Fractional Ablative Skin Resurfacing with the Pixel Laser

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ABSTRACT

The growing market for cosmetic procedures demands safe and effective treatment modalities with little or no downtime. Traditional laser procedures provoke epidermal injury (ablative) and non-specific dermal bulk heating, (non-ablative). Fractional ablative photothermolysis procedures target microscopic segments of the skin, leaving uninjured surrounding skin to facilitate rapid wound healing. The HarmonyPixel laser device and Pixel® 2940nm module (Alma Lasers Ltd., Caesarea, Israel) for fractional ablative skin resurfacing uses micro-lens technology to produce matrices of tiny wounds with varying penetration depths. The procedure is easy to perform and may be used in combination with other modalities. Downtime is minimal and adverse effects are mild.

INTRODUCTION

Advances in laser technology have fueled the growth of cosmetic procedures for the past six years. Modern laser devices offer more wavelengths, greater precision and specificity, and a lower risk of complications than ever before. Clinical experience and new applications of laser physics have also increased our knowledge of laser-tissue interaction.

Many ablative and non-ablative lasers are available. Users of ablative lasers can treat broad areas of skin but the risk for complications is high and recovery time can be long. With the CO_2 and Er:YAG lasers, a single pass of pulsed energy vaporizes a thin layer of skin and leaves a layer of coagulated cells. When healing is complete, the skin is smoother and tighter due to shrinkage of dermal collagen. These lasers have been considered the gold standard for ablative skin resurfacing.

Non-ablative lasers also improve the appearance of skin, but without epidermal damage. The 1320nm Nd:YAG laser and 1450nm semiconductor diode laser improve facial rhytids by gentle dermal heating via non-specific absorption in water. These lasers use cryogen spray cooling to minimize epidermal damage during treatment.[1] Efficacy is due to relatively weak absorption by water and the deeper penetration of the longer-wavelength light, while reduction in severity and duration of adverse effects is due to epidermal cooling.[2]

Although designed to take advantage of selective photothermolysis (SP), pulsed near-infrared lasers for non-ablative skin remodeling do heat a large volume of dermis. Efficacy relies on selective absorption of light by pigmented target structures. Therapeutic response depends on wavelength, fluence, and pulse duration. However, the high power required and large spot size may produce unwanted bulk heating.

Despite these technological advances, aesthetic physicians and patients want still greater efficacy, fewer treatments, and less downtime. Since non-ablative techniques (including pulsed light) offer less downtime, they are often the first choice for skin rejuvenation. However, a laser-based modality with the efficacy of ablative therapies and safety of non-ablative techniques would be well received by the aesthetic community.[3-5] A minimally ablative technology, fractional photothermolysis (FPT),[6-9] offers a new choice. The efficacy and safety of various ablative, non-ablative, and minimally ablative lasers are compared in Figure 1. Potential adverse effects of procedures with these lasers are compared in Table 1.

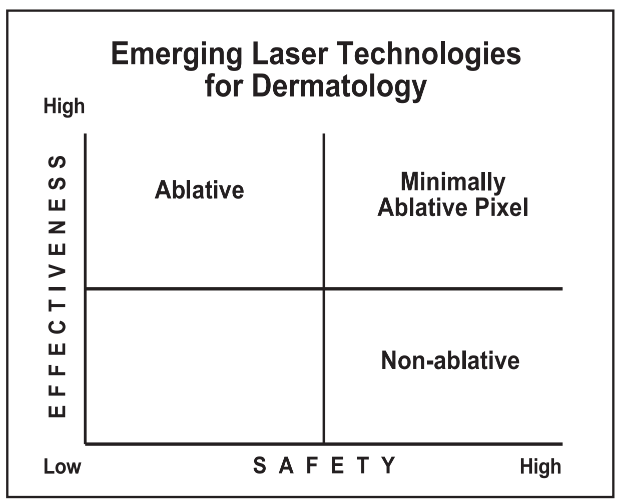


Fig. 1. Comparison of effectiveness and safety of ablative, non-ablative, and minimally ablative lasers.

– = *None* + = *Mild* ++ = *Moderate* +++ = *Severe*	Ablative	Minimally Ablative	Non-ablative
Wound severity	++	+	–
Downtime	+++	–	–
Redness	+++	+/–	–
Edema	++	–	+/–
Wound care	+++	+/–	–
Scarring	++	–	–
Dyspigmentation	++	+/–	+/–

Table 1. Potential adverse effects and downtime of ablative, minimally ablative, and non-ablative laser/light treatments

FRACTIONAL PHOTOTHERMOLYSIS vrs. SELECTIVE PHOTOTHERMOLYSIS

Although minimally ablative procedures are truly ablative, downtime and the risk of complications are greatly reduced compared to traditional ablative procedures. The Pixel® 2940nm Module of the Harmony platform and the dedicated HarmonyPixel system (Alma Lasers Ltd., Caesarea, Israel) offer minimally ablative treatment by combining fractional and Erbium YAG technologies.

To understand how the Pixel 2940nm technology works, consider first how conventional lasers work. Both ablative and non-ablative lasers are designed to heat target tissues by selective photothermolysis (SP), a concept introduced in 1983.[10] In SP, only wavelengths of light that are more strongly absorbed by the target than by the surrounding tissue are used, thus increasing selectivity. If light is delivered in a continuous beam, it would eventually diffuse to the cooler surrounding tissue and cause damage. To prevent this, light is delivered in pulses instead of continuously. By this, energy is delivered to the target in less time than is required for the heat to diffuse to the surrounding tissue. As a result, the pulsed energy is absorbed by the target before it has time to diffuse to the surrounding tissue.

In fractional photothermolysis (FPT), heat is imparted to the tissue in columns rather than in layers. These columns will be referred to as pixels, similar to the millions of tiny squares of a digital photograph. Each pixel is produced by focusing the laser beam to achieve localized heating in the tissue. Average irradiance is kept low to avoid bulk heating. During treatment, a pattern of tiny thermal wounds is created without damaging the tissue surrounding each wound. The uninjured tissue acts as a reservoir to accelerate wound healing. This healing is more rapid due to the short migration path for new viable epidermal stem cells and transient amplifying (TA) cell populations.

The therapeutic response to FPT depends on the shape, depth, and pattern of the pixel footprint and on the number of passes.

The thermal responses to treatment with the Pixel 2940nm Module for the Harmony platform are shown in Figure 2. The regular Er:YAG 2940nm laser technology of the Harmony platform ablates the entire surface area, whereas the Pixel 2940nm laser causes fractional tissue vaporization on the treated area. By sparing healthy tissue in this way, wound healing is accelerated. As the size of the injury decreases, wound healing time decreases.[8]

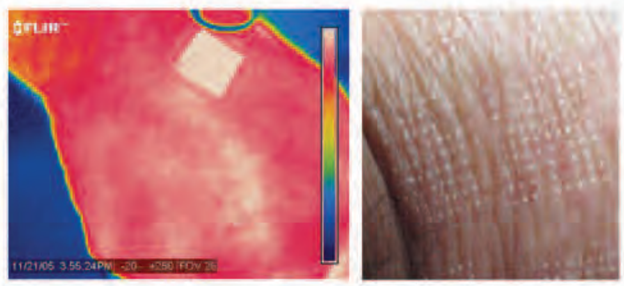


Fig. 2. Tissue thermal response (left) and actual skin response with the Pixel 2940nm technology (right).

PIXEL TECHNOLOGY

The Pixel 2940nm technology is designed to produce a matrix of tiny wounds surrounded by undamaged skin. Before reaching the skin, the Pixel beam passes through a micro-lens that divides the beam into microbeams arranged in either a 7 x 7 or 9 x 9 pattern. The microbeams penetrate the skin and create microscopic injured zones (pixels) in either a 7 x 7 or 9 x 9-dot matrix (Figure 3). The 7 x 7 matrix has 49 pixels and the 9 x 9 matrix has 81 pixels. If the amount of energy is constant, a beam divided into 49 microbeams has more energy per microbeam than the same beam divided into 81 microbeams. For example, a 49-dot microbeam delivers 28 mJ/pixel for deeper penetration, whereas a 81-dot microbeam delivers 17 mJ/pixel for shallower penetration. Each pixel within a matrix is approximately 50μ in diameter. When applied to the skin, these pixels encourage the growth of new cells and stimulate epidermal re-epithelialization to accelerate wound healing.

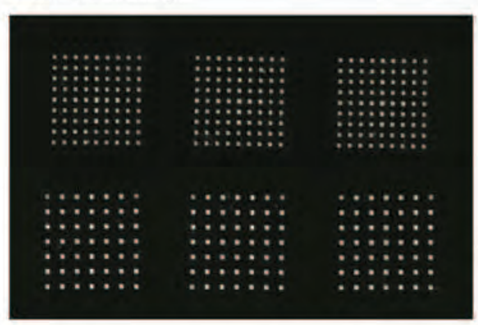


Fig. 3. 9 x 9 (above) and 7 x 7 (below) Pixel matrixes.

Damage to surrounding tissue during FPT treatment depends on the number of stacked passes, matrix size, and amount of energy used. A double- or triple-stacked pulse produces high energy density which penetrates >50 to 150μ into skin. The depth of penetration depends on the number of stacked passes (50μ per stack, up to 3 stacks). The characteristic Pixel footprint demonstrates treated and non-treated areas. If several (up to three) pulses from the Pixel handpiece (Figure 4b) are stacked, then the penetration depth is greater and the clinical efficacy is also greater without appreciable collateral thermal damage.

a. *b.*

Fig. 4. (a) Spot size (11 x 11) of the Pixel 2940nm handpiece (b) Pixel 2940nm handpiece

CLINICAL EXPERIENCE

The Pixel 2940nm laser device is designed for fractional ablative skin resurfacing of the face, neck, chest, and hands with short healing time (5-7 days). In the author's experience, post-treatment redness resolves within two to four hours. The post-treatment course resembles that of a mild sunburn that persists two to four days. Slight flaking occurs within four to six days. Most patients continue with their daily life on the same day since there is no appreciable downtime with this procedure.

The author has obtained optimal results with multiple treatment sessions spaced approximately two weeks apart. The first session consists of a single pass with the 9 x 9 matrix. Small white pixel marks will be visible on the skin as treatment progresses; the end point should be erythema. Erythema should be clearly visible after 3 passes. Additional passes depend on immediate skin response. In subsequent sessions, the author uses the 7 x 7 matrix and titrates the number of passes by observing skin response. Treatment intervals vary from 1 to 4 weeks, depending on the patient's skin response and healing time. No anesthesia or gel is used and "bronzing" or "tattooing" have not been observed. The Pixel application has been easy for clinical staff to learn and use. Initial clinical studies conducted by the manufacturer suggest that immediate and progressive results are obtained in three sessions spaced 7 to 14 days apart. Clinical photos are shown in Figures 6 and 7.

COMBINATION THERAPY

The Pixel 2940nm Module may be used with other non-invasive modules of the Harmony platform (Figure 5) - the 780-950nm ST Module, the 540-950nm AFT VP Module, and the 570-950nm AFT SR Module - thus increasing the clinical efficacy and cost effectiveness of the Harmony platform to rejuvenate skin. The Pixel application may also be combined with pulsed light and skin-tightening systems physicians already may use, injectable dermal fillers, and minimally invasive surgical procedures such as loop lifts, string lifts, and surgical wire scalpels.

CONCLUSION

The Pixel 2940nm laser device is a safe and effective modality for minimally ablative fractional skin resurfacing. Initial reports from physicians worldwide indicate that the Pixel 2940nm Module and the dedicated HarmonyPixel system may also be used for the treatment of rhytids, skin laxity, scars (including acne), and other skin irregularities such as melasma. The system is particularly well suited to photorejuvenation of the face, neck, chest, and hands — areas difficult to treat with non-invasive procedures and hazardous to treat with invasive procedures. The Pixel procedure is quick, relatively painless, and well tolerated, and may be combined with other therapies with minimal additional treatment time for the clinical staff.

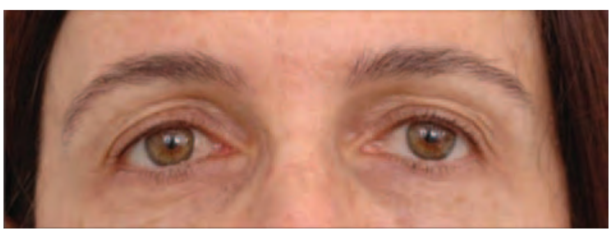
Fig. 5. Harmony, multi-application, multi-technology platform with 11 separate modules

CLINICAL EVIDENCE

a. b.

Fig. 6. Before (a) and one week after (b) a single treatment with the Pixel 2940-nm Er:YAG laser; 3 passes at 1100 mJ/pulse; long pulse at 5 Hz.
Photographs courtesy of John Hamel, MD, Complete Laser Clinic, NC, USA.

a.



b.

Fig. 7. Before (a) and 15 days after (b) a single treatment with the Pixel 2940-nm Er:YAG module. Three passes were made at 600 mJ/pulse.
Photographs courtesy of Guilherme Olsen de Almeida, MD, Hospital Sirio-Libanes, São Paulo, Brazil.

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