High Power Q-Switched Nd:YAG 1,064-nm Fractional Laser for Non-Ablative Skin Remodeling

KeeLee Tan, MD. Rejuvenate Clinic, Perth, Western Australia

ABSTRACT

Introduction. Q-switched lasers are often used for tattoo removal and other applications which demand high laser intensities in nanosecond pulses. Interestingly, the Q-switched 1064-nm neodymium:YAG (Nd:YAG) laser was the first non-ablative laser clinically tested over a decade ago. Recently, a new generation of these lasers featuring higher power and fractionated beams have been introduced for non-ablative skin remodeling and rejuvenation. The purpose of this report is to summarize the initial clinical experience with this new High Power Q-Switched Nd:YAG 1,064-nm Fractional Laser.

Material & Methods. The Pixel® QSW module (Harmony®XL platform) is a fractional Q-switched 1064-nm Nd:YAG handpiece with a passive refractive optical element that creates a 5x5 matrix with 25 microscopic holes (~200μm in diameter /each) and high power density per pixel (60-130J/cm²). The repetition rate of the laser can be adjusted to 1, 2 or 5Hz. Treatment was performed on sixty patients (58 female and 2 male; age range 31-83; mean age 49.63; Fitzpatrick skin type I-VI) at the Rejuvenate Clinic in Perth, Australia between June 2010 – March 2011. Patients were randomly assigned for 3 treatments performed each week. Follow-ups were done 1 week, 3 months and 6 months after the last treatment.

Results. Significant clinical improvement was observed in most treated areas 1 week and 3 months after the last treatment. The degree of clinical improvement was found to be in most patients clinically significant.

Conclusion. The Pixel QSW offers a painless and comfortable procedure that doesn’t require pre-treatment or post-treatment care. The treatment is very safe for all Fitzpatrick skin types (I-VI).

INTRODUCTION

Fractional lasers thermally alter only a small volume of the target tissue, hence avoiding complete destruction of both the epidermal and dermal compartments. Consequently, fractional selective photothermolysis has become the "gold-standard" modality in non-ablative and ablative laser applications for the treatment of multiple skin imperfections such as acne scars, surgical, atrophic and hypopigmented scars, melasma, lentigines, poikiloderma of civatte and dyspigmentation. The fractional non-ablative technique uses near-to-mid-infrared range lasers. The aim with a fractional non-ablative laser is to deliver a controlled dermal wound without harming the overlying epidermis so that all stages of wound healing and skin remodeling occur under the biologic protection of an intact epidermis (1,2).

Long pulse 1,064nm Nd:YAG lasers have been used non-ablatively, both alone and in combination with other lasers, for improvement in wrinkles, along with mild skin tightening. However, the clinical results were considered modest at best, and were associated with patient discomfort due to pain.

By contrast, short-pulse Q-switched 1,064 nm Nd:YAG lasers are often used in applications that demand high laser intensities in nanosecond pulses; such as tattoo removal (3). Interestingly, it was the first non-ablative laser clinically tested more than a decade ago for the treatment of rhytides (4).

TECHNOLOGY

The new Pixel QSW module is a fractional, high power, short pulse, 1,064nm Nd:YAG laser used with the Harmony®XL platform (Alma Lasers Ltd., Caesarea, Israel). Since the Q-Switched 1,064-nm wavelength laser beam is only modestly absorbed in melanin and hemoglobin, it enables deep penetration to the papillary and reticular dermis. The laser beam is fractionated by a passive refractive optical element, creating a 5x5 matrix of 25 microscopic holes (~200μm in diameter) and distributed within a 5mm x 5mm footprint (Figure 1).

Figure 1. High Power Pixel QSW Nd:YAG 1064-nm laser hand piece and its 5x5 pixel matrix on a 0.5 x 0.5 cm footprint.
The PixelQSW creates high power density of each pixel (range 60 – 130J/cm²) to facilitate non-specific thermal injury of the dermal milieu, which is believed to promote collagen remodeling – albeit with short pulse duration in the nanosecond range. The energy settings range between 400–12000 mJ/P. The pulse repetition rate of the Pixel QSW is adjustable: 1 Hz, 2 Hz or 5 Hz.

**PATIENTS & METHODS**

This is a prospective study of sixty patients (38 female and 2 male; age range 31-83; average 49±7.4; Fitzpatrick skin type I-VI) who visited the Rejuvenate Clinic between June 2010 and March 2011. Patients were randomly assigned to the Pixel QSW for correction of photaging skin-related imperfections including fine lines, rhytides and skin laxity etc. Treatments were done on the face, arm, neck and jowl areas. Patients were given an explanation of the risks, benefits, and potential complications, and written informed consents were obtained from each patient. Table 1 depicts patient demographic and treatment characteristics.

**RESULTS**

The procedure on all patients was found to be pain-free and safe for all Fitzpatrick skin types (I-VI). Patient clinical outcome was evaluated with high resolution before and after photography by 2 independent photo-raters. Score of improvement was rated according to the following scale: I = no improvement (0%); II=minor improvement (<25%); III moderate improvement (26-50%); IV=very significant improvement (76-100%). Table 2 depicts patient results before and 3 months after the last treatment for 10 different areas (total of 450 areas) such as the forehead, lower lid, glabella and crow’s feet’s areas for a total of 432 treated areas on the face and 6 areas on the neck, forearm and jowl. Fifteen percent of the patients have demonstrated very significant clinical improvement (76%–100%) and approximately 22% of the patients have demonstrated improvement rates between 51.75%. In the upper and lower-lids area, 50% of the patients treated have demonstrated marked-to-very significant improvement (>51%-100%). The arm area showed the lowest clinical score with 66% of the patients (n=6) having showed no-to-mild improvement.

**DISCUSSION**

This is the first reported clinical experience with a short pulse fractional Q-switched 1064-nm Nd:YAG laser for non-ablative skin remodeling and rejuvenation. The accumulated clinical results and evidence from the past six months demonstrates that the Pixel QSW ameliorated the signs of photaged skin irregularities. Significant improvement was seen for superficial rhytides in the supra-orbital and nasolabial areas (with less noticeable changes in the glabella and smokers-line), three months and six months after only three serial treatment sessions for most of the patients. Some degree of variation in the clinical outcome can be expected, depending on patient age, skin type, degree of pre-existing photo-damage/age, smoking history and genetics. It might be that older patients with a higher degree of photo-damaged skin responded poorly in comparison with younger patients.

Typically, photo-damaged skin ground substances can histologically and microscopically be identified at 300-400μm below the epidermis. Current research in laser-induced tissue damage and remodeling has focused on the extracellular matrix or collagen.

This remodeling involves an initial inflammatory phase characterized by massively high levels of the enzymes matrix metalloproteinases (MMPs), which degrade the fragmented collagenous matrix followed by substantial and extended production of new undamaged collagen. Fibroblasts in both photo damaged and chronologically aged human skin possess substantial capacity to produce new collagen when removed from their fragmented extracellular matrix. That being said, histologic and biochemical data performed after laser tissue irradiations indicates that collagen fragmentation is responsible for loss of structural integrity and impairment of fibroblast function in aged human skin. Thus, for age-related wrinkle or skin laxity improvement, the Pixel QSW, 1064-nm wavelength and its high power density energy at each pixel and penetration (~2mm) is ideal to induce, non-invasively, cascade of wound healing reaction.

The Pixel QSW is thought to stimulate new collagen production by producing a micro-thermal injury to the dermis that initiates a wound healing response. This micro-thermal injury-induced fibroblastic proliferation and apparent up-regulation of collagen expression (neocollagenesis/remodeling) leads to a thicker dermis. During wound healing, pro-collagen and type III collagen fibers with a small diameter are initially produced. Later, thicker type I collagen fibers are made and cross linking occurs, leading to an increase in the average diameter of collagen fibers in the dermis. A decrease in collagen fiber diameter has been associated with production of new collagen, which is thought to increase skin firmness and improve skin texture in patients after treatment.

Heat shock protein (HSP70) has been suggested to play a significant role in ablative and non-ablative thermal laser interventions, as well as during wound healing (6). Interestingly, non-ablative thermal laser intervention with a 1540-nm Er-glass laser resulted in a uniform up-regulation of HSP70 protein expression in the epidermal layers immediately (about 60 min) after laser procedure, with maximal expression one to three days post-intervention (7).

The skin’s sub-dermal layer and the underlying collagen-containing tissue are heated without substantially modifying the melanocytes and other epithelial cells in the epidermis. The result is a contraction of the collagen tissue and a tightening of the skin. Controlled thermal injury may result in tissue shrinkage followed by an inflammatory response accompanied by the migration of fibroblasts into the area. The area is reinforced with additional connective tissue deposits as part of the tissue repair and healing phase, which is followed by a period of maturation of the newly deposited connective tissue, exhibiting resulting in contracture and tightening of the injured tissues and the tissue overlying dermis-epidermis interface. This newly deposited connective tissue matrix may be used to strengthen the old skin.

Historically, the Q-switched 1064-nm Nd:YAG laser has been used successfully to effect non-ablative dermal remodeling, despite its epidermis injury, pigment specificity and relative lack of absorption by water-containing tissue. Its relatively long wavelength is able to penetrate tissue depths sufficient for papillary dermal wounding, while its brief (nano-second) pulse duration limits thermal diffusion.

The Q-switched Nd:YAG laser was the first laser used as a non-ablative tool for skin rejuvenation. In their study, Goldberg and Withrow (5) compared the results of traditional pulse-dye lasers with the SilkTouch CO2 laser and the UltraPulse CO2 laser. The CO2 lasers demonstrated improvement in all patients. In 3 of 11 patients the Q-switched Nd:YAG laser produced results that were indistinguishable from those of the CO2 lasers. In six patients, clinical improvement was noted with the Q-switched Nd:YAG laser, but this was not as marked as with the pulsed CO2 lasers. In two patients, no improvement with the Q-switched Nd:YAG laser was noted. The adverse effects from the use of the Nd:YAG laser were pinpoint bleeding and transient erythemas. Re-epithelialization lasted an average of 3-5 days.

An improvement in the grade of wrinkles or the skin texture and elasticity by use of the Q-switched Nd:YAG laser was also cited in two additional studies by Goldberg et al., (4) which reported about 97% improvement of wrinkles that were classified at least as “slight”, the investigators in the second study stated that there was clinical improvement in thighs in six of eight patients which qualified at least as “fair”.

---

**Figure 2. Treatment end-points after 1000mJ/P at 5Hz; Upper red rectangle showing erythema, Skin warmth 1.5-2 degrees centigrade vs no treatment area (lower white rectangle).**

**Table 1: Patient demographics.**

<table>
<thead>
<tr>
<th>Demographic Criteria</th>
<th>No. of Patients (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>FM</td>
</tr>
<tr>
<td>Age range</td>
<td>35-64</td>
</tr>
<tr>
<td>Treatment Area (n)</td>
<td>Face*</td>
</tr>
<tr>
<td></td>
<td>Forehead</td>
</tr>
<tr>
<td></td>
<td>Nose</td>
</tr>
<tr>
<td></td>
<td>Neck</td>
</tr>
<tr>
<td>Skin Types (n)</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>IV</td>
</tr>
<tr>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>VI</td>
</tr>
</tbody>
</table>

*Face= forehead; glabella; upper lid; lower lid; crow’s feet; Naso-labial fold; mentolabial fold; smokers-line

**Table 2: Percentage of patient improvement (color scale) by treatment area, 3 months post treatment.**

<table>
<thead>
<tr>
<th>Area/Area</th>
<th>Forehead</th>
<th>Nose</th>
<th>Neck</th>
<th>Upper-lid</th>
<th>Lower-lid</th>
<th>Cheek*</th>
<th>Crowsfeet</th>
<th>Nasolabial</th>
<th>Mentolabial</th>
<th>Jaw*</th>
<th>Arms*</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10</td>
<td>20</td>
<td>35</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>20</td>
<td>20</td>
<td>22</td>
<td>18</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>II</td>
<td>10</td>
<td>16</td>
<td>30</td>
<td>14</td>
<td>26</td>
<td>23</td>
<td>23</td>
<td>14</td>
<td>20</td>
<td>18</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>III</td>
<td>10</td>
<td>16</td>
<td>26</td>
<td>14</td>
<td>12</td>
<td>20</td>
<td>20</td>
<td>14</td>
<td>12</td>
<td>18</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>IV</td>
<td>10</td>
<td>16</td>
<td>22</td>
<td>14</td>
<td>12</td>
<td>18</td>
<td>20</td>
<td>14</td>
<td>12</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>V</td>
<td>10</td>
<td>16</td>
<td>22</td>
<td>14</td>
<td>12</td>
<td>18</td>
<td>20</td>
<td>14</td>
<td>12</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

---

Post-treatment care included only sun protection lotion. Patients were followed up 1 week, 3 and 6 months (on-going) after the last treatment. High resolution photography (Sony DSC T500; Japan) was taken before and 1 week after the last treatment. No adverse side effects or down-time for any of the patients was documented.

---

**PROTOCOL**

Face & neck protocol: The laser tip was kept in contact with the patient’s skin throughout the procedure. The treatment was done on dry skin without any conductive medium between the laser and the skin. Three treatments were done every week on the entire face & neck for three consecutive weeks at the following settings: week 1 – 600mJ/P at 10Hz; week 2 – 700mJ/P at 10Hz; week 3 – 800mJ/P at 10Hz. Pause: One pass was done on the entire face; 2 passes for target areas. Average pulses per face were about 350 pulses. No viable clinical end points were noticeable on the skin except slight skin warmth sensation upon palpation.

No preoperative preparation was required. Prior to treatment, the skin was cleansed and any makeup was removed. No topical anesthesia or other analgesic means were used in any patients.
CONCLUSION

The clinical findings suggest that the Pixel QSW 1,064-nm Nd:YAG laser is a safe and effective non-ablative instrument for all skin types for the purpose of improving photo-aging skin imperfections. Furthermore, this procedure requires no preoperative or post-operative care and is painless. The noticeable improvement is believed to be consistent with collagen structural changes related to wound healing such as collagenase, type I collagen, and platelet derived growth factor with the end result of dermal remodeling.

REFERENCES