Alteration of Argon Laser-Induced Scars by the Pulsed Dye Laser

Tina S. Alster, MD, Amal K. Kurban, MD, Gary L. Grove, PhD, Mary J. Grove, MD, and Oon Tian Tan, MD

Washington Institute of Dermatologic Laser Surgery and Georgetown University, Washington, DC 20037 (T.S.A.); University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania 19104 (G.L.G., M.J.G.); The Laser Center at Boston University Medical Center (A.K.K.) and The Laser Research Laboratory at Boston City Hospital, Boston, Massachusetts 02118 (O.T.T.)

Ten patients with portwine stains (PWS) with test sites previously exposed to an argon laser were evaluated and subsequently treated with five pulsed dye (585 nm) laser treatments over a 10 month period. Clinical assessments, skin surface texture analyses using optical profilometry, and light microscopic histological evaluations were performed prior to commencement and at the end of the study in all ten patients. A change in the skin texture with return of skin markings approximating those of normal skin measured by optical profilometry was observed in the argon treated PWS skin following pulsed dye laser treatments.

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Key words: portwine stains, optical profilometry, skin surface texture, scars

INTRODUCTION

Portwine stains (PWS) are congenital vascular lesions which are present at birth, can involve any area of the skin, but are most often located on the face [1]. These birthmarks are comprised of ectatic blood vessels lined by a single layer of non-proliferating endothelial cells. Portwine stain vessels characteristically enlarge commensurately with the growth of the affected individual, and unlike hemangiomas, never spontaneously involute. Thus, PWS tend to darken in color with maturation of the individual, a change often accompanied by hypertrophy of the affected area.

Many treatment modalities have been used to treat these birthmarks [2–14]. The continuous wave argon laser at 488/514 nm was the first laser used to specifically treat large numbers of patients with PWS. “Good to excellent” results have been reported as responses to argon laser treatment of PWS [3–9]. In spite of such good results, unacceptable complications were reported following argon treatment [7,8]. Adverse effects, including scar formation accompanied by hyper- and/or hypopigmentation, were reported to be especially severe in the pediatric population [7]. Such complications have not been encountered by the pulsed tunable dye laser (577/585 nm) at a pulse duration of 360 μsec [9–14].

In none of these studies was it possible to quantify the extent of injury induced in the laser exposed sites because of the lack of an objective method of measuring the skin surface texture. All changes in response to laser treatment were assessed clinically and by photographic documentation alone. Although the latter is universally used to document response to treatment, it is well recognized that it is almost impossible to reproduce exactly equivalent sequential photographs spaced over time even when equipment, lighting, and operator remain constant. This difficulty is compounded when the response or change relies upon skin surface textural changes as well as small degrees of change of color. The exact role of skin texture, in addition to color, is difficult to quantify in the overall clinical assessment of a lesion or the response of such a lesion to treatment, but experience suggests that it is significant.

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TABLE 1. PWS/Argon Scar Study Subjects

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>PWS location</th>
<th>Duration since argon Rx (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>24</td>
<td>Cheek</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>50</td>
<td>Cheek</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>20</td>
<td>Cheek</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>31</td>
<td>Temple</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>31</td>
<td>Neck</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>26</td>
<td>Nose</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>33</td>
<td>Neck</td>
<td>120</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>34</td>
<td>Thigh</td>
<td>120</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>16</td>
<td>Cheek</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>27</td>
<td>Chest</td>
<td>60</td>
</tr>
</tbody>
</table>

This study aimed to examine whether the pulsed dye laser could modify the results of PWS previously treated by the argon laser by using optical profilometry to measure changes in skin texture and comparing these results to histological and clinical examinations.

MATERIALS AND METHODS

Ten healthy, consenting adult PWS subjects who had previously had test sites exposed to the argon laser were included in the study. All 10 subjects (8 females and 2 males) between the ages of 16 and 50 years were skin type I/II subjects. Each subject had received one argon laser test site to a part of their PWS sometime between 15 to 120 months prior to presentation for dye laser treatment of their birthmark. The locations of their PWS are listed in Table 1.

Clinical evaluation, photographic documentation silicone rubber impressions (Syringe Elasticon, Healthco Internatl, Westborough, MA), and 3 mm skin punch biopsies were obtained from each subject from the argon treated site as well as from the adjacent untreated portwine stain prior to, and then following, five treatments using the pulsed dye laser. No local or topical anesthesia was utilized during the laser treatments, thereby eliminating any potential skin surface textural changes caused by external factors. No silicone rubber impressions were obtained from normal unaffected skin due to the fact that the normal surrounding skin was not of the same demographic unit as the area under study. In summary, a total of four surface impressions and four biopsies were obtained from each subject.

The rubber skin surface impressions were analyzed using the Magiscan Digital Image Processing system [15] incorporated with a computer program entitled “Optical Profilometry” which was originally developed by the National Aeronautics and Space Administration (NASA) to map the lunar surface [16]. The program processes digital images of skin surface replicas and provides a suitable methodology for objective quantification of facial lines and wrinkles with a significant degree of correlation with clinical grading [17]. The parameters available for assessing skin surface topography, Rz and Ra, were measured from each skin surface impression. Ra was the deviation measured above and below an average line running through the profile. Rz was computed as the average of minimal and maximal differences in 5 equal segments along the profile’s x-axis, and was recognized as the best single measure describing textural differences.

Three millimeter diameter punch biopsies were obtained from argon laser irradiated and untreated PWS skin following infiltration of the skin with 1% lidocaine without epinephrine. The specimens were processed and stained with hematoxylin and eosin for light microscopy. The biopsy specimens were evaluated for 1) the size and number of blood vessels present, 2) presence of pigmentary incontinence in the dermis, 3) presence or absence of dermal appendages, and 4) presence of dermal fibrosis and scar formation.

The entire PWS lesion in each subject was exposed to the SPTL-1 Candela flashlamp pumped dye laser (Candela Laser Corp., Wayland, MA) at a wavelength of 585 nm, a pulse duration of 360 μsec and a fluence of between 6.0 and 7.0 J/cm² every 7–8 weeks. Each subject received a total of 5 treatments to the entire portwine stain during the study period of 10 months.

Skin surface impressions and biopsies were then obtained in an equivalent manner as described above. The skin surface measures, Ra and Rz, for each of the four tested conditions were then compared using a one-tailed t-test for significance.

RESULTS

Clinical Assessment

In all patients studied, there was an improvement in the clinical appearance of the argon scars with successive pulsed dye laser treatments. The improvement was manifested either as flattening of the hypertrophic portions of the scars and/or the reappearance of skin surface markings in the atrophic areas.
Skin Surface Analysis

Optical profilometry of the skin surface impressions was measured from the molds taken of normal untreated PWS skin, PWS treated with the argon laser, argon laser treated PWS subsequently treated with the dye laser, and PWS treated with the dye laser alone. Lower Rz values reflect less skin surface markings (less deviation between minimal and maximum measurements), whereas higher Rz values indicate more skin surface markings (increased difference between minimal and maximum measurements). The values are a measurement of the fine skin surface texture markings, rather than of obvious ridges and indentations. Comparisons of Rz values of normal, untreated PWS skin with argon laser treated PWS skin revealed that fewer skin markings were present in the argon laser exposed site \( (P = 0.0008) \) (Fig. 1). Measures taken from argon treated PWS which were exposed to five pulsed dye laser treatments documented that treatment with the dye laser can improve and bring the skin texture back towards that of normal PWS \( (P = 0.0039) \) (Fig. 2). Lastly, comparison of dye laser treated with normal PWS skin texture demonstrated that no scarring was present in skin exposed to this laser \( (P = 0.19) \) (Fig. 3).

Histology

Large dilated vascular channels in the upper dermis were observed in 9 of the 10 biopsy specimens taken from the non-argon-treated PWS prior to the pulsed dye laser treatment. In one patient, the number of vascular channels was increased but not unduly dilated. No other abnormalities were noted. The dilated vascular channels were cleared following five pulsed dye laser treatments in 8 of 10 patients, but remained unaltered in two.

Scarring, as evidenced by the presence of thick hyalized collagen in the papillary and reticular dermis and by the absence or marked diminution of dermal appendages, was seen in 8 of the 10 specimens taken from PWS areas previously treated with the argon laser taken at the initiation of the study (Fig. 4). Scattered within the scars were dilated vascular channels. Pigmentary incontinence was also seen in five of the ten patients examined. Following 5 pulsed dye laser treatments, the residual dilated vascular channels cleared and the dermal vessels replacing the abnormal vessels appeared to be within normal limits in size and number (Fig. 5).
DISCUSSION

In the past, evaluation of skin texture and color had been limited to clinical assessment, photography, and histopathologic analysis. Although useful, some of these tools have been criticized on the grounds of subjectivity when used to assess adverse effects such as scar formation. The addition of optical profilometry for analysis of skin surface replicas provides a more objective means for assessing skin topography or degree of dermal scarring.

Since the surface of a scar typically has fewer skin surface markings, the Ra and Rz values will be lower when they are computed over a scar as compared to non-scarred normal skin. This was indeed the case in all of the patients studied; the argon scars recording lower Ra and Rz values than the adjacent PWS areas, both before and after pulsed dye laser treatments. However, following five dye laser treatments the argon induced scars demonstrated an increase in the Ra and Rz values to levels closer to those of non-argon treated PWS skin.

The increase in the Ra and Rz parameters indicating an increase in skin markings correlated with the improvement of the clinical assessment of the scar. These changes were also accompanied by a less hypertrophic appearance of the scars themselves. While the explanation for such a phenomenon is not clear, it seems reasonable to assume that part of the flattening which was observed within the hypertrophic areas of the scars resulted from the eradication by the pulsed dye laser treatment of the residual enlarged blood vessels trapped in the sclerotic collagen.

Light microscopic examination of argon laser irradiated sites confirmed earlier reports that damage which is induced by the laser repairs by producing dermal collagen fibrosis [18,19]. Of in-
interest was the finding that residual dilated vascular channels were observed in the argon laser treated PWS, which accounted for the persistent red color seen in these treated birthmarks. However, these ectatic blood vessels decreased in size and number following the subsequent pulsed dye laser treatment.

Independent of the detailed assessment of the scar texture, the overall clinical appearance of the portwine stains also improved with successive pulsed dye laser treatments as evidenced by color lightening. However, such subjective color changes were not the focus of this study. The fact that there was incomplete clearance of the PWS in this study group relates to the total number of laser treatments delivered to each subject. It has previously been reported that at least 7 laser treatments are required for complete lesion lightening in children <7 years old with PWS [14]. Because all the PWS in this study were in subjects >16 years, it would be reasonable to extrapolate that at least 7 treatments would have been required to produce significant lightening of their PWS. Based upon this, it is likely that further laser treatments (greater than 5) would continue to significantly lighten the PWS and perhaps even lead to total clearance in some instances.

CONCLUSIONS

This study emphasizes several aspects of laser treatment of vascular lesions. Firstly, that the pulsed dye laser, while producing excellent lightening of the PWS, does not alter skin texture of the laser exposed site in the treatment of PWS.

Secondly, because of the specificity of the laser damage induced and the penetration depth of the 577/585 nm pulsed dye laser beam, PWS vessels lying beyond the argon induced dermal fibrosis can be eradicated by this laser.

Thirdly, not only can the residual PWS vessels in the argon sites be removed using the dye laser, but this treatment appears to “improve” the surface texture of the skin previously scarred by the argon laser. Following a number of pulsed dye laser treatments, the skin surface markings within the argon laser induced scars approximated those values of normal PWS skin when measured objectively using optical profilometry.

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