral skin resurfacing treatments are especially effective to treat smokers’ lines, while peri-ocular treatments are often used to treat crow’s feet.

- Follow the general pretreatment guidelines as described in the earlier sections of this Applications Manual.
- No special pre-treatment is required.
- Prophylactic oral anti-viral medication for patients with a history of herpes simplex.
- Anesthesia:
  - Topical anesthetic cream or
  - Regional nerveblocks with 2% xylocaine and 0.5% marcaine without epinephrine, if necessary, in deep peel treatments.

**Utilized handpieces:** R04-Ti, R11, PS01, PS02, PS03, S-Runner

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhytides (peri-ocular, peri-oral)</td>
<td>2–6</td>
<td>SP / LP</td>
<td>3-5</td>
<td>2-10</td>
</tr>
<tr>
<td>Cleansing ablation</td>
<td>2-4</td>
<td>VLP / XLP</td>
<td>3-12</td>
<td>2-10</td>
</tr>
</tbody>
</table>

*Table 5.11. Suggested Parameters for treatment of Peri-Ocular and Peri-Oral Regions*

**Suggested Treatment Technique**

When treating rhytides, ablate to the papillary dermis or until the wrinkles are effaced. Regularly sponge off debris to assess progress. For repeated passes apply a wet sponge, dampened in physiological solution in order to enhance ablation. The number of repeat passes depends on the treated area, type of wrinkles and the intended clinical end-point. Punctuate bleeding indicates that the papillary dermis has been reached. More significant bleeding than punctuate bleeding in the papillary dermis would indicate the reticular dermis has been reached. Do not ablate beyond the papillary dermis; doing so will dramatically increase the risk of side effects with no clinical benefit.
Punctuate bleeding in the papillary dermis can be controlled by wetting the treated area with gauze soaked in epinephrine solution or with a diathermocautery device. Alternatively, coagulation can be achieved by using the Er:YAG laser with the following treatment parameter settings: 300 – 500 mJ (Energy), VLP mode, 7 mm (Spot size), frequency setting according to the practitioner’s skills.

To speed up healing time, finish the treatment by passing over the treated area with the Er:YAG laser to ablate any remaining necrosis and obtain a clean result. Passing over the treated area at higher energy and long pulse width increases heat penetration into the dermis; this will improve the result by stimulating collagen growth in the dermis.

If may be necessary to repeat the procedure in 3 – 9 months, or as soon as the recovery period allows. Explain this to the patient prior to the procedure.

**Suggested Post-operative Care**

Post-operative care protocol provided courtesy of Dr. Paciolla, Medlight Institute, Firenze, Italy

- Apply an antibiotic ointment (gentamicine) immediately after treatment.
- Apply occlusive dressings for approximately 3 days, leaving the treatment site covered with antibiotic ointment.
- An oral analgesic may be necessary during the first 2 days.
- After 7 days patients can use a moisturizing cream.
- Use oral anti-viral medication for ten days for patients with a history of cold sores.
- Once the treated areas are no longer crusting/scabbing, sunblocks should be applied for at least three months.
- For those patients who develop post-inflamatory hyperpigmentation, a hydroquinone-containing cream, mixed with glycolic acid or Retin-A and hydrocortisone can be applied twice daily for approximately three months.

*Figure 5.19. Peri-Oral Resurfacing, Before (left) and 60 Days After (right)*

Courtesy of Dr. Paciolla, Italy
5.4 SMOOTH Mode Rejuvenation Treatments

The unique Fotona SMOOTH mode is a more aggressive approach within the medium-depth skin resurfacing treatment range. It is more aggressive than a medium depth peel but not as aggressive as a full, deep papillary dermal skin resurfacing treatment.

SMOOTH mode treatments provide a non-ablative dermal rejuvenation effect that, used at the settings given in Table 4.4, is uniquely complemented with a minimal ablative skin resurfacing element. The resulting remodeling and stimulation of new collagen provides a tighter and smoother feel to the skin.
The SMOOTH mode modality is based on a burst (train) of SP mode Er:YAG laser pulses in which the cumulative fluence of the burst of pulses can be defined by the practitioner. The repetition rate of the burst is fixed (auto). The predefined laser pulse widths and repetition rate give SMOOTH mode a larger degree of thermal effect in the skin than conventional Er:YAG laser treatment settings. It is this thermal effect that stimulates collagen remodeling.

It is important to evenly cover the treatment area in SMOOTH mode rejuvenation treatments. To ensure this, it is advisable to choose a minimally ablative energy setting. This will give visual feedback of which areas have been treated and which areas have not. To achieve effective temperature 2-4 burst of pulses per spot are recommended. Generally 2 passes at approximately 90° angles to each other are performed.

When continuous train of SMOOTH pulses is used for rejuvenation, brushing technique with constant movement of the handpiece must be performed to avoid over-heating of the tissue. Skin surface temperature should not exceed 42°C.

After the procedure the patient will have a red-bronze appearance and the skin in the treated area will start peeling within 2 – 4 days post-operatively. The peel is similar to, but deeper than a Las Vegas peel, and is associated with a significant degree of dermal collagen heating and consequent remodeling.

A SMOOTH mode treatment is recommended as a tune-up treatment for patients without rhytides who need a deeper treatment for a tightening and smoothing effect on sagging skin. Follow the guidelines set forth in Section 3 of this Applications Manual.

- No special pre-treatment is required.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Use prophylactic oral anti-viral for the patients with a history of herpes simplex.
- The use of cold air cooling is recommended.

**Utilized handpieces:** R04-Ti, R11, PS01, PS02, PS03, T-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 – 3</td>
<td>SMOOTH</td>
<td>7-10</td>
<td>1.6 – 2 Hz</td>
</tr>
</tbody>
</table>

*Table 5.12a. Suggested Parameters for Smooth Mode for skin.*

**Suggested Treatment Technique**

To allow feedback from the patient, no anesthesia is recommended.

Perform two full face passes consecutively with a 20 – 50% overlap. To achieve effective temperature 2-4 burst of pulses per spot are recommended.

**Suggested Post-operative Care**

Specific post-operative treatments are not required.
Utilized handpieces: PS03*, (R11)

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R11</td>
<td>1.5 – 3</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>PS03*</td>
<td>5 - 9</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>R11 LA</td>
<td>1.5 - 3</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>PS03 LA</td>
<td>5 - 9</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
</tbody>
</table>

* PS03 is recommended handpiece.

Table 5.12b. Suggested Parameters for Smooth Mode for mucosa.

**Suggested Treatment Technique**

For easier access to hard-to-reach areas in the mouth, the use of an intra-oral LA adapter is recommended.

To allow feedback from the patient, no anesthesia is recommended.

To achieve the effective temperature, a burst of 2 to 4 SMOOTH pulses per spot is recommended, therefore, lower fluences are needed.

**Suggested Post-operative Care**

Specific post-operative treatments are not required.

### 5.5 Benign Skin Lesions Removal

- Do not treat any suspicious lesions that could be malignant.
- Biopsy any suspicious lesions.
- Consult a dermatologist for skin cancer screening before initiating ablative laser therapy.
- No special pre-treatment therapy is required. The working area should be cleaned and dried.
- Anesthesia can be given depending on the lesion size and location, taking into consideration the pain threshold of the patient.
  - Topical anesthetic cream or
  - Local anesthesia in the form of 1% xylocaine.
Suggested Treatment Parameters

![Applications library screen for Fotona pre-set parameters for Benign Skin Lesions treatment](image)

Figure 5.23. Applications library screen for Fotona pre-set parameters for Benign Skin Lesions treatment

**Utilized handpieces:** R04-Ti, R11, S-Runner

<table>
<thead>
<tr>
<th>Lesion Type</th>
<th>Fluence</th>
<th>Mode</th>
<th>Spot size</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seborrhoic warts</td>
<td>3 – 7 J/cm²</td>
<td>MSP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Senile lentigenes</td>
<td>3 – 6 J/cm²</td>
<td>MSP-SP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Epidermal nevi</td>
<td>3 - 6 J/cm²</td>
<td>MSP-SP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Milia</td>
<td>1.4 – 3 J/cm²</td>
<td>MSP-SP</td>
<td>2-3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Xanthelasma palpebrarum</td>
<td>4 - 6 J/cm²</td>
<td>MSP-SP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Hidradenoma</td>
<td>2 – 5 J/cm²</td>
<td>MSP-SP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Plane warts</td>
<td>3 – 7 J/cm²</td>
<td>MSP-SP</td>
<td>2-3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Actinic keratosis</td>
<td>3 - 6 J/cm²</td>
<td>MSP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Fibroepithelial papillomata</td>
<td>3 - 6 J/cm²</td>
<td>MSP-SP</td>
<td>3 mm</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Epidermal Melasma</td>
<td>2 J/cm²</td>
<td>MSP</td>
<td>3-5 mm</td>
<td>3 Hz</td>
</tr>
</tbody>
</table>

Table 5.13. Suggested Parameters for Benign Skin Lesion Removal
Case Samples - Removal of Benign Skin Lesions

Figure 5.24. Removal of Seborrhoeic Keratosis: before (left) and 3 months after (right)
Courtesy of Dr. Drnovšek, Slovenia

Figure 5.25. Removal of Senile Lentigenes: before (left) and Immediately after (right)
Courtesy of Dr. Luppino M.D., Italy

Figure 5.26. Removal of Epidermal Nevus: Before (left) and after (right)
Courtesy of Dr. Luppino M.D., Italy
Figure 5.27. Removal of Xanthelasma Palpebrarum: Before (left) and after (right)
Courtesy of Dr. Luppino M.D., Italy

Figure 5.28. Removal of Hydradenoma Palpebrarum: Before (left) and 6 months after (right)
Courtesy of Dr. Drnovšek, Slovenia

Figure 5.29. Removal of Actinic Keratosis: Before (left) and after (right)
Courtesy of Dr. Luppino M.D., Italy

Figure 5.30. Removal of Fibroma: Before (left) and 3 months after (right)
Courtesy of Dr. Drnovšek, Slovenia
5.6 General Surgery

The Er:YAG laser cuts soft tissue with surgical precision. With the proper settings, bleeding can be minimized or avoided.

Figure 5.31. Applications library screen for Fotona pre-set parameters for Surgical treatment

- Follow the guidelines set forth in Section 3 of this Applications Manual.
- No special pre-treatment therapy is required.
- The area should be cleaned with 5% chlorhexidine in 70% alcohol, and carefully dried out with sterile gauze, making sure the alcohol has completely evaporated.
- Anesthesia: 2% hylocaine and 0.5% marcaine subcutaneously.
Utilized handpieces: R04-Ti, R11

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 – 14</td>
<td>MSP-SP</td>
<td>2-3</td>
<td>10 – 30</td>
</tr>
</tbody>
</table>

Table 5.14. Practitioner-suggested parameters for general surgery

Utilized handpiece: R08-Ti,

<table>
<thead>
<tr>
<th>Energy (mJ)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 - 120</td>
<td>MSP</td>
<td>0.45</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 5.15. Practitioner-suggested parameters for general surgery

Treatment Technique

- Mark the contour line of the cut on the tissue.
- Move the handpiece smoothly along the line. Avoid overlapping the laser pulses for an even cut.

Post-operative Care

Post-operative care is the same as after surgery with a scalpel.


6. **ND:YAG LASERS IN DERMATOLOGY AND AESTHETICS**

6.1 **Introduction**

Nd:YAG lasers are widely regarded as the Gold Standard for non-ablative aesthetic treatments in both medical and aesthetics settings. They have received wide clinical acceptance because of their long-term results, non-invasive nature, minimal treatment discomfort, and the speed and ease with which procedures can be performed. Commercial laser and flashlamp light (IPL) systems differ in wavelength, pulse duration and fluence generating capabilities, laser beam delivery system and skin cooling method; all of which have an effect on the outcome of the treatment. When deciding on the most appropriate light source for aesthetic laser treatments, tissue interactions should be thoroughly studied and taken into consideration. The various light sources currently available for non-ablative aesthetic treatments include IPL (broad spectrum), ruby lasers (694 nm), alexandrite lasers (755 nm), diode lasers (810 nm), and Nd:YAG lasers (1064 nm). Scientific evaluation studies have evaluated the safety and efficacy of Fotona VSP (Variable Square Pulse) Nd:YAG lasers in comparison with other commercially available light sources and have concluded that the advantages of VSP Nd:YAG are numerous:

- The appropriate wavelength with low absorption in the epidermis and deep penetration down to the deepest skin structures.
- The ability to treat all skin types while sparing the epidermis.
- The capability of generating appropriately high fluences at sufficiently short pulse durations in order to be able to treat thin, fine and light skin structures.
- The capability of delivering top-hat beam profiles.
- The most advanced VSP laser technology that can deliver high energies, high pulse powers and average laser powers in the same device.
- The largest range of spot sizes to adjust the depth of treatment to the particular skin type and position on the body.
- The safest and fastest skin coverage with computer controlled SOE (Scanner Optimized Efficacy) scanners.

To fully understand and benefit from the advantages of Fotona VSP Nd:YAG lasers, some key physical and technical characteristics of Nd:YAG lasers need to be studied and considered.

6.1.1 **Nd:YAG Wavelength Considerations**

The choice of wavelength is dictated by the need for good absorption of the laser or light energy in the target structures deep in the skin, while avoiding unnecessary damage to the epidermis. Successful non-ablative aesthetic treatments require light to penetrate deeply into the skin because it is necessary to destroy or thermally affect specific skin structures. Depending on the location on the body, light must penetrate 2 to 7 mm into the skin to be effective.

The optical properties of human skin are determined by two processes: absorption and the scattering of light.
Absorption

For the absorption of incident light energy, assuming no scattering, the beam intensity is described by the equation:

\[ I(z) = I_o e^{-\alpha z} \]

where \( z \) is depth, \( \alpha \) absorption coefficient and \( I_o \) the intensity of the laser beam on the surface of the skin.

In day-to-day practice a more illustrative parameter is penetration depth \( \delta \), defined as

\[ \delta = 1/\alpha \]

Penetration depth tells you at which depth the intensity of the laser beam falls to the level \( 1/e \) (36.78%) of the incident laser beam.

Figure 6.1. shows the absorption characteristics of various skin chromophores in isolation.

In real tissue, the absorption coefficients look much different than they do in the isolated chromophores; in Figure 6.2. the absorption spectrums for subcutaneous fat and dermis are shown.

Non-ablative aesthetic laser treatments require light energy to penetrate deep into the skin to reach the target skin structures. Figure 6.1. shows that light is absorbed by various skin chromophores throughout the visible and near-infrared spectrum.
Figure 6.2. Measured absorption coefficient $\mu_a$ and the reduced scattering coefficient $\mu_s'$ of subcutaneous fat and dermis as a function of laser wavelength. For both tissues there are two peaks of higher absorption around 1210 and 1450 nm.

Theoretically, numerous wavelengths can be used in non-ablative laser treatments. However, strong absorption in hemoglobin in small superficial blood vessels prevents light sources in the 400-590 nm wavelength range from penetrating deeply enough to have an effect on deep-lying skin structures, such as hair follicles. Other devices utilize wavelengths in the 650-850 nm range (ruby laser at 694 nm, alexandrite laser at 755 nm, diode laser at 810 nm) because of their high absorption in melanin. However, as skin color darkens the amount of melanin in the skin increases, and consequently penetration depth decreases. At these wavelengths light is more easily absorbed in melanin, and therefore using a non-Nd:YAG wavelength increases risk of undesired thermal injury to the epidermis, resulting in more pain and harsher side effects.

The Nd:YAG laser hold the most prominent position due to its longer, 1064 nm wavelength. In terms of absorption, this wavelength lies in an optical window that allows its energy to penetrate deeply into the skin, while its absorption in the target chromophores will remain strong enough to either destroy or thermally affect the desired skin structure.

**Scattering**

The effect of light scattering in human tissue must be taken into account when considering non-ablative aesthetic treatments. Scattering of laser light substantially influences the beam propagation through tissue and thus affects energy absorption in the skin as shown in the figure below.
Once light penetrates into the dermis, the depth of penetration becomes strongly influenced by scattering. The degree of laser light scatter in the skin before reaching the target chromophores, and therefore preventing any effect on the target structures, depends on the laser wavelength.

The next figure shows the dependence of the scattering coefficient in skin on laser wavelength. A high scattering coefficient corresponds to high scattering in the skin and therefore short penetration depths. As can be seen from the Figure 6.4, the Nd:YAG laser has a low scattering coefficient and thus penetrates deeper compared to other laser wavelengths that are also used in non-ablative aesthetic laser treatments.

After several scattering events, light no longer travels unidirectionally in the skin; its direction becomes random (see figure below), causing the light to bounce back and forth inside the skin until it is absorbed in one of the skin chromophores (for example in a hair follicle). By traveling randomly in skin at this point, the probability of light affecting skin chromophores becomes higher than if it were to travel through the skin unidirectionally. This effect enhances the absorption of Nd:YAG laser light in target skin structures making this wavelength extremely effective for non-ablative aesthetic treatments.
In order to penetrate as deeply as the Nd:YAG laser, other wavelengths require the use of larger spot sizes and consequently more energy to achieve the same clinical effect. The influence of spot size on the penetration depth and the energies required to attain a certain clinical effect are explained in more detail further in this chapter. To reach the same depth, a ruby laser would thus require a larger spot size and energy than an alexandrite laser, an alexandrite laser in turn requires a larger spot size and energy than a diode laser and a diode would require a larger spot size and energy than an Nd:YAG laser.

Intense Pulse Light (IPL) devices are sometimes used in aesthetics. These devices emit a very broad wavelength spectrum of light and are therefore not as selective and fine-tuned to particular target tissue absorption characteristics. They have average absorption characteristic and average scattering phenomena.

### 6.1.2 Pulse width Considerations

Since it is clinically desirable to selectively treat target skin structures without producing any injury to the surrounding tissue, laser energy is always delivered in single, short pulses. The target tissue approaches its maximum temperature once the laser pulse has ended. It then cools by transferring the heat to the adjacent tissue. The time required for the target tissue temperature to decrease by 63% is the thermal relaxation time (TRT). In order to destroy the target tissue and to avoid damage to surrounding tissue, the laser pulse duration (pulse width) should be lower than or equal to the target tissue’s TRT. To avoid unwanted injury to surrounding tissue, the laser pulse width should be much longer than the TRT of the surrounding tissue.

Because the epidermis is the first tissue exposed to the incoming beam of light, injury to the epidermis is most likely to occur, but only if the energy is delivered in too short a period of time. For this reason, the pulse width should exceed the TRT of the epidermis.

Likewise, in order to destroy or affect any skin structure, the laser energy must be delivered in a pulse of which the duration is shorter than or equal to that structure’s TRT. If the pulse is too long, the structure will be able to dissipate the energy before reaching a temperature that will destroy or correctly affect it.
For example, the TRT of the epidermis is estimated to be between 3 and 7 msec, depending on its thickness. The TRT for a hair follicle is estimated to be between 1 and 100 msec, depending on its diameter. The thinner the hair - the shorter its TRT. Ideally, laser systems for hair removal must be capable of delivering laser pulses with a pulse width longer than the TRT of the epidermis (e.g. 5 msec), but shorter than the TRT of the treated hair follicle (e.g. 15 msec). [Fig. 6.5, Fig. 6.6] Some commercial devices are capable of producing sufficient energy in pulse width durations that fall within these specifications, but many devices, especially diode lasers and IPL devices are not. Namely their pulse power generating capacity is not high enough to deliver sufficient energy in short enough pulse width durations.

![Figure 6.6. Tissue thermal relaxation times](image)

![Figure 6.7. Effects of pulse length on epidermal and hair follicle temperature](image)

Figure 6.7 demonstrates that in short laser pulses (short pulse width) the TRT of the epidermis is reached, while in long laser pulses (long pulse width) it is not. Short laser pulses are therefore more likely to cause injury to the epidermis than long laser pulses.

### 6.1.3 Variable Square Pulse Technology

Light energy must be delivered into the skin in appropriately short pulses to be safe, and yet remain effective by only thermally affecting the desired target tissues.

To generate light pulses with a high enough energy content to be effective, most devices rely on standard Pulse Forming Network (PFN) technology. PFN pulses have a typical temporal shape (shown Figure 6.8) with a slow rise time and a relatively long declining tail; the pulse power is not constant during the pulse and the exact pulse width is not defined.

While PFN pulses have been shown to be useful and effective for hair removal; the newer, more advanced Variable Square Pulse (VSP) technology generates pulses with higher treatment precision, efficacy and safety. Figure 6.8 shows a square pulse generated using VSP technology compared to a standard laser pulse. A significant difference between the two types of pulses is that the average power and the peak power of a square pulse is nearly the same, which cannot be said of PFN generated pulses. This means that the effect of VSP pulses on the skin is far more predictable than PFN pulses, which ultimately leads to superior treatment outcomes, with less discomfort and fewer side effects.
Figure 6.8 Comparison of PFN and VSP shaped pulses

An additional advantage of VSP technology is that it allows the user to easily adjust the pulse width and laser power, or even form a controlled train of micropulses within a larger overall pulse thereby optimizing the efficacy and safety of treatments, by making each pulse with a particular pulse width completely predictable from a clinical outcome point of view.

**Second Generation VSP Technology**

The majority of first generation non-ablative aesthetic laser systems produce pulses that are significantly shorter in duration than the epidermal TRT. This causes excessive injury to the epidermis and unwanted side effects.

Second generation Nd:YAG laser systems based on the Pulse Forming Network (PFN) technology are capable of producing laser pulses of longer durations. However, many of these second generation systems use a “double pulse” method that may be misleading to the user. The figure below shows a typical double pulse sequence emitted by a PFN Nd:YAG laser system and shows how laser energy is emitted in two single micropulses separated by a time period that is defined by such devices as the laser pulse width. This method does not improve safety for the epidermis since most of the heating is achieved within short periods of micropulses. Since all the laser energy must be delivered in two micropulses, the single-pulse energy, and therefore instantaneous temperature increase is relatively high. Note also that the second pulse does not contain much energy and that therefore most of the energy is contained in the first pulse.

![Figure 6.9. Typical two-pulse sequence of some PFN Nd:YAG laser devices. Pulse width is adjusted by changing the interval between two pulses.](image)
The pulse structure of Variable Square Pulse (VSP) technology Nd:YAG laser systems is much better adjusted to the TRT requirements of skin tissue. The next figure shows a typical pulse structure of a VSP laser pulse. The overall pulse width is increased by adding more micropulses to the overall laser pulse, and not just by increasing the separation between two micropulses. Also, the energy is distributed evenly over all micropulses. This ensures that the pulse width can be optimized to the particular TRT’s of the epidermis and the hair follicles.

![Figure 6.10. Typical VSP pulse structure for different pulse durations: a) 11 ms; b) 14 ms](image)

To treat extremely thin or light color hair follicles, VSP technology allows the practitioner to decrease micropulse widths to 0.1 msec.

In conclusion, VSP Nd:YAG laser systems provide the necessary precision and versatility to match the pulse width with the appropriate amount of fluence (energy density) necessary to provide effective non-ablative aesthetic treatments.

### 6.1.4 Pulse Energy and Fluence Considerations

#### Fluence

The fluence is one of the main treatment settings for non-ablative aesthetic treatments. It is defined as energy density:

$$f = \frac{E}{S}$$

where \(f\) is fluence, \(E\) is the energy of the laser pulse and \(S\) is the laser spot area on the skin surface. Usually it is measured in \(\text{J/cm}^2\).

#### Beam profile

Standard laser handpieces emit laser beams with a Gaussian profile with an energy distribution that resembles a conical shaped curve as described in the following figures. The principal effect of this is to create higher focal fluences at the center of the spot while the fluence decreases towards the edge of the spot. Gaussian profile handpieces are less appropriate for laser hair removal treatments where a uniform fluence is desired over the whole spot. However, they are very useful for treating vascular lesions.

Fotona has developed special “top-hat” profiled handpieces (R33, R34, and S11) which are ideal for hair removal.
When considering treatment settings it is important to understand that for a selected fluence on the laser system keyboard (which is in reality only the average fluence), a 4 mm spot with a “Gaussian” handpiece will emit laser radiation in the center of the spot with a focal fluence twice the value of the "top-hat" handpiece, and practically zero fluence at the edges of the spot. If a 60 J/cm² fluence value is selected on the keyboard the “Gaussian” handpiece will emit 120 J/cm² at the center of the spot. This is demonstrated in the Figure 6.12 below.

It is important to note that where a user is used to treating with a top-hat handpiece at certain selected fluences, a much lower fluence setting is required when working with a Gaussian handpiece. This is because for the same (average) selected fluence, the fluence at the center of the spot is much higher with a Gaussian handpiece, i.e. 3.8 times higher with a 2 mm spot, 3.1 times higher with a 3 mm spot and 2 times higher with a 4 mm spot.

### 6.1.5 Spot Size Considerations

The importance of the spot size of the emitted beam as a treatment parameter is not to be underestimated.
Theoretically, if the spot size is increased and the laser energy is simultaneously increased to maintain the same energy fluence, the clinical effect should be similar. However, due to random laser light scattering, spot size does make a difference to the treatment outcome. As a beam propagates into the skin, light scattering spreads the beam radially outward, which decreases the beam’s intensity as it penetrates into the skin. This effect is more pronounced at smaller spot sizes where the penetration depth is much lower than it would be, if only absorption characteristics were considered. This in principle means that small spot sizes (e.g. 2-3 mm) are good for treatments where heat has to be deposited superficially in the skin, as in skin rejuvenation and treatment of vascular lesions. Following the same reasoning, larger spot sizes are better for laser hair removal treatments because the aim of these treatments is to achieve thermal effects deep in the skin, where the hair follicles are located. However, the more tissue the laser light is required to thermally affect, the more energy is needed from the laser system. This means that in practice it is important to optimize the spot size and therefore the penetration depth to the actual depths of the hair follicles.

It is important to note that the sensation of pain also increases with the laser spot size. The larger the spot size, the more discomfort is felt by the patient. For this reason it is advisable not to use a spot size that is larger than needed to reach the necessary depth where hair follicles are located. Also, scanning a large area with a large number of smaller laser spots with a scanner is therefore preferable to covering the same area with a small number of large laser spots.

### 6.2 Cold Air Cooling During Fotona Nd:YAG Treatments

**S-11 Scanner operation - Pre-cooling the treatment site with cold air cooling**

- Position the scanner correctly over the treatment area, in accordance with the scanner operator manual.
- Aim the cold air flow at the treatment area to pre-cool the treatment site. Maximum patient comfort during the laser treatment can be reached when the surface skin temperature has reached 20°C. The manufacturer’s operator manual for the relevant cooling system should be able to advise you about suitable settings to achieve this temperature.
7. ND:YAG TREATMENT GUIDELINES & PARAMETERS

The following section describes individual treatment modalities and techniques, and provides guidelines and parameters for these procedures. These guidelines and suggested treatment parameters have been provided by practitioners who use Fotona's laser technology in their practice on a daily basis.

It should be noted that each individual treatment will be different as patients and conditions differ from case to case. Treatment strategy and medical opinion may also differ from practitioner to practitioner. Fotona urges to use common sense, medical training and experience in interpreting these guidelines and parameters.

![Figure 6.13. Treatment groups selection screen for the Nd:YAG laser source](image)

7.1 Laser Hair Removal

7.1.1 Treatment Principle

In the past, shaving, plucking, waxing, and electrolysis were the only methods of removing unwanted hair. In the early 1990's, the first reports of using laser energy to selectively destroy hair follicles were published, and since the mid 1990's, laser hair removal has become the “Gold Standard” in hair removal treatments.

Laser-assisted hair removal was introduced to remove unwanted body hair over large areas of skin. Laser hair removal can be achieved in two different ways: selective photothermolysis and homogeneous photothermolysis.
The principle of **selective photothermolysis** is based on the selective thermal destruction of a pigmented target when sufficient energy is absorbed by the target for a duration equal or less than the thermal relaxation time of the target. Because of the competition between melanin in the skin and melanin in the hair to absorb the laser energy, which may lead to hyper- or hypopigmentation, or burns, selective photothermolysis is not the ideal treatment option for darker skin types.

**Homogeneous photothermolysis** is based on the fact that laser energy acts on a certain tissue volume homogeneously. Rapidly dividing cells with high cellular metabolism are the first to be affected by absorbed laser energy. The hair bulb cells in the anagen phase (period of active stable growth) have a high metabolic rate and are much more sensitive to heat. The surrounding tissue is preserved, while at the same time, hair follicles are irreversibly destroyed. Due to the very low absorption in melanin, competition between skin and hair pigment is less, which makes this method more suitable for darker skin types.

Fotona's Nd:YAG laser treatment principle is based on both selective and homogeneous photothermolysis, and thus combines the best characteristics of both. This laser source has the depth of penetration necessary to reach even the deepest hair follicles without causing any collateral damage to the skin. The 1064 nm wavelength of the Nd:YAG laser primarily targets hemoglobin, targeting the blood flow in the base of hair follicles. Because of the minimal hemoglobin elsewhere in the skin, collateral damage is reduced and thus Nd:YAG laser treatments can be administered safely and effectively for all skin types.

It is important to know that in some cases an initial rise in hair numbers after the first laser treatment has been reported. It is believed that this increase occurs because of treatment induced synchronicity in the hair cycle, resulting in simultaneous anagen in the affected follicles. The initial rise will be followed by a reduction after further treatments.

### 7.1.2 Hair Biology

Hair is a dermal appendage found almost everywhere on the human body except the palms, soles, and lips. Vellus hairs are fine, colorless hairs covering most of the body, except those areas covered with terminal hairs, which are coarse, pigmented hairs found on the scalp and eyebrows. They can transform into terminal hairs when stimulated by androgens (male sex hormones), especially those on the face, back, chest, abdomen, axillae, and genitalia at puberty, but they can also transform into terminal hairs with aging. The number of hair follicles present in the skin is fixed at birth.

The hair shaft is composed of a protein, keratin, which is produced in the lower part of the follicle, or bulb. The middle part of the follicle contains an opening for the sebaceous gland, the attachment of the errector pili muscle, and a thickened area in the root sheath called the bulge, which is believed to contain the stem cell, important for regeneration of the hair follicle. Melanin is produced in the bulb and possibly in the bulge, and is concentrated in the hair shaft and upper part of the bulb. Depending on the thickness of the skin, the bulb may be as deep as 7 mm below the skin in the subcutaneous tissue. Actively growing, or anagen hair follicles are longest and deepest, while in follicles just coming out of dormancy, the bulb is much more superficial.
7.1.3 Hair Growth Cycle

Human hair grows in a continuous cyclic pattern, which includes the anagen, catagen, and telogen phases.

The anagen phase is a period of active stable growth, high metabolic activity, rapid bulb matrix cell division, and differentiation.

The catagen phase is a relatively brief period of 2 – 4 weeks of hair follicle degradation proceeding the resting period.

The telogen phase is a period of complete inactivity, lasting 2–5 months.

In general, the duration of each phase depends on the body area. The difference in the duration of a certain phase related to the hair location in the human body may be significant – from a few weeks to a few years.

### HAIR GROWTH TABLE

<table>
<thead>
<tr>
<th>Body Area</th>
<th>% Resting Hairs Telogen</th>
<th>% Hairs Anagen</th>
<th>Duration of Telogen</th>
<th>Duration of Anagen</th>
<th># Follicles per sq. cm</th>
<th>Daily Growth Rate</th>
<th>Approx. Depth of Terminal Anagen Follicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalp</td>
<td>13</td>
<td>85</td>
<td>3-4 months</td>
<td>2-6 years</td>
<td>350</td>
<td>0.35 mm</td>
<td>3-5 mm</td>
</tr>
<tr>
<td>Eyebrows</td>
<td>90</td>
<td>10</td>
<td>3 months</td>
<td>4-8 weeks</td>
<td>880</td>
<td>0.16 mm</td>
<td>2-2.5 mm</td>
</tr>
<tr>
<td>Ears</td>
<td>85</td>
<td>15</td>
<td>3 months</td>
<td>4-8 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheeks</td>
<td>30-50</td>
<td>50-70</td>
<td>10 weeks</td>
<td>1 year</td>
<td>800</td>
<td>0.32 mm</td>
<td>2-4 mm</td>
</tr>
<tr>
<td>Beard (chin)</td>
<td>30</td>
<td>70</td>
<td>6 weeks</td>
<td>16 weeks</td>
<td>500</td>
<td>0.38 mm</td>
<td>1-2.5 mm</td>
</tr>
<tr>
<td>Mustache</td>
<td>35</td>
<td>65</td>
<td>4 months</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axillae</td>
<td>70</td>
<td>30</td>
<td>4 months</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pubic Area</td>
<td>70</td>
<td>30</td>
<td>12 weeks</td>
<td>1 month</td>
<td>70</td>
<td>3.5-4.75 mm</td>
<td></td>
</tr>
<tr>
<td>Arms</td>
<td>80</td>
<td>20</td>
<td>18 weeks</td>
<td>13 weeks</td>
<td>80</td>
<td>0.30 mm</td>
<td>2.5-4 mm</td>
</tr>
<tr>
<td>Legs &amp; Thighs</td>
<td>80</td>
<td>20</td>
<td>24 weeks</td>
<td>16 weeks</td>
<td>60</td>
<td>0.21 mm</td>
<td>2.5-4 mm</td>
</tr>
<tr>
<td>Breasts</td>
<td>70</td>
<td>30</td>
<td></td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 6.1. Hair Growth Table*

Source: Cosmetic and Medical Electrolysis and Temporary Hair Removal, R.N. Richards M.D., G.E. Meharg R.N. Medric Ltd. 1991

### Treatment Results and Patient Expectations

The efficacy of laser hair removal is measured by the percent of hair reduction after one month and one year. The results depend on hair type, laser parameters, number of treatments and treatment schedule. Treatment success can be ranked according to 5 categories:
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad</td>
<td>less than 25% of hairs removed</td>
</tr>
<tr>
<td>Moderate</td>
<td>25-50% of hairs removed</td>
</tr>
<tr>
<td>Good</td>
<td>50-75% of hairs removed</td>
</tr>
<tr>
<td>Very good</td>
<td>75-95% of hairs removed</td>
</tr>
<tr>
<td>Excellent</td>
<td>more than 95% of hairs removed</td>
</tr>
</tbody>
</table>

*Table 6.2. Treatment Results*

Research has shown that the number of treatments influences the *one-month follow-up* after hair reduction as follows:

- after one treatment 44.9% patients exhibit greater than 50% hair reduction.
- after two treatments 71.5% patients exhibit greater than 50% hair reduction.

(S. Lorenz et al., Lasers in Surgery and Medicine 30: 127-134, 2002)

Additional treatments *do not* significantly affect the one month follow-up result. Excellent results (more than 95% hair reduction) can be expected in 20% of patients treated with a single treatment and 40% of patients after the second treatment.

Additional treatments *do* affect the long-term results. The duration of hair reduction success with single or two treatments lasts approximately 2 months; with 4 and 5 treatments hair is reduced for 4 to 12 months.

In addition to the heat-mediated inactivation of hair follicles, laser treatment can influence the growth dynamics of hair through growth delay and can switch hair stem cells from the anagen to telogen phase. Sometimes, with repeat treatments, hair growth cycles become synchronized. This increases the effectiveness of consecutive treatments.

Hair growth can be the result of medication, genetic disposition or age-related hormonal changes. For example, as women age they will generally lose hair on the legs, underarms, and bikini areas and may develop facial hair; men tend to lose hair on the head, while gaining hair on the back, chest and abdomen. Laser hair removal cannot prevent these changes. A laser hair treatment can only affect actively growing follicles. Treatment results, goals, and expectations can be very different at different ages.
### 7.1.5 Suggested Hair Removal Parameters

**Figure 6.14. Applications library screen for Fotona pre-set parameters for Hair removal treatment**

**Before starting a treatment always:**

- Discuss the phases of hair growth with your patient, determine a treatment schedule and define realistic treatment expectations.
- Discuss and define the patient’s hair type, skin type, levels of previous and future sun exposure, medication regimes and general health.
- Remove make-up and deodorant.
- Shave the treatment area.
- Verify laser eye protection conditions.

**These additional steps are strongly recommended:**

- Review a consent form in detail with the patient and obtain consent.
- Test the patient’s reaction to laser hair removal, by administering a few laser shots on the target area and observing the skin reaction a week later. This is important when it is difficult to assess the patient’s skin or hair type, or when the patient has a dark skin type and heavy hair growth.
- Take standardized photographs before each treatment session. Shave the target area and mark and photograph a 5 cm² portion. These photographs will show the reduction in hair follicle density achieved by the treatment.

A standard laser hair removal treatment concept requires medium-to-long laser pulse durations (15 – 50 ms). Based on recent scientific studies*, Fotona has introduced an additional Nd:YAG hair removal treatment regime that is based on a self-induced, three-dimensional fractional FRAC3 skin treatment concept. With high peak pulse power available with Fotona VSP technology, this treatment regime can be performed with pulse durations below 2 ms, and promises to offer higher hair removal efficacy without unduly sacrificing the safety of the epidermis.

Utilized handpieces: R33, R33-T, R34, R 34-T, S11

<table>
<thead>
<tr>
<th>Standard laser hair removal parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Pulse width (ms)</td>
</tr>
<tr>
<td>Skin type I – III</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
<tr>
<td>Skin type IV</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
<tr>
<td>Skin type V – VI</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
</tbody>
</table>

Table 6.3. Standard laser hair removal parameters based on skin type.

Utilized handpieces: R33, R33-T, R34, R 34-T, S11

<table>
<thead>
<tr>
<th>FRAC3 laser hair removal parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Pulse width (ms)</td>
</tr>
<tr>
<td>Skin type I – III</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
<tr>
<td>Skin type IV</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
<tr>
<td>Skin type V – VI</td>
</tr>
<tr>
<td>Thick hair</td>
</tr>
<tr>
<td>Fine hair</td>
</tr>
</tbody>
</table>

Table 6.4. FRAC3 laser hair removal parameters based on skin type.
Blond hair requires higher fluence values and shorter pulse widths to be effectively and efficiently removed. Darker hair in darker skin types requires lower fluence values and longer pulse widths for effective and efficient hair removal.

When deciding on the treatment settings, also consider the structure of the hair in addition to the skin type. A large hair will absorb more energy and retain it longer. Therefore lower fluence and higher pulse width settings may be chosen. For thinner hair, a higher fluence and lower pulse width may be needed. Always consider the skin sensitivity in the treatment area.

Use the settings given in Table 6.3. to pick initial treatment parameters. Perform a test shot on the treatment area before starting full-scale treatment. Reserve enough time between the test and the treatment to allow adverse effects to appear. The darker the skin type, the longer the time between the test and the treatment should be. Ideally, perform a number of test shots on the patient in an area close to the actual treatment site and wait until the following week to perform the full treatment. Always start test shots at the lowest energy setting, only increase the energy if there are no adverse effects.

In some long pulse Nd:YAG studies, fluences of 60 J/cm² in combination with a 30 ms pulse width have been used to treat hair. In cases like this, it is imperative to thoroughly test the patient’s reaction to the laser energy before pursuing treatment. The Fotona long pulse Nd:YAG laser systems can achieve these fluences at certain spot sizes and repetition rate settings.

Peri-follicular edema is usually not a clinical endpoint in laser treatment with Fotona long-pulse Nd:YAG laser. The clinical end point of Fotona long pulse Nd:YAG laser treatment is different from the clinical endpoint of shorter wavelength lasers. Short wavelength laser light is highly absorbed in epidermal melanin, and can cause peri-follicular and overall edema.

Long pulse Nd:YAG laser light primarily targets the chromophores of hemoglobin, and is less absorbed in epidermal melanin than short wavelength lasers. Thus the majority of its energy is transferred to the lower region of the hair follicle, rather than being absorbed in epidermal melanin. This is the reason less sparking is observed on the skin surface when using a long pulse Nd:YAG laser. After the treatment, hair should fall out in approximately three weeks. Peri-follicular edema may still be observed in some cases, however, it is not a necessary clinical endpoint.
The Fotona scanner function is the best way to ensure complete coverage when treating large areas. It can be pre-programmed to perform a random scan with 13%, 20% or 30% laser spot overlap, thus eliminating the risk of untreated skin areas and also improving both the treatment result and patient comfort.

Using a scanner can significantly decrease the procedure time.

All of the parameters and considerations discussed in the previous subsection, Suggested Hair Removal Parameters apply to laser hair removal with a scanner.

**Suggested Scan Patterns for Large Areas**

**Full leg hair removal**
- Draw a pen line across the top of the thigh as a starting point reference.
- Draw a line down the lateral and medial lengths of the leg.
- Scan medial to lateral on the anterior leg and repeat on the posterior.

**Back hair removal, including shoulders and upper arms**
- Draw a pen line across the top of the back, shoulders and down the arm.
- Draw a line (with contact/cooling gel) down the center of the back.
- Scan medial to lateral.

### 7.1.6 Laser Hair Removal Treatment Schedule

The treatment schedule will depend on each individual's hair growth cycle.

Generally, underarm, facial and bikini-line hair should be treated approximately every 4 to 6 weeks, if and only if new growth is present. Forearms, back, chest and legs should be treated approximately every 2 months, if and only if new growth is present.

Follicles treated in the anagen phase will shed hair 2 to 3 weeks after treatment. Remind the patient of this by giving a date at which they can expect to see the follicles drop hair.

Do not re-treat if growth is not present. Ask the patient to observe hair growth several days prior to the scheduled treatment session and reschedule if growth is not present.

### 7.1.7 Suggested Eyebrow Hair Removal Protocol

Consider the following points before performing eyebrow hair removal:

- Consider the coarseness of the hair and the sensitivity of the skin around the eye area.

- If the shaping of the eyebrow provides any problems, it may be advisable to ask the patient to have a professional eyebrow wax to the desired shape and return for the treatment 2 weeks later.

- Lower fluence settings by a minimum of 10 – 15 J/cm² and consider increasing the pulse width to 25 ms.
- Use the manual handpiece to ensure the patient’s eye safety.
- In the “uni-brow” area the scanner can be used.
- Maintain a maximum of eye protection and contain laser shots over the boney orbital margin. Aim the laser beam away from the eye orbit at all times.
- Remove eye make-up.
- Trim any excess length of the eyebrow hair to be treated.
- Consider applying cooling for 3 – 5 minutes after the treatment.

### 7.1.8 Miscellaneous Considerations in Hair Removal

- Before starting laser hair removal treatments with the Fotona S-11 scanner, run the system with cold air cooling for approximately 2 minutes to ensure stable and efficient skin cooling during the treatment.
- Pre-cool the skin for 15 to 30 seconds prior to starting the treatment. **Also see the Cold Air Cooling section in this chapter for more information.**
- Do not use very low settings on the cold air cooling system. Some patients may find high cold air cooling settings disturbing or uncomfortable, especially during facial treatments. Fotona Cool Skin Laser Gel can be used to enhance the effect of cold air cooling and thus allow lower cold air cooling settings. **Contact your local Fotona representative for more information on the Fotona Cool Skin Laser Gel.**
- To treat deeper-lying, hard-to-reach hairs (e.g. underarms and bikini line) 15 mm or 20 mm spot sizes can be used. We recommend the use of lower fluence settings as would be used with smaller spot sizes. It is suggested to start with lower fluence settings and gradually increase them during the treatment based on the comfort levels of the patient.
- The 6 mm scanner spot size is reported to be the most comfortable scanner spot size setting when using the S-11 scanner for typical hair removal treatments. Frequency settings should be set to accommodate the tolerance levels of the patient. For more sensitive areas, such as underarms or bikini lines we recommend decreasing the frequency settings to 1.5 Hz.

**Case Samples: Laser Hair Removal**

Full Back Hair Removal

*Figure 6.17: Full Back Hair Removal: Before (left) and After (right)*

*Courtesy of Dr. Blaha, Ljubljana, Slovenia*
Underarm Hair Removal

Figure 6.18 Underarm Hair Removal: Before (left) and After (right)
Courtesy of Robin Sult, Willmar MN, USA

"Unibrow" Hair Removal

Figure 6.19. Unibrow Hair Removal: Before (left) and After (right)
Courtesy of Robin Sult, Willmar MN, USA

7.2 Vascular Lesion Treatments

Lasers have been used to treat various vascular lesions since the 1970’s. By introducing new wavelengths and variable pulse durations, the laser treatment of vascular lesions has become safer and more effective.

Hemoglobin is the primary target of Nd:YAG laser light. As the energy is absorbed by the blood in the vessel, heat is created and the vessel wall will be destroyed. Eventually the blood vessel recedes and the body’s natural processes clear away the blood vessel tissue in the same way a bruise is cleared over a period of days to a couple of weeks. Generally blood vessels with a diameter up to 4 mm can be treated.

Ideal parameters depend on wavelength, pulse duration, and spot size. In general, longer wavelength laser light penetrates deeper into skin and should be chosen to target deeper vessels. The larger the vessel diameter, the longer the required pulse duration needed to slowly heat the entire vessel. Larger spot sizes penetrate deeper into tissue and optimize fluence delivery to the target.
7.2.1 Treatment Principles

Variations in vessel size, flow, depth, and type preclude the possibility of a single effective laser wavelength to treat all different vascular conditions. The best results are achieved by combining selective photothermolysis and homogeneous photothermolysis.

While the method of selective photothermolysis is to be used for superficial red-colored blood vessels, homogeneous photothermolysis is an ideal tool for larger, deeper-lying blood vessels.

Lasers with a longer wavelength, such as the Fotona Nd:YAG laser, penetrate deeper into tissue and are able to heat large vessels more uniformly than lasers with shorter wavelengths. The lasers with shorter wavelengths merely create a shield of coagulated blood on the upper edge of the blood vessel (shield effect), leaving a large portion of the vessel unaffected and open. With Nd:YAG lasers, homogenous heating affects the blood vessels more because coagulation factor proteins in the blood are much more sensitive to the temperature increase than the coagulation factors in the surrounding tissues. Thus, the deeper blood vessels coagulate before any permanent effects are induced in the surrounding tissues.

Lasers with shorter wavelengths, such as the Fotona KTP Nd:YAG laser, are more effective for treating thinner, superficial vessels (1 mm or less in diameter). Despite the high absorption in blood chromophores, the small diameter of the superficial vessels and proper treatment parameters allow the laser light to penetrate deeply enough into the vessel to coagulate it. No shield effect occurs in this case.

To summarize, successful laser treatment of vascular structures requires:

- a wavelength which is able to penetrate deeply enough to reach the blood vessel
- sufficient energy to achieve coagulation without damaging the overlying skin
- a pulse duration long enough to coagulate the blood vessel without damaging the skin or surrounding tissue (related to thermal relaxation time)

7.2.2 Classification of Cutaneous Vascular Lesions

A great deal of confusion and inconsistency exists in the terminology of vascular lesions. Often the same name is given to different lesions by different specialty fields, thereby confusing both inter-specialty communication as well as the analysis of reports on pathophysiology and treatment.

Mulliken and Young have proposed a standardized terminology based on cell kinetics. According to their classification, there are 3 major categories of lesions.
Hemangiomas

All lesions demonstrate endothelial hyperplasia
Capillary Hemangiomas (superficial)
Cavernous Hemangiomas (deep)

Malformations

All lesions demonstrate normal endothelial turnover
Capillary malformations
Port-wine stains (PWS)
Telangiectasias
  - Simple
  - Arborized
  - Spider
  - Papular
Lymphatic malformations
Venous malformations
Arterial malformations
Complex-combined malformations

Ectasias

Lesions with normal turnover but with vascular dilatation
Cherry Angioma
Spider Angioma
Angioma Serpiginosum

Table 6.5. Classification of Cutaneous Vascular Lesions

7.2.3 Suggested Vascular Treatment Parameters

Treatment of veins

Utilized handpieces: R33, R33-T

<table>
<thead>
<tr>
<th>Vessel Size (mm)</th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1</td>
<td>90 – 180</td>
<td>10 – 15</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>1 – 2</td>
<td>90 – 180</td>
<td>10 – 20</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>2 – 3</td>
<td>90 – 180</td>
<td>15 – 30</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>3 – 4</td>
<td>90 – 180</td>
<td>20 – 40</td>
<td>4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 6.6. Suggested Vascular Treatment Parameters for red veins.

<table>
<thead>
<tr>
<th>Vessel Size (mm)</th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1</td>
<td>90 – 150</td>
<td>10 – 15</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>1 – 2</td>
<td>90 – 150</td>
<td>10 – 20</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>2 – 3</td>
<td>90 – 150</td>
<td>15 – 30</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>3 – 4</td>
<td>90 – 150</td>
<td>20 – 40</td>
<td>4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 6.7. Suggested Vascular Treatment Parameters for blue veins.
The use of skin cooling is recommended before, during and after laser vascular treatments. Please refer to section 3.4: “Cold Air Cooling During Fotona Nd:YAG Treatments”.

When treating smaller blood vessels (1 – 2 mm) and facial blood vessels it is suggested to start at lower fluence and lower pulse width settings. After administering 2 to 3 laser pulses to the vessel, check for blanching. If no change is seen, fluence settings may be increased by 10 J/cm² increments until blanching of the blood vessels can be seen. Use these final settings to treat similar sized vessels on the same patient. One pass over the vessel will usually be sufficient to close the vessel and achieve the required clinical end-point.

For deeper-seated blood vessels whose boundaries are initially blurred, the end point of the treatment is reached when the color changes from lighter shades of blue-green to darker, more blurred shades 5-10 minutes after treatment. There is no visual blanching with the deep-seated blood vessels.

When treating blood vessel clusters, check for feed and out-flow blood vessels with a venoscope. Mark invisible feed and out-flow blood vessels with a pen and treat over the outline with the laser. As the vessel size increases, pulse width settings may be increased and fluence settings decreased to ensure patient comfort and to protect the skin.

When treating larger blood vessels, where lower pulse width and fluence settings are generally used, a second pass with the same lower settings may be indicated. An indication of the clinical result for the initial pass over the larger vessels may be in the sensation the patient experiences during a second pass. When the patient does not experience any sensation during the second pass, it indicates that the vessel is not absorbing any energy and has been fully closed. Other areas along the vessel may still absorb energy to close, in which case the patient will experience a sensation.

While some patients may want their blood vessels completely cleared, others may only want them to be less visible. Having a discussion with the patient about treatment expectations and limitations will help avoid disappointment. The patient should expect multiple treatment sessions if complete clearing of unsightly blood vessels is desired. While many people may need only one or two treatments, most people will be completely clear of unsightly blood vessels after the third treatment. It is important to stress that reabsorption of blood vessel tissue is different from person to person and that the period to complete recovery may last from a couple of days to weeks.

It is also very important to note that people who have developed unsightly blood vessels may eventually develop them again. Facial blood vessels are the most likely to redevelop in time. Develop a maintenance plan to check results and/or reoccurrence.

A suggested treatment/maintenance schedule may be:

- Initial primary treatment
- Follow-up treatment at 4 – 6 weeks (if necessary)
- Secondary treatment 6 months after the follow-up treatment (if necessary)
- Follow-ups as determined by the patient’s desired results.

Note that endovenous laser procedures may be a good treatment option for patients with large varicose (leg) veins. The Fotona XP-2 laser system offers both endo-vascular and exo-vascular treatment options. Contact your local Fotona distribution partner or visit [www.fotona.com](http://www.fotona.com) for more information.
Post Treatment Guidelines

- Recommend elastic bandaging (e.g. ace wraps) for 3 days after the initial treatment for better results and to actively engage the patient in the assessment of their post-treatment results.

- Avoid hot baths for at least 3 days. The patient may shower (lower temperatures are recommended) if the elastic bandaging is reapplied afterwards.

- Avoid exercising for 3 days. Exercise increases the blood flow and may recannulate the blood vessel.

- An aloe vera-based gel can be used to soothe the skin.

- Use sunblock for a minimum of 6 weeks post-treatment.

- If facial blood vessels are the treatment targets then the skin on the cheeks may get swollen and sore for 4 – 5 days. Treat with an aloe vera-based gel or aloe vera and cortisone 0.5% for 3 – 4 days to soothe the skin.

Other Vascular Lesion Treatments

![Figure 6.21. Applications library screen for Fotona pre-set parameters for treatment of vascular lesions.](image)

Treatment of lip hemangioma

**Utilized handpieces**: R33, R33-T

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Rep Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75-120</td>
<td>25</td>
<td>3-4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*Table 6.8. Case Sample Vascular Lesion Parameters*
Rosacea Treatment

The Nd:YAG laser can be used to treat the appearance of visible blood vessels that can appear as a symptom of rosacea.

Rosacea is a common but often misunderstood condition that is estimated to affect over 45 million people worldwide. The condition initially presents with flushing and redness centrally on the face, across the cheeks, nose and forehead. Neck, chest, scalp and ears are less commonly affected. As the condition progresses other symptoms can develop such as permanent redness, red bumps (some with pus), red gritty eyes, burning and/or stinging sensations, small blood vessels visible near the skin surface, and in advanced cases, a bulbous nose. Rosacea can be confused, but also co-exist, with acne vulgaris and or seborrheic dermatitis. Fair-skinned people are disproportionately affected. Rosacea affects both men and women of all ages, but middle-aged women are more susceptible because of hot flushes during menopause.

Suggested Rosacea Treatment Parameters

Utilized handpieces: R33, R33-T, S11 scanner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 – 50</td>
<td>25-50</td>
<td>2 - 6</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 7.9. Suggested Rosacea Treatment Parameters

Case Sample: Rosacea Treatment

Figure 6.22. Lip hemangioma: Before (left) and After (right)
Courtesy of Robin Sult, Willmar MN, USA
Fluence (J/cm$^2$) | Pulse width (ms) | Spot size (mm) | Frequency (Hz)
---|---|---|---
35 – 50 | 50 | 6 | 2.0

*Table 6.10. Rosacea Case Sample Parameters*

Treatment of spider veins on the interior of the lower thigh

**Utilized handpieces:** R33, R33-T

<table>
<thead>
<tr>
<th>Fluence (J/cm$^2$)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75-130</td>
<td>20</td>
<td>3</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*Table 6.11. Case Sample Vascular Lesion Parameters*

*Figure 6.24. Spider Veins: Before (left) and After (right)*  
Courtesy of Robin Sult, Willmar MN, USA

Treatment of spider veins on the left nasal labia

*Figure 6.25. Nasal Spider Veins: Before (left) and After (right)*  
Courtesy of Robin Sult, Willmar MN, USA
Treatment of facial telangiectasias

Figure 6.26. Facial telangiectasias: Before (left) and After (right)
Courtesy of Robin Sult, Willmar MN, USA

Treatment of deeper lying veins

Figure 6.27. Treatment of deep lying veins: Before (left) and After (right)
Courtesy of Robin Sult, Willmar MN, USA
7.3 Non-Ablative, Nd:YAG Skin Rejuvenation

The decreasing activity of fibroblasts in connective tissue and the decreasing tightness and thickness of collagen fibers in the papillary dermis are the main causes of skin-aging. The most common skin rejuvenation techniques are based on stimulating a responsive restorative process in the papillary dermis.

Chemical peels and dermabrasion are popular skin rejuvenation options but their relatively low efficacy and the high risk of papillary damage and scarring are major drawbacks. The thought of using chemicals, the immediate visible effects of both treatments and the long downtime do not appeal to patients.

The Fotona non-invasive Nd:YAG photo-collagen remodeling technique or T³ treatment is more appealing to patients because of its low downtime. T³ treatment is based on the absorption of Nd:YAG laser energy by hemoglobin with partial coagulation of the microvasculature in the papillary dermis and release of inflammatory mediators. The process results in micro-vascular renewing, fibroblast stimulation and new collagen remodeling. The end result will be smoother skin and smaller pore sizes, characterized by improvements in skin Tightness, Tone and Texture (T³).

7.3.1 Suggested Treatment Parameters

![Figure 6.28. Applications library screen for Fotona pre-set parameters for Skin rejuvenation treatments.](image)

Figure 6.28. Applications library screen for Fotona pre-set parameters for Skin rejuvenation treatments.
Utilized handpieces: R33, R33-T, R34, R34-T, S11

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I – III</td>
<td>15-50</td>
<td>15-50</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>15 – 40</td>
<td>15 – 50</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

Table 6.12. Suggested Treatment Parameters for Skin rejuvenation

*Spot size applies to both manual handpieces and scanner

In general the treatment does not require anesthesia. To ensure maximum patient comfort, skin cooling may be used before, during and after the T²³ treatment. Please refer to the “Cold Air Cooling during Fotona Laser Treatments” section in this manual.

Because of the very high frequency levels that can be achieved with the S-11 scanner, lower fluence settings will lead to comparable results as with other long pulse Nd:YAG modalities. Lower fluence settings in turn mean that cold air cooling is generally not required. This can be an added advantage in facial rejuvenation treatments, where patients often find cold air cooling directly on the face unpleasant.

FRAC3 is a special non-ablative treatment modality used for dermal rejuvenation. Pioneered by Fotona, and made possible by the superior performance characteristics of the Fotona Nd:YAG laser, FRAC3 treatments stimulate the skin’s natural capacity to rejuvenate by selectively inducing micro-wounds in prematurely aged or damaged portions of the dermis and epidermis. The laser action creates a 3 dimensional matrix of micro-wounds, which are concentrated at the specific depths of the existing skin damage. The natural healing response of the skin then acts to repair the micro-wounds, thereby rejuvenating the skin. In contrast with other laser rejuvenation treatments this gentle, non-ablative anti-aging treatment provides results with no downtime and little risk.

Utilized handpieces: R33, R33-T, R34, R34-T, S11

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)*</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I – III</td>
<td>15-50</td>
<td>0.6-1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>10 – 40</td>
<td>0.6-1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

Table 6.13. Suggested Treatment Parameters for Skin rejuvenation using FRAC3 mode

*Spot size applies to both manual handpieces and scanner

In general the treatment does not require anesthesia. To ensure maximum patient comfort, skin cooling may be used before, during and after the FRAC3 treatment. Please refer to the “Cold Air Cooling during Fotona Laser Treatments” section in this manual.
PIANO is a special non-ablative treatment modality used for dermal rejuvenation. This new, super long, PIANO modality extends the Nd:YAG pulse durations to the seconds regime. The duration of the PIANO mode is much longer than the thermal relaxation time of the epidermis or any other skin structures, and does not cause high initial temperature peaks in the epidermis. The PIANO modality is thus perfectly indicated for treatments where overall homogeneous, bulk heating of the dermis is desired. Treatments in the PIANO mode are because of the deeper thermal effect denoted also as “PIANO sculpting” treatments.

Utilized handpieces: R33, R33-T,R34, R34-T, S11

<table>
<thead>
<tr>
<th>Skin type</th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (s)</th>
<th>Spot size (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I – III</td>
<td>70 - 110</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
<tr>
<td>IV – VI</td>
<td>60 - 90</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
</tbody>
</table>

Table 6.14. Suggested manual handpiece treatment parameters for skin rejuvenation using PIANO mode

*Spot size applies to both manual handpieces and scanner
**Treatments administered, once per month for 5 months

When PIANO mode is performed with a manual handpiece, a brushing technique with constant movement of the handpiece must be used. The temperature on the skin should not exceed 42°C.

For better control of the PIANO sculpting treatment, the S11 scanner with automatic scanning (i.e., “controlled brushing”) of the laser spot over the scanned treatment area is recommended to be used. In the S11 PIANO sculpting (L-Runner) mode, the cumulative PIANO fluence can be controlled by setting the Treatment Time and the Power Density = Fluence/Treatment Time (in W/cm²). For example, if a Power Density of 1.2 W/cm², and a Treatment Time of 90 sec are selected, the cumulative delivered fluence during the PIANO sculpting treatment will be equal to Fluence = Power Density x Treatment Time = 108 J/cm².

To allow feedback from the patient, no anesthesia is recommended whenever the PIANO brushing or scanning technique is used. To ensure maximum patient comfort, skin cooling may be used before, during and after the PIANO treatment. Please refer to the “Cold Air Cooling During Fotona Laser Treatments” section in this manual.

Post Treatment Guidelines

- 3 – 6 follow-up visits are recommended at 4 – 6 week intervals. It is important to discuss the level of follow-up treatments with the patient, so that it is clearly understood that the follow-up treatments will keep the collagen in a positive growth phase in order to maintain and enhance the results.
- Wrinkles will continue to vanish over the 12 months after the initial treatment, as the natural rejuvenation process takes course.
Case Samples: T³ Treatment

Figure 6.29. Wrinkles Treatment before (left), after 12 months (middle) and 4 years after 5 treatments per year (right)
Courtesy of Dr. Blaha, Ljubljana, Slovenia

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50</td>
<td>6</td>
<td>2.0 – 3.0</td>
</tr>
<tr>
<td>24</td>
<td>50</td>
<td>10</td>
<td>2.0 – 3.0</td>
</tr>
</tbody>
</table>

Table 6.16. Case Sample T³ Parameters

Figure 6.30. Wrinkles Treatment before (left) and after (right)
Courtesy of Dr. Blaha, Ljubljana, Slovenia

7.4 Treatment of Mild-to-Moderate Inflammatory Acne Vulgaris

The Nd:YAG laser is a very effective modality in the treatment of mild-to-moderate inflammatory acne vulgaris as well as cystic acne.

As a foundation of the mild-to-moderate inflammatory acne vulgaris treatment, recommend that the patient adopt an appropriate skin care routine.

Mild-to-moderate inflammatory acne vulgaris infections increase blood supply in the affected area. Therefore laser energy will be well absorbed in the infected areas. Fotona’s Nd:YAG laser safely penetrates the skin to an optimal treatment depth to thermally and selectively destroy overactive sebaceous glands. In general, mild-to-moderate inflammatory acne vulgaris will fade away within 1 or 2 days.
Note that the suggested parameters for Nd:YAG mild-to-moderate inflammatory acne vulgaris treatments are similar to those for hair removal treatments. If mild-to-moderate inflammatory acne vulgaris is treated in the beard growth area, it is advisable to use the Nd:YAG handpiece with a 6 mm spot size and administer pulses over each affected spot individually.

Hair reduction in the treatment area can be an unwanted side-effect of mild-to-moderate inflammatory acne vulgaris treatments.

### 7.4.1 Suggested Treatment Parameters

![Figure 6.31. Applications library screen for Fotona pre-set parameters for the treatment of mild-to-moderate inflammatory acne vulgaris.](image)

**Utilized handpieces:** R33, R33-T, S11

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I - III</td>
<td>30 – 50</td>
<td>10 – 25</td>
<td>4 – 6</td>
<td>1.0 – 1.8</td>
</tr>
<tr>
<td>Skin type IV - VI</td>
<td>20 – 40</td>
<td>15 – 25</td>
<td>4 – 6</td>
<td>1.0 – 1.8</td>
</tr>
</tbody>
</table>

Table 6.17. Suggested Treatment Parameters for Mild–to-Moderate Inflammatory Acne Vulgaris

When using Frac3:

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I - III</td>
<td>15 – 50</td>
<td>0.6 – 1.6</td>
<td>4 – 6</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Skin type IV - VI</td>
<td>15 – 40</td>
<td>0.6 – 1.6</td>
<td>4 – 6</td>
<td>1.0 – 2.0</td>
</tr>
</tbody>
</table>

Table 6.18. Suggested Treatment Parameters for Mild-to-Moderate Inflammatory Acne Vulgaris

**NOTE!**

DO NOT use the laser to treat acne patients who have taken Accutane, Retin-A or other medications that can induce light sensitivity (see section 2.2 for more information).
7.4.2 Post Treatment Guidelines

- 3 to 6 follow-up visits are recommended at 1 week intervals.

Case Sample: Acne Treatment

Figure 6.32. Acne Treatment: Before and 6 months after
Courtesy of Robin Sult, Willmar MN, USA

Figure 6.33. Acne Treatment: Before and after
Courtesy of Robin Sult, Willmar MN, USA
7.5 Nd:YAG Laser in Podiatry

7.5.1 Wart Treatment

Administer a single laser shot in the center of the wart followed by laser shots around the circumference, ending with an additional single shot in the center of the wart. The patient should be followed up in 2 – 4 weeks as needed.

The callous part of the wart can be removed using a scalpel.

Suggested Wart Treatment Parameters

Utilized handpieces: R33, R3-T

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 - 200</td>
<td>15 - 25</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>4</td>
<td>1 Hz several passes</td>
</tr>
</tbody>
</table>

Table 6.19. Suggested Wart Treatment Parameters

Case Sample: Wart Treatments

Figure 6.34. Wart Treatment, before (left) and after (right)

Courtesy of Robin Sult, Willmar MN, USA

7.5.2 Temporary increase of clear nail in patients with onychomycosis

(e.g. dermatophytes, Trichophyton rubrum and T. mentagrophytes, and/or yeast Candida albicans, etc.)

Suggested Treatment Parameters

Utilized handpieces: R33, R33-T, S11

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot Size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 40</td>
<td>15 - 40</td>
<td>4 - 6</td>
<td>1,5</td>
</tr>
</tbody>
</table>

Table 6.20. Suggested Treatment Parameters
Utilized handpieces: R27 with 600 or 1000 µm fiber

<table>
<thead>
<tr>
<th>USER INTERFACE MODE</th>
<th>QCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPOT SIZE</td>
<td>1 – 1.5 mm</td>
</tr>
<tr>
<td>PULSE WIDTH</td>
<td>0.1 ms</td>
</tr>
<tr>
<td>PULSE ENERGY</td>
<td>0.2 J</td>
</tr>
<tr>
<td>POWER</td>
<td>4 W</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>20 Hz</td>
</tr>
<tr>
<td>TREATMENT TIME</td>
<td>&lt; 0.5 s on the same spot</td>
</tr>
</tbody>
</table>

Table 6.21. Suggested Treatment Parameters

**Treatment Pass #1 – Horizontal Pattern:**

Holding the fiber tip perpendicular to the infected toenail, move the fiber tip horizontally (medial-lateral direction) over the entire surface of the toenail as well as to the skin approximately 2 millimeters beyond the perimeter edges of the toenail. To each irradiated spot deliver a pattern of 0.5 seconds of consecutive laser spots of 1 to 1.5 millimeters in diameter.

**Treatment Pass #2 – Vertical Pattern:**

Holding the fiber tip perpendicular to the infected toenail, move the fiber tip vertically (proximal-distal direction) over the entire surface of the toenail as well as to the skin approximately 2 millimeters beyond the perimeter edges of the toenail. To each irradiated spot deliver a pattern of 0.5 seconds of consecutive laser spots of 1 to 1.5 millimeters in diameter.

The total therapy should consist of four sessions with a one week interval between each session.
8. **ND:YAG LASERS IN GENERAL SURGERY**

![Applications library screen for Fotona pre-set parameters for Nd:YAG General Surgery treatments](image)

**Figure 8.1.** Applications library screen for Fotona pre-set parameters for Nd:YAG General Surgery treatments

8.1 **Nd:YAG Lasers in Endovenous Laser Therapy**

8.1.1 **Introduction**

Varicose veins occur when blood does not properly return from the lower leg to the heart. All veins have valves that open to allow the flow of blood to the heart and close to prevent back flow (known as "reflux") of blood to the foot. When the valves fail to function properly, blood leaks through them and flows down the leg in the wrong direction. The blood overfills and distends the superficial veins under the skin, resulting in the bulging seen in varicose veins.

The walls and valves of veins are thin and elastic, and can stretch due to a variety of conditions including pregnancy, heredity and age. A severe case of varicose veins is referred to as chronic venous insufficiency. Symptoms of chronic venous insufficiency include aching, pain, easy leg fatigue and leg heaviness; symptoms worsen as the day progresses. Left untreated, chronic venous insufficiency can cause ulcerations, which can be very difficult to treat.

Approximately half of the population has some form of venous disease, with varicose veins affecting about one out of two people over the age of 50 and approximately 15 to 25% of all adults.

**Ligation and Vein stripping**

Until recently the standard treatment of large or perforating varicose veins was ligation and vein stripping. In ligation, one or more incisions are made over the varicose veins, and the vein is tied off. If the ligation can isolate a faulty valve and the vein and valves below the faulty one are healthy, the remaining vein may be left in place to continue circulating blood. If several valves in the vein and the vein itself are heavily damaged, the vein (or the diseased part of the vein) is usually removed (stripped). To strip a vein, an incision is made below the damaged vein and the vein is grasped and surgically removed. Vein stripping can take as long as eight hours and require general anesthesia and up to six weeks of recovery.
Because varicose vein surgery is an invasive procedure, it has the same risks as general surgery, including infection, bleeding, and anesthesia risks. If one of the largest veins in the leg (the great saphenous vein, or GSV) is stripped below the knee, numbness may result due to nerve injury. Common side effects from vein stripping and ligation surgery may include temporary pain or discomfort, bruising, haematoma, numbness, and, less frequently, wound infection.

Vein stripping is an invasive procedure and should not be performed on older adults for whom surgery poses a high risk due to other medical conditions. It is also not an appropriate choice for people who have circulatory problems of the legs, skin infections, blood-clotting defects or an abnormal passageway between an artery and vein. Pregnant women are also inappropriate candidates for vein stripping. Since stripping is a surgical procedure some patients are often left with scars that never disappear.

**Sclerotherapy**

Sclerotherapy emerged after vein stripping and ligation for the treatment of varicose veins and surface veins. Sclerotherapy is performed by injecting a solution into the damaged veins causing them to collapse, stick together, and eventually break down naturally in the body. Normal blood flow in the leg is rerouted through deeper veins.

A typical sclerotherapy session lasts from 15 minutes to an hour. Approximately one injection of the sclerosant is administered for every inch of vein. Upon completion compression hosiery is worn. Although the needle used to administer the sclerosant is small some patients report pain during the process.

Side effects can include brown lines or spots on the skin at the site of the injected blood vessels. In most cases, this discoloration will disappear in time. In a small number of people (less than five per cent), the brown lines may last up to a year or longer. Lumps may occur in larger injected veins. These are called 'trapped blood' and are not dangerous. They will either be removed a few weeks after the injection or will clear by themselves. Other effects may include swelling, matting, ulcers and inflammation.
Laser treatments

The use of lasers for the treatment of varicose veins received FDA approval in the year 2000.

A Comparison of Conventional Treatment and Endovenous Laser Treatment

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Endovenous Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>Inpatient/day-case</td>
<td>Outpatient</td>
</tr>
<tr>
<td>Treatment Location</td>
<td>Operating theater</td>
<td>Office/treatment room</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>Regional/general</td>
<td>Local/regional</td>
</tr>
<tr>
<td>Normal activity</td>
<td>4 weeks</td>
<td>50% within 72 hours</td>
</tr>
<tr>
<td>Incisions</td>
<td>Groin/knee + phlebectomies</td>
<td>Incision for insertion of fiber</td>
</tr>
<tr>
<td>Complications</td>
<td>5% skin numbness</td>
<td>&lt; 1 % skin numbness</td>
</tr>
<tr>
<td></td>
<td>5-10% wound infection</td>
<td>0 % wound infection</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>Extensive</td>
<td>Minimal</td>
</tr>
<tr>
<td>Cosmetic</td>
<td>Scars from incisions</td>
<td>No scars</td>
</tr>
<tr>
<td>Recurrency</td>
<td>10% - 50% after 10 years</td>
<td>2% - 5% after 3 years</td>
</tr>
<tr>
<td>Cost</td>
<td>High, direct and indirect</td>
<td>Reduced direct, low indirect</td>
</tr>
</tbody>
</table>

Table 8.1. Comparison of Conventional Treatment and Endovenous Laser Treatment

How Endovenous Laser Treatment works

Endovenous Laser Treatment works by means of thermal destruction of the venous tissues. Laser energy from the 1064 nm Nd:YAG laser is delivered to the desired location inside the vein with a bare laser fiber. When the laser is fired, it deposits thermal energy in the blood and venous tissues, causing irreversible localized venous tissue damage.

Figure 8.2. Laser action inside the vein
The laser is repeatedly fired as the laser fiber is gradually withdrawn along the course of the vein until the entire vessel is treated. Permanent occlusion of the vein is caused by thermal injury to the entire circumference of the vessel.

Endovenous Laser Treatment is of value in the treatment of truncal varicose veins (e.g. the greater saphenous vein) in patients with or without sapheno-femoral or sapheno-popliteal terminal valve incompetence.

The procedure is also effective in the treatment of large branch veins and large tributaries. A laser-introducing catheter can even be passed along small crooked veins, but it cannot be passed along an extremely tortuous vein with ease.

Endovenous Laser Treatment is less invasive than traditional surgical methods of varicose vein removal. It has a lower complication rate and is well tolerated by patients. Moreover, recovery time is quick and the treatment produces good cosmetic results.

### 8.1.2 Varicose Veins Treatment

**WARNING!**

*Use proper aseptic technique when removing single-use sterile fibers from their original sterile packaging.*

*Do not reprocess fibers that are intended for single-use!*

**Pre-Operative Treatment**

- Hemodynamic mapping of the varicose vein using a duplex ultrasound (US) scanner.
- If required by the type of anesthesia used, patient should be fasted accordingly.
- Pre-medicate the patient with benzodiazepine and NSAID.
- Select an appropriate entry point; mark the course of the vein and the anticipated entry point on the skin with a surgical marker.
- Prepare the patient by completely disinfecting the leg and draping the patient.
- Prepare the sterile operating field with all necessary equipment and accessories:
  - Prepare the sterile surgical tools.
  - Cover the US probe with a watertight sterile plastic cover. There should be a layer of gel inside the cover.
  - Open the sterile endovenous catheter kit and the fiber.
  - Measure the length of the vein to be occluded.
  - Position the fiber stopper on the fiber:
    - Take the fiber stopper from its sterile package and pass 1 m of fiber through it.
o Assemble the fiber and catheter. Pass the sterile bare-tipped laser fiber through the catheter until 2.5 cm of fiber protrudes from the end of the catheter.

o Keeping the pre-assembled catheter and fiber fixed, connect the fiber stopper to the catheter and only then tightly fix the stopper to the fiber (during the endovenous laser procedure, this prevents the laser fiber from slipping back into the catheter, the fiber is secured to the catheter by using this stopper).

o Disconnect the fiber stopper from the catheter and pull the fiber out of catheter, keeping the stopper firmly fixed on the fiber at the proper position.

o Prepare the tumescent anesthesia and delivery system (via syringe or via pump).

Anesthetic can be used to numb the site of cannulation (local intradermic anesthesia by means of infiltration with a 27 G needle at the point of percutaneous insertion).

**Treatment Parameters**

<table>
<thead>
<tr>
<th>User Interface Mode</th>
<th>QCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse width</td>
<td>0.3 ms</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 - 100 Hz</td>
</tr>
<tr>
<td>Power</td>
<td>20 - 25 W</td>
</tr>
</tbody>
</table>

*Table 8.2. Endovenous Treatment Parameters*

**Handpieces:** Not applicable – a bare fiber is used.

**Treatment Technique**

**Step 1:** Introduction and positioning of the fiber inside the vein

The Seldinger technique is used to introduce the catheter and the laser fiber through the vein entry point and to push them all the way up to the groin. The final positioning of the tip of the fiber is done under US control.

- Puncture the vein under US control using a 19G needle from the endovenous catheter kit. Perform reflux verification by aspiration with a sterile syringe.
Introduce the 0.035” J wire (from the endovenous catheter kit) through the 19G needle.

* all pictures in this chapter: Courtesy of Dr. A.Sikovec
- US control of the tip of the J wire.
- Make a stab incision with a blade no. 11 knife along the entering point of the wire.
- Introduce the dilator over the wire.

**Figure 8.5. Dilator Introduction**

- Introduce the dilator over the wire and expand the entry point for the 5F catheter.
- Extract the dilator and introduce the 5F catheter over the J wire to the desired position at the Sapheno-Femoral Junction (SFJ) if the Great Saphenous Vein is being treated, or at the Sapheno-Popliteal Junction (SPJ) if the Short Saphenous Vein (SSV) is being treated.

**Figure 8.6. 5F Catheter introduction**

- Extract the J wire and introduce the fiber into the catheter until its tip protrudes out of the catheter.
- Fix the fiber to the catheter using the fiber stopper, this ensures that the fiber tip protrudes 2.5 cm out of the catheter and prevents the fiber from slipping back into the catheter during pull-back.
Figure 8.7. Stopper fixation

Figure 8.8. US Control of fiber position

- Visualize SFJ or SPJ under US control.
- Connect the distal end of the fiber via connector to the laser system.

**Step 2: Tumescent anesthesia**

The endovenous laser treatment is performed under tumescent anesthesia, applied around and along the treated vein. In addition to its main anesthetic role, the tumescent anesthesia also functions as a cooling media around the vein. In this role it helps to prevent thermal damage to the tissue surrounding the vein. This thermal damage could potentially be caused by heat generated during the thermal destruction of the vein itself.

- Introduce tumescent anesthesia under US control (could be executed either manually via syringe, or with the special pump) starting from the groin towards the entry point.

Figure 8.9. Application of tumescent

Figure 8.10. US control of tumescent

Tumescent solution used:

- for manual (syringe) application: 20 ml of 2% Xylocaine (lignocaine) diluted in 100 ml of saline with the addition of bicarbonate
- for pump application: 40 ml of 2% Xylocaine (lignocaine) diluted in 500 ml of saline with the addition of 8 ml of 8.4% Na-bicarbonate and 1 ml of 0.1% Epinephrine

**Step 3: Laser vein obliteration**

Putting the laser system in the ready state causes the activation of the pilot beam, which glows red and is visible on the skin surface. Failure to observe the pilot beam is indicative of an incorrect alignment of the fiber in relation to the catheter, a failure of the laser beam delivery system, or a failure of pilot beam generation and transport inside the laser system.
- Activate the laser system, checking the pilot beam presence and the laser parameter settings.
- While firing the laser by pressing the footswitch, slowly pull back the fiber-catheter assembly. For the first 5-7 cm use US to supervise the laser beam photothermal interaction inside the vein.
- Control the speed of pull back and efficacy of the vein occlusion by observing the cumulative laser energy (J) fired into each 5 cm of vein length and comparing it with desired values.

Note the approximate rule for energy applied:

LEED (linear endovenous energy density in J/cm) = Diameter of the vein (in mm) X 10.

In the first 5 cm behind the SFJ or SPJ an additional increase of 50% is added to the calculated value of LEED (Ref. 36).

When the red pilot beam is 2 cm from the entry point, the procedure is complete. The catheter and the fiber are withdrawn from the vein and pressure is applied to the puncture site for a minute or two.

**Step 4: Post laser procedure**

In most cases after finishing the laser occlusion of the varicose vein, miniphlebectomies under local (the same tumescent) anesthesia are performed to clear the leg of smaller varicose branches in the same surgical session.

When miniphlebectomies are finished the complete procedure is finalized by:

- Closure of the entry point and other skin openings (miniphlebectomies incisions) with sterile-strips and self-adhesive pad covers.
- Application of compression stockings (Class 2 stockings for 3 days and nights, then during the day for 4 Weeks).
Selective use of LMW (low-molecular-weight) Heparin.

**Post Treatment Guidelines**

- Walking for 15 to 20 minutes immediately after the procedure is recommended.
- If travel to the patient’s home lasts longer than 1 hour, the patient should stop every hour and take a 10-minute walk. This exercise improves blood circulation in the leg, which can be hampered by a long car ride.
- Mild pain can occur after the effects of tumescent anesthesia fade (approx. 1 hour after the procedure). The patient should take an analgesic, preferably one to which she or he is accustomed.
- Compression stocking should be worn day and night for the first three days. After the first three days the compression stockings need not be worn at night.
- A telephone interview with the patient during the first week after the procedure is recommended.
- The covering pads should be kept dry at least for 7 days. If needed the covering pads can be removed and replaced after 3 days. Both pads and sterile-strips can be removed after 7 days – this can be done at the patient’s family doctor’s office.
- The patient should avoid heavy physical activity for the first two weeks after the procedure.
• It is recommended that the patient regularly walk, bicycle and perform other prescribed exercises.
• Bruising along the treated leg is a normal side effect and should disappear after a few weeks.
• Edema is a normal side effect of the operation. For up to 10 days there will be slightly stronger pain and the sensation of pulling present.
• The pain that patients feel 5–8 days following the procedure is related to the inflammation resulting from a successful endovenous ablation (i.e. wall thickening). It is not related to the presence or degree of ecchymosis nor is it the result of non-target laser damage to perivenous tissue. During this period analgesics and contact cooling with ice packs can aid in pain control.
• From 10 days to two weeks after the procedure the pain should lessen and healing will continue.
• Follow-ups at 1, 3 (if possible) and 6 months with US control are recommended.

**Examples of Endovenous Laser Treatment**

(Courtesy of Dr. A. Šilovec)

*Figure 8.15. Case 1: before (left), after (right)*

*Figure 8.16. Case 2: before (left), after (right)*
Figure 8.17. Case 3: before (left), after (right)
8.2 Nd:YAG Lasers in Laser Lipolysis and Laser-Assisted Liposuction

8.2.1 Introduction

Laser lipolysis is an effective treatment for fat reduction. In laser lipolysis, laser light is used to affect the heat-mediated swelling and rupture of adipocytes.

Laser energy is delivered to the fatty tissue through an optical fiber. The optical fiber is inserted into a thin cannula and interstitially introduced to fatty tissue in the hypodermis. High-level photo energy is delivered directly to the fatty tissue and is absorbed by the adipocytes and converted to heat; this causes the adipocytes to swell and rupture.

When a small volume of fat (100-200 cc) is treated, laser lipolysis can be used without the aspiration of the melted fat. In these cases the melted fat is left in place to be absorbed by the body. The treatment of larger volumes requires liposuction (aspiration) of the melted fat in addition to laser lipolysis.

Liposuction

Liposuction is the surgical procedure used to remove excess adipose tissue of the body for aesthetic purposes. It was popularized at the beginning of 1980's and is one of the most popular aesthetic procedures. In the beginning it was performed without the addition of tumescent anesthesia (in the so-called dry regime), with blunt cannula and an aspiration pump. Due to relatively high blood loss, a "wet" technique that causes much less blood loss was developed.

The most widely used Liposuction technique today is the Wet technique: Liposuction with tumescent anesthesia in which a saline and Lidocaine solution is injected into the target region before surgery.

There is also a Super Wet technique. The Super Wet technique is similar to the wet technique, but less tumescent solution is injected. In this technique the volume of solution injected is approximately equal to the volume of fat removed.

The Ultrasonic Assisted Liposuction technique (UAL) can also be used to remove adipose tissue. This technique uses high frequency ultrasonic waves to excite water particles, or any other fluid particles, causing them to boil and break the fat tissue. If not properly controlled this technique can cause post-operative burns.

Another technique on the market is Power-Assisted Liposuction (PAL or MicroAire Technique). PAL is a newer technique in which the cannula eases through the fatty tissue (even fibrous) with less trauma than traditional techniques and without the burn risks associated with UAL techniques. A machine performs liposuction using a special high-speed "linear reciprocating" suction cannula that eases the work for the surgeon and speeds up the procedure.
**Tumescent Anesthesia**

Laser lipolysis is usually performed with tumescent infiltrated anesthesia, with or without oral sedation. The composition of a typical tumescent fluid will be 0.1% lidocaine and epinephrine at 1 to 1 million. Typically, this solution will be made by using 50 cc of 2% lidocaine, 1 ml of epinephrine at 1 to 1,000, 10 ml of sodium bicarbonate 8.4%, and 1 L of normal saline. When mixed, this will provide a tumescent fluid of 0.1% lidocaine and 1 to 1 million epinephrine. Typical fluids for tumescent anesthesia will range from this concentration to half this concentration of 0.05% lidocaine.

Tumescent anesthesia fluid serves several purposes in laser lipolysis. The first is obviously to achieve analgesia and anesthesia. In addition, the infiltration of the local anesthetic decreases the density of the tissue in the area, making the passage of the cannula somewhat easier. The fluid also acts as a heat sink, distributing heat away from the surface tissue or diffusing the heat before it reaches the surface tissue, creating a safer environment for the dermis and epidermis.

The maximal safe dose of infiltrated tumescent anesthesia as lidocaine is approximately 55 mg per kilogram of body weight. This is an absolute number and should never be exceeded. If the planned areas of lipolysis are such that a volume of lidocaine greater than 55 mg per kilogram is anticipated, the procedure should be broken up into different operative days. Alternatively, one might use a more dilute concentration such as 0.05% lidocaine in the tumescent fluid for areas that are less tender and use a more concentrated lidocaine for those places that tend to be more tender. Typically, the abdomen, medial thigh, breasts and flanks tend to be among the more tender areas treated with lipolysis. Other areas tend to be less sensitive and a lower concentration can often be used.

Once the tumescent anesthesia is infiltrated, one should wait long enough to see skin blanching. This is the key indicator that the epinephrine has caused vasoconstriction and that lidocaine administration was effective.

The tumescent anesthesia generally lasts from 45 to 60 minutes, after which re-infusion will be necessary. For this reason, infiltrating patients in a manner that allows the surgeon to complete the tasks at hand within 45 minutes to 60 minutes is recommended.

Tumescent anesthesia can be applied to small areas with a simple spinal needle and syringe and to larger areas with a pump system and cannulas.

### 8.2.2 Laser Lipolysis and Laser Assisted Liposuction Treatment

**Pre-Operative Treatment**

- To prepare for surgery, please heed the following recommendations:
  - The patient should take measures to strengthen the immune system, such as taking vitamin C, and the patient should stop smoking (smoking slows the healing process by diminishing blood circulation).
  - The patient should inform the surgeon about prescribed medications that she/he is taking.
• Before arrival at the clinic, the patient should shower and wash the target area with disinfectant or antiseptic soap.

• Depending on the anesthesia used the patient must fast for approximately 2-6 hours before treatment.

• At the clinic, the preparation of a sterile operating field with all necessary equipment and accessories is required:
  - preparing the sterile surgical tools
  - opening the sterile laser system handpiece, cannulas and the fiber
  - preparing the tumescent anesthesia and delivery system (via syringe or via pump).

• Procedure planning – marking the areas to be treated, defining the number of regions to be treated, defining the entry points for laser and tumescent introduction.
• Prepare the patient on the operating table. Completely disinfect the areas to be treated and drape the patient.
• Anesthetic is used to numb the site of cannulation (local intradermic anesthesia by means of infiltration with a 27 G needle at the point of percutaneous insertion).

**Treatment Parameters**

**Utilized Handpiece:** R27

<table>
<thead>
<tr>
<th>User Interface Mode</th>
<th>QCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse width</td>
<td>0.3 ms</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Power</td>
<td>6-15 W</td>
</tr>
</tbody>
</table>

Table 8.3. Suggested Treatment Parameters for Laser Lipolysis and Laser Assisted Liposuction

**Treatment Technique**

• Infiltrate tumescent anesthesia through the previously selected entry points. Infiltration of tumescent could be performed either manually with syringes or with the pump. In addition to its anesthetic effect, tumescent liquid inflates the region and spreads the fat tissue, enabling easier cannula penetration.

• Set up the laser surgical set consisting of: laser fiber, handpiece and cannula:
  - Disassemble the R27 handpiece, by unscrewing the handpiece head from its body and removing the fiber holder (stopper).
  - Introduce the bare fiber into R27 HP from the distal end and advance it into the handpiece until it protrudes well out of the HP on the proximal end.
  - Put the fiber holder on the fiber and push down the fiber until it sits inside the R27 HP.
  - Reassemble the handpiece head with the housing so that the proximal (bare) fiber tip protrudes through the handpiece head. Don’t fix the fiber in the R27 HP yet. Don’t screw on the HP head to the end of the fiber.
- Take the cannula chosen for this particular treatment (cannulas could be of 1.1 mm (19G), or of 3 mm) and in accordance with the cannula’s length, pull the fiber through the HP so that the length of the fiber looking out of the HP is longer than the length of the cannula.

- If the cannula used is of 1.1 mm thickness, install the Luer-lock adapter onto the HP head by putting it over the fiber and screwing it to the HP head.

- Push the fiber through the cannula, until it protrudes out from the cannula on the other end and fix the cannula on the HP (in the case of 1.1 mm cannula by Luer-lock adapter, or in the case of 3 mm cannula, by directly screwing it into HP head).

- Check how much the bare fiber tip protrudes out of the cannula and pull back the fiber until it protrudes by approx. 2 mm.

- Fix the position of the fiber by firmly screwing on the HP head.

![Figure 8.24. R27 handpiece assembled with 3 mm cannula](image)

![Figure 8.25. R27 handpiece assembled with 1.1 mm cannula](image)

- Putting the laser system in the ready state causes the activation of the pilot beam, which glows red and is visible at the tip of the fiber.

- Using the same entry points made previously for tumescent infiltration, introduce the cannula with the fiber into the subcutaneous fat tissue and activate the laser. When the laser is activated (by pressing the footswitch) move the cannula with the fiber in a gentle forward-backward motion, firstly linearly and then radially, covering the whole region treated. If the region has a thicker fat layer, repeat the procedure on a deeper layer to achieve uniform fat melting throughout the entire depth of the treated region.

![Figure 8.26. Radial movement of the laser cannula](image)
Figure 8.27. Laser firing is performed during movement in both directions

Monitor the fiber tip location by observing the red pilot beam and the skin temperature by holding one hand on the skin surface.

During the laser action, a characteristic “pop-corn” effect indicates the breaking of adipocytes, which can be heard and also felt with the hand.

Figure 8.28. Hand control of laser action (Left), Pilot beam control of laser action (Right)

- Laser action end point - uniform softening of the treated region.
- In most cases, laser lipolysis is followed by suction of the melted fat. Suction can be performed either manually with syringes, or by a machine supported by a pump.

Figure 8.29. Aspiration with a syringe (Left), melted fat (Right)
After suction, some practitioners perform one more pass of laser interstitial irradiation to coagulate blood vessels broken by suction and to tighten the skin.

The complete procedure is finalized with:
- Closure of entry points with sterile-strips and self-adhesive pad covers
- Application of compression garments or bandages

Post Treatment Guidelines

- The patient can be released immediately after surgery, but should not drive for at least 12 hours after the surgery.
- Mild pain will occur after the effect of tumescent anesthesia fades (approx. 1 hour after the procedure). Administering an analgesic is recommended. Ideally the patient should already be used to the analgesic.
- To minimize the risk of infection, the patient must take an oral antibiotic for one week.
- Upon returning home the patient must drink at least 1-2 liters of fluid a day. The patient should increase her or his food intake gradually; the patient can resume her or his normal diet after 24 hours.
- The patient should rest for the first 12 hours after the surgery, but total rest is not recommended because it can lead to venous thrombosis. To avoid thrombosis frequent movements requiring minimal effort are recommended.
- The surgeon should determine, based on the type of work, how long the patient should stay at home. Most patients return to work 2 to 4 days after surgery.
- Resumption of normal (moderate) physical activity can start the third week after surgery. Regular sport and gym activity can be started in the first month after surgery.
- Compression: During the first two weeks after surgery, the patient should use the provided compression at all times. After the first two weeks, this use is optional. The compression must be applied homogeneously over the entire treated area.
Compression bandages: dressing, changing and cleaning has to be done the day following the operation. The patient should be able to take a shower after this, using warm water and carefully drying the incision area. The incision area should be wiped with an alcohol-soaked compress.

During the first 24 hours post-surgery, fluids will leak from the treated regions. Such fluid drainage is normal and the liquid is a mix of the anesthetic solution, liquid fat from the destroyed fat cells and some blood. Wet dressings should be regularly exchanged.

During the first several days the treated zones will appear swollen due to the edema that appears during any surgery. This sensation will diminish with time, while the skin adapts to the body and the new adipose content. The total time for healing is estimated from three to six months, depending on many factors ranging from skin type to the zone that is treated.

A telephone interview with the patient during the first week after the procedure is recommended.

Follow-up visits are recommended at 1, 3 and 6 months.

Examples of Laser Lipolysis and Laser-Assisted Liposuction

Case 1: Hips

![Figure 8.31. Laser Lipolysis of the Hips: Before (left) and after (right)](Courtesy of Prof. K. Massoud)

Case 2: Male breasts

![Figure 8.32. Laser Lipolysis of Male Breasts: Before (left) and after (right)](Courtesy of Prof. K. Massoud)
Case 3: Abdomen

Figure 8.33. Laser Lipolysis of Abdomen: Before (left) and after (right)
Courtesy of Latinmed

Case 4: Neck (submandibular region)

Figure 8.34. Laser Lipolysis of Neck: Before (left) and after (right)
Courtesy of Latinmed
8.3 Nd:YAG Lasers in Laser Assisted Reduction of Axillary Hyperhidrosis

8.3.1 Introduction

Laser assisted reduction of axillary hyperhidrosis is a surgical procedure performed under local tumescent anesthesia, where the apocrine glands are destroyed with the laser energy and removed from the armpit with suction probe (modified Blugerman-Schavelzon model).

Laser energy is delivered to the apocrine glands through an optical fiber. The optical fiber is inserted into a thin cannula and interstitially introduced to the apocrine glands in the hypodermis.

8.3.2 Laser Assisted Reduction of Axillary Hyperhidrosis Treatment

Pre-Operative Treatment

- To prepare for surgery, please heed the following recommendations:
  - The patient should take measures to strengthen the immune system, such as taking vitamin C, and the patient should stop smoking (smoking slows the healing process by diminishing blood circulation).
  - The patient should inform the surgeon about prescribed medications that she/he is taking.
- Before arrival at the clinic, the patient should shower and wash the target area with disinfectant or antiseptic soap.
- Depending on the anesthesia used the patient must fast for approximately 2-6 hours before treatment.
- At the clinic, the preparation of a sterile operating field with all necessary equipment and accessories is required:
  - preparing the sterile surgical tools
  - opening the sterile laser system handpiece, cannulas and the fiber
  - preparing the tumescent anesthesia and delivery system (via syringe or via pump)
- To detect the location of sweat glands perform an iodine-starch test on patients prior to treatment.
- Procedure planning – marking the areas to be treated, defining the number of regions to be treated, defining the entry points for laser and tumescent introduction.
- Prepare the patient on the operating table. Completely disinfect the areas to be treated and drape the patient.
- Anesthetic is used to numb the site of cannulation (local intradermic anesthesia by means of infiltration with a 27 G needle at the point of percutaneous insertion).
**Figure 8.35:** Iodine-starch test and measurement of sweat-producing axillar region (Courtesy of Poliklinika Dr. Maletić)

**Figure 8.36:** Treatment detail – subdermal laser action (Courtesy of Poliklinika Dr. Maletić)

**Figure 8.37:** Removal of destroyed glands (Courtesy of Poliklinika Dr. Maletić)

**Treatment Parameters**

**Utilized Handpiece:** R27

<table>
<thead>
<tr>
<th>User Interface Mode</th>
<th>QCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse width</td>
<td>0.3 ms</td>
</tr>
<tr>
<td>Frequency</td>
<td>40 Hz</td>
</tr>
<tr>
<td>Power</td>
<td>6-15 W</td>
</tr>
</tbody>
</table>

Table 8.4. Treatment Parameters for Laser Assisted Reduction of Axillary Hyperhidrosis

**Treatment Technique**

- Infiltrate tumescent anesthesia through the previously selected entry points. Infiltration of tumescent could be performed either manually with syringes or with the pump. In addition to its anesthetic effect, tumescent liquid inflates the region and spreads the tissue, enabling easier cannula penetration.
- Set up the laser surgical set consisting of: laser fiber, handpiece and cannula:
  - Disassemble the R27 handpiece, by unscrewing the handpiece head from its body and removing the fiber holder (stopper).
  - Introduce the bare fiber into R27 HP from the distal end and advance it into the handpiece until it protrudes well out of the HP on the proximal end.
  - Put the fiber holder on the fiber and push down the fiber until it sits inside the R27 HP.
  - Reassemble the handpiece head with the housing so that the proximal (bare) fiber tip protrudes through the handpiece head. Don’t fix the fiber in the R27 HP yet. Don’t screw on the HP head to the end of the fiber.
  - Take the cannula chosen for this particular treatment (cannulas could be of 1.1 mm (19G), or of 3 mm) and in accordance with the cannula’s length, pull the fiber through the HP so that the length of the fiber looking out of the HP is longer than the length of the cannula.
  - If the cannula used is of 1.1 mm thickness, install the Luer-lock adapter onto the HP head by putting it over the fiber and screwing it to the HP head.
- Push the fiber through the cannula, until it protrudes out from the cannula on the other end and fix the cannula on the HP (in the case of 1.1 mm cannula by Luer-lock adapter, or in the case of 3 mm cannula, by directly screwing it into HP head).
- Check how much the bare fiber tip protrudes out of the cannula and pull back the fiber until it protrudes by approx. 2 mm.
- Fix the position of the fiber by firmly screwing on the HP head.

- Putting the laser system in the ready state causes the activation of the pilot beam, which glows red and is visible at the tip of the fiber.
- Using the same entry points made previously for tumescent infiltration, introduce the cannula with the fiber into the subcutaneous tissue and activate the laser.
- The procedure itself consists of three steps. Access for instruments is through the same entry points made previously for tumescent infiltration

**Step 1:** Subdermal tissue dissection. Dissection enables easier movement of cannula with the fiber beneath the skin as well as proper position for upward laser shooting. Skin with sweat glands is dissected from lower structures using blunt spatula.

**Step 2:** Laser irradiation of sweat glands. Handpiece should be moved in the forward to backward motion and slowly displaced radially, covering the whole region treated. Laser energy is applied only when moving the handpiece backwards. Tissues, lying in the direction of the laser beam should be carefully manipulated by hand, so that the beam hits the skin as perpendicularly as possible.

Before, during and after the treatment the skin surface could be cooled with cold to prevent surface skin temperatures from rising above 40 °C.

**Step 3:** Curettage and suction. Using the grating cannula, destroyed glands are evacuated from the subdermis.

**Post Treatment Guidelines**

- The patient can be released immediately after surgery, but should not drive for at least 12 hours after the surgery.
- Mild pain will occur after the effect of tumescent anesthesia fades (approx. 1 hour after the procedure). Administering an analgesic is recommended. Ideally the patient should already be used to the analgesic.
- To minimize the risk of infection, the patient must take an oral antibiotic for one week.
- Upon returning home the patient must drink at least 1-2 liters of fluid a day. The patient should increase her or his food intake gradually; the patient can resume her or his normal diet after 24 hours.
- The patient should rest for the first 12 hours after the surgery, but total rest is not recommended because it can lead to venous thrombosis. To avoid thrombosis frequent movements requiring minimal effort are recommended.

- The surgeon should determine, based on the type of work, how long the patient should stay at home. Most patients return to work 2 to 4 days after surgery.

- Resumption of normal (moderate) physical activity can start the third week after surgery. Regular sport and gym activity can be started in the first month after surgery.

- Compression: During the first two weeks after surgery, the patient should use the provided compression at all times. After the first two weeks, this use is optional. The compression must be applied homogeneously over the entire treated area.

- Compression bandages: dressing, changing and cleaning has to be done the day following the operation. The patient should be able to take a shower after this, using warm water and carefully drying the incision area. The incision area should be wiped with an alcohol-soaked compress.

- During the first 24 hours post-surgery, fluids will leak from the treated regions. Such fluid drainage is normal and the liquid is a mix of the anesthetic solution, liquid fat from the destroyed fat cells and some blood. Wet dressings should be regularly exchanged.

- During the first several days the treated zones will appear swollen due to the edema that appears during any surgery. This sensation will diminish with time, while the skin adapts to the body and the new adipose content. The total time for healing is estimated from three to six months, depending on many factors ranging from skin type to the zone that is treated.

- A telephone interview with the patient during the first week after the procedure is recommended.

- Follow-up visits are recommended at 1, 3 and 6 months.

### 8.4 Incision and Excision, Removal of Post-Surgical Granulations

<table>
<thead>
<tr>
<th>USER INTERFACE MODE: QCW</th>
<th>HANDPIECES: R27-C in R27 (600 µm fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSE WIDTH: 0.6 ms</td>
<td></td>
</tr>
<tr>
<td>POWER: 4.5 W</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY: 40 Hz</td>
<td></td>
</tr>
</tbody>
</table>

*Table 8.5. Suggested Treatment Parameters*

Hold the target tissue with surgical tweezers. Cut around the target tissue with the laser. The laser will vaporize the tissue around the target tissue, allowing the target tissue to be removed.
8.5 Biopsies

<table>
<thead>
<tr>
<th>USER INTERFACE MODE: QCW</th>
<th>HANDPIECES: R27-C in R27 (600 μm fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSE WIDTH: 0.3 ms</td>
<td></td>
</tr>
<tr>
<td>POWER: 2 W</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY: 19 Hz</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.6. Suggested Treatment Parameters

8.6 Fibroma Removal

<table>
<thead>
<tr>
<th>USER INTERFACE MODE: QCW</th>
<th>HANDPIECES: R27-C in R27 (600 μm fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSE WIDTH: 0.3 ms</td>
<td></td>
</tr>
<tr>
<td>POWER: 2 W</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY: 19 Hz</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.7. Suggested Treatment Parameters

Hold the fibroma with surgical tweezers. The laser energy absorbed by the tissue will evaporate the tissue. Small blood vessels in the surrounding area are sealed as a result of the thermal effect of laser energy. In addition, the hemostasis provided by the laser reduces hematoma formation and leads to a more comfortable recovery. In most cases stitching is not required after the procedure. The wound should heal without problems through the formation of new fibrin.

The use of the Nd:YAG laser is recommended if a bloodless procedure is required.
8.7 Hemostasis

<table>
<thead>
<tr>
<th>USER INTERFACE MODE: QCW</th>
<th>HANDPIECES: R27-C in R27 (600 μm fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSE WIDTH: 0.1 ms, 0.6 ms</td>
<td></td>
</tr>
<tr>
<td>POWER: 3 – 5 W</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY: 45 Hz</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.8. Suggested Treatment Parameters

Coagulation is the main effect of the Nd:YAG laser; it can be effectively used to reduce and/or stop bleeding after conventional surgical treatments.

The coagulation effect depends on the laser power and size of the blood vessels. If bleeding is very strong then the coagulation effect may not be complete.

It is important to hold the optical fiber in a non-contact position. The larger the distance from the tissue, the larger the exposed surface, which means that the energy per surface decreases. Note that only blood vessels up to an approximate diameter of 0.5 mm can be fused.
9. COMBINED TREATMENT GUIDELINES & PARAMETERS

9.1 Introduction

Skin resurfacing and rejuvenation treatments can be performed either in ablative modes with an Er:YAG laser or non-ablative with either a Nd:YAG or ER:YAG laser, depending on the particular aesthetic outcome that the patient and practitioner wish to achieve. In addition, ablative and non-ablative treatments can also be combined into a comprehensive anti-aging treatment solution, such as Fotona’s TwinLight® treatments.

Figure 9.1. Treatment group selection screen for combined treatments.

9.2 TwinLight® Rejuvenation

With Fotona’s TwinLight® Rejuvenation method, the laser light precisely targets imperfections in the skin, leaving the surrounding healthy skin untouched. The heat from the laser energy also stimulates the production of new collagen in the dermis, and the surrounding untreated skin helps to speed the rejuvenation process. This treatment is suitable for all skin types, with minimal patient downtime.

TwinLight® Rejuvenation is performed in four steps: FRAC3®, VERSA Rejuvenation, Fractional Skin Resurfacing and Full-Beam Skin Resurfacing.

Each laser treatment combined in this method is discussed in detail in previous sections. There should be enough time given between steps in order to avoid side effects as a result of laser energy accumulation.
9.2.1 Suggested Treatment Parameters

Follow the guidelines set forth in Section 3 of this Applications Manual.

For each step of the procedure follow the guidelines discussed in sections where the specific step of the procedure is described in detail.

- The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Anesthesia:
  
  If deemed necessary, a topical anesthetic cream or regional nerveblocks with 2% xylocaine and 0.5% marcaine, without epinephrine, can be applied.

![Figure 9.2. Applications library screen for the TwinLight® Rejuvenation protocol](image)

1. Step: FRAC3®:

Utilized handpieces: R33, R33-T, R34, R34-T, S11

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)²</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I – III</td>
<td>15 – 50</td>
<td>0.6 - 1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>15 – 40</td>
<td>0.6 - 1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

Table 9.1. Suggested Treatment Parameters for FRAC3® mode
2. **Step: VERSA rejuvenation:**

**Utilized handpieces:** R33, R33-T, R34, R34-T, S11

<table>
<thead>
<tr>
<th>Skin type I – III</th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 – 50</td>
<td>15 – 50</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>15 – 40</td>
<td>15 – 50</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

*Table 9.2. Suggested Treatment Parameters for Skin rejuvenation*

3. **Step: Fractional skin resurfacing:**

**Utilized handpieces:** FS01, F-Runner

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Coverage</th>
<th>Frequency (Hz)</th>
<th>Number of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS01</td>
<td>2.2 – 8</td>
<td>MSP-VLP</td>
<td>5%</td>
<td>2-3</td>
<td>1-2</td>
</tr>
<tr>
<td>F22</td>
<td>8</td>
<td>MSP-LP</td>
<td>5%</td>
<td>2-3</td>
<td>1-2</td>
</tr>
</tbody>
</table>

*Table 9.3. Suggested treatment parameters for Light Fractional Skin Resurfacing*

4. **Step - Full beam skin resurfacing:**

**Utilized handpieces:** R04-Ti, R11, S-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1– 4</td>
<td>MSP</td>
<td>4 – 7</td>
<td>2</td>
</tr>
</tbody>
</table>

*Table 9.4. Suggested treatment parameters for cold Er:YAG ablation.*

**Suggested Post-Treatment Guidelines**

- Apply a thin layer of antibiotic ointment immediately after the treatment. Instruct the patient to apply the ointment 2 – 3 times per day for 4 – 7 days.
- Adequate sun protection is needed for at least 1 month after the last treatment.
9.3 Fotona 3D™ and Fotona 4D™ rejuvenation

Fotona3D™ and Fotona4D™ represent a series of non-invasive laser treatments of both the exterior facial and interior oral cavity, enabling full-thickness contraction of collagen for persistent, no-downtime tightening and volumization, without injectables.

Fotona's 3D and 4D rejuvenation treatments are performed in a series of three-to-four steps using the following treatment modes:

- **SmoothLiftin™** - non-ablative Er:YAG intraoral treatment for controlled and gentle “bulk-heating” to stimulate collagen contraction.
- **FRAC3®** - nonablative modality with a self-induced, fractional effect for treatment of specific, deeper imperfections.
- **PIANO®** - ultra-long Nd:YAG pulse mode causes bulk tissue heating safely and rapidly, from the outside in, by concentrating energy delivery subcutaneously.
- **SupErficial™** (with Fotona4D™) - a light cold Er:YAG ablation additionally improves the appearance of the skin and reduces imperfections.

With two laser wavelengths (Er:YAG and Nd:YAG) and 3 to 4 treatment modes, anti-aging is synergistically approached from multiple levels, working on deeper, medial and superficial connective tissue structures of the skin as well as targeting skin imperfections.

Each laser treatment combined in this method is discussed in detail in previous sections. There should be enough time given between steps in order to avoid side effects as a result of laser energy accumulation.

9.3.1 Suggested Treatment Parameters

Follow the guidelines set forth in Section 3 of this Applications Manual.

For each step of the procedure, follow the guidelines discussed in the sections where the specific step of the procedure is described in detail.

- The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Anesthesia: if deemed necessary, a topical anesthetic cream or regional nerveblocks with 2% xylocaine and 0.5% marcaine (without epinephrine) can be applied.
Figure 9.3. Applications library screen for the 4D rejuvenation protocol.

**Step 1: SmoothLiftin™**

**Utilized handpieces:** PS03*, (R11)

<table>
<thead>
<tr>
<th>Handpiece</th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R11</td>
<td>1.5 – 3</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>PS03</td>
<td>5 - 9</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>R11 LA</td>
<td>1.5 - 3</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
<tr>
<td>PS03 LA*</td>
<td>5 - 9</td>
<td>SMOOTH</td>
<td>7</td>
<td>1.6 Hz</td>
</tr>
</tbody>
</table>

* PS03 LA is recommended handpiece.

**Table 9.5. Suggested treatment parameters for SMOOTH mode for mucosa.**

For easier access to hard-to-reach areas in the mouth, the use of an intra-oral LA adapter is recommended.

To allow feedback from the patient, no anesthesia is recommended.

To achieve the effective temperature, a burst of 2 to 4 SMOOTH pulses per spot is recommended, therefore, lower fluences are needed.

**Step 2: FRAC3®**

**Utilized handpieces:** R33, R33-T,R34, R34-T, S11

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (ms)</th>
<th>Spot size (mm)*</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I – III</td>
<td>15- 50</td>
<td>0.6- 1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>15 – 40</td>
<td>0.6- 1.6</td>
<td>4-15</td>
<td>1.0 – 1.5</td>
</tr>
</tbody>
</table>

**Table 9.6. Suggested treatment parameters for FRAC3® mode.**
Step 3: PIANO®

Utilized handpieces: R33, R33-T, R34, R34-T

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (s)</th>
<th>Spot size (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin type I – III</td>
<td>70 - 110</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
<tr>
<td>Skin type IV – VI</td>
<td>60 - 90</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
</tbody>
</table>

Table 9.7. Suggested treatment parameters for PIANO mode.

Perform a brushing technique with constant movement of the handpiece. The skin surface temperature should not exceed 42°C.

To allow feedback from the patient, no anesthesia is recommended whenever the brushing technique is used. To ensure maximum patient comfort, skin cooling may be used before, during and after the PIANO treatment. Please refer to the “Cold Air Cooling During Fotona Laser Treatments” section in this manual.

Step 4: SupErficial™

Utilized handpieces: R04-Ti, R11, PS01, PS02, PS03, S-Runner, T-Runner

<table>
<thead>
<tr>
<th></th>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–4</td>
<td>4 – 12</td>
<td>MSP</td>
<td>4 – 12</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 9.8. Suggested treatment parameters for SupErficial™ cold Er:YAG ablation.

Suggested Post-Treatment Guidelines

- Apply a thin layer of vaseline or antibiotic ointment immediately after the treatment. Instruct the patient to apply the ointment 2 – 3 times per day for 4 – 7 days.
- Adequate sun protection is needed for at least 1 month after the last treatment.
9.4 Fotona TightSculpting™ rejuvenation

The TightSculpting™ procedure was developed as a combined method to address both body fat as well as the surface appearance of the skin. The method is based on the combined application of 1064 nm Nd:YAG and 2940 nm Er:YAG laser for superficial as well as deep heating of the skin, with the purpose of reducing adiposity by destroying localized fat and shaping the body by heating shrinkable connective structures.

The procedure consists of two steps:

First, by using 1064 nm Nd:YAG in super-long PIANO pulse modality, deep bulk heating of the skin is achieved. The generated heat is transmitted through the entire thickness of the fat layer and acts to increase microcirculation and accelerate deep thermo-contraction with a lipolytic effect.

In the second step, a prolonged Er:YAG non-ablative thermal pulse is used for superficial tightening of the skin. Controlled surface tissue heating results in subsequent collagen remodeling with the purpose of additionally improving skin thickness, elasticity and firmness.

Through an increase in fat metabolism and tightening of deep and superficial connective tissues, TightSculpting™ acts as a non-invasive procedure to significantly improve skin flaccidity as well as the surface appearance of the treated area.

9.4.1 Suggested Treatment Parameters

Follow the guidelines set forth in Section 3 of this Applications Manual.

For each step of the procedure, follow the guidelines discussed in the sections where the specific step of the procedure is described in detail.

- The use of anti-viral medication is recommended for patients with a history of herpes simplex or recent herpes infection or outbreak.
- Perform test patches, especially on patients with a history of pigment changes or scarring.
- Anesthesia: if deemed necessary, a topical anesthetic cream or regional nerveblocks with 2% xylocaine and 0.5% marcaine (without epinephrine) can be applied.
Figure 9.4. Applications library screen for the TightSculpting™ protocol.

**Step 1: PIANO® Sculpting**

**a) Utilized manual handpieces:** R33, R33-T, R34, R34-T

<table>
<thead>
<tr>
<th>Skin type</th>
<th>Fluence (J/cm²)</th>
<th>Pulse width (s)</th>
<th>Spot size (mm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I – III</td>
<td>70 - 110</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
<tr>
<td>IV – VI</td>
<td>60 - 90</td>
<td>5 - 7</td>
<td>9-20</td>
</tr>
</tbody>
</table>

Table 9.9. Suggested manual handpiece treatment parameters for PIANO mode.

Perform a brushing technique with constant movement of the handpiece. The skin surface temperature should not exceed 42°C.

To allow feedback from the patient, no anesthesia is recommended whenever the brushing technique is used. To ensure maximum patient comfort, skin cooling may be used before, during and after the PIANO treatment. Please refer to the “Cold Air Cooling During Fotona Laser Treatments” section in this manual.
b) Utilized scanning handpiece: S11

For better control of the PIANO sculpting treatment, the S11 scanner with automatic scanning (i.e., “controlled brushing”) of the laser spot over the scanned treatment area can be used. In the S11 L-Runner PIANO sculpting mode, the cumulative PIANO fluence can be controlled by setting the Treatment Time and the Power Density = Fluence/Treatment Time (in W/cm²). For example, if a Power Density of 1.2 W/cm², and a Treatment Time of 90 sec are selected, the cumulative delivered fluence during a PIANO sculpting treatment will be equal to Fluence = Power Density x Treatment Time = 108 J/cm².

<table>
<thead>
<tr>
<th>Power Density (W/cm²)</th>
<th>Scan Size (X x Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 1.5</td>
<td>Dependent on the desired treatment area. Adjusted up to approximately 80 x 80 mm²</td>
</tr>
</tbody>
</table>

Table 9.10. Suggested S11 handpiece treatment parameters for PIANO sculpting mode.

The skin surface temperature should not exceed 42°C. To allow feedback from the patient, no anesthesia is recommended. To ensure maximum patient comfort and treatment results, skin cooling is recommended to be used during the scanning PIANO sculpting treatment. When cold air cooling is used the skin temperature should not exceed 39°C. Please refer also to the “Cold Air Cooling During Fotona Laser Treatments” section in this manual.

Step 2: SMOOTH Tightening

Utilized handpieces: R11, R04, T-Runner

<table>
<thead>
<tr>
<th>Fluence (J/cm²)</th>
<th>VSP Mode</th>
<th>Spot size (mm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 2</td>
<td>SMOOTH</td>
<td>7-12</td>
<td>3.3 Hz</td>
</tr>
</tbody>
</table>

Table 9.11. Suggested treatment parameters for SMOOTH tightening.

Perform a brushing technique with constant movement of the handpiece. The skin surface temperature should not exceed 42°C.

To allow feedback from the patient, no anesthesia is recommended whenever the brushing technique is used. To ensure maximum patient comfort, skin cooling may be used before, during and after the SMOOTH tightening. Please refer to the “Cold Air Cooling During Fotona Laser Treatments” section in this manual.


10. CONTRIBUTORS

Andrej Šikovec, MD, MSc
Avelana Vein Clinic
Otočec, Slovenia

Edward Zimmerman, MD
Private Practice, Las Vegas, USA

Prof. Uroš Ahčan, MD, PhD.
Department for Plastic Surgery and Burns
University Clinical Center Ljubljana, Slovenia

Duško Maletić, MD, MSc
Private Practice
Daruvar, Croatia

Prof. Karim Massoud, MD, Ph.D
Ain-Shams University
Cairo, Egypt

Diego Schavelzon, MD
Clinica B&S de Excelencia en Cirugía Plástica
Buenos Aires, Argentina

Pareskevas Kaka, MD, Ph.D
Center for Advanced Surgery
Thessaloniki, Greece

Lidija Volovec, MD
Private Practice
Brezice, Slovenia

Ivano Luppino, MD
Private Practice, Catania, Italy

Assist. Prof. Brigita Drnovšek-Olup, MD, PhD.
University Eye Clinic, Ljubljana, Slovenia

Feyke Hogenbirk
Hooghe Birck Kliniek, Doetinchem, The Netherlands

Jasna Blaha, MD
Private Practice, Ljubljana, Slovenia

Thomas A. Sult, MD
Aesthetics Lasers, Inc., Willmar (MN), USA

Robin A. Sult, RN
Aesthetics Lasers, Inc., Willmar (MN), USA

Franco Paciolla, MD
MedLight Laserterapia s.r.l., Firenze, Italy

Patrick Voegele, MD
Belviso Facial Aesthetics, Santa Maria (CA), USA