Complete Elimination of Large Café-au-Lait Birthmarks by the 510-nm Pulsed Dye Laser

Tina S. Alster, M.D.
Washington, D.C.

Traditional treatment modalities for café-au-lait spots include cryotherapy, dermabrasion, and excision with or without skin grafting. These treatments have shown varying degrees of success and, in some cases, have yielded significant side effects, such as permanent pigmented alteration and scarring. The 510-nm pulsed dye laser has been shown to selectively destroy melaninomes that make up such epidermal pigmented lesions as café-au-lait spots without significant adverse sequelae.

Thirty patients with 34 large café-au-lait birthmarks received 510-nm pulsed dye laser treatments at 6- to 8-week intervals with energy densities ranging from 2.0 to 4.0 J/cm². An average of 8.4 laser treatments were necessary to achieve complete elimination of the café-au-lait marks under study. No lesional recurrences have been observed 1 year following termination of treatment. (Plast. Reconstr. Surg. 96: 1660, 1995.)

An estimated 10 to 20 percent of the population is affected by café-au-lait spots. Fortunately, most of these lesions are small and, therefore, are of little significance to the affected individual. Large lesions, on the other hand, commonly are presented to the plastic surgeon for removal because of obvious disfigurement.

Given the cosmetic nature of these lesions, it is important not only that the treatment be effective but also that it be as free of adverse sequelae as possible. Treatment, therefore, should be highly selective for the epidermal pigmented cells that make up the lesions without indiscriminate destruction of the normal surrounding skin. This selectivity has been achieved for a variety of targets in the skin through laser surgery.

While there have been previous attempts to remove café-au-lait spots using several different laser systems, including the argon (488 and 514 nm), Nd:YAG (532 and 1064 nm), ruby (694 nm), and pulsed dye (510 nm) lasers, prior reports have been limited by the small number and size of lesions studied, as well as by incomplete removal of lesions. In addition, undesirable side effects, such as scarring with the argon laser, hyperpigmentation with the Nd:YAG laser, and hypopigmentation with the ruby laser, have been observed. Occasional lesional recurrences (usually within 1 year) have been reported following treatment with each of these laser systems.

This study was designed to follow a large series of patients with extensive café-au-lait birthmarks through 510-nm pulsed dye laser treatment until total eradication of the lesions had been achieved in order to determine the actual number of laser sessions necessary to obtain lesional clearance and to determine the incidence of side effects or recurrences with long-term follow-up.

PATIENTS AND METHODS

Thirty patients (average age 21 years) with 34 large café-au-lait birthmarks (average area 47 cm²) were entered into the study (Table I). All patients had skin types I and II and had no personal or family history of melanoma.

The café-au-lait lesions were exposed to the 510-nm, 300-ns pulsed dye laser (PLDL, Candela Laser Corporation, Wayland, Mass.) at 6- to 8-week intervals. The laser irradiation of an individual lesion involved covering the entire area with single, nonoverlapping 5-mm laser spots. Laser sessions lasted 5 to 30 minutes depending on the size of the lesion treated. Energy fluences used ranged from 2.0 to 4.0 J/cm², re-

From the Georgetown University Medical Center and the Washington Institute of Dermatologic Laser Surgery. Received for publication August 31, 1994.
<table>
<thead>
<tr>
<th>Lesion Location</th>
<th>No. of Lesions</th>
<th>Age (mean)</th>
<th>Sex (M/F)</th>
<th>Lesion Size, cm²</th>
<th>Prior Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheek</td>
<td>3</td>
<td>0.5-54</td>
<td>1/2</td>
<td>18-120 (50)</td>
<td>1</td>
</tr>
<tr>
<td>Forehead</td>
<td>2</td>
<td>1.5-18</td>
<td>2/2</td>
<td>20-64 (40)</td>
<td>0</td>
</tr>
<tr>
<td>Chin</td>
<td>2</td>
<td>22-27</td>
<td>2/2</td>
<td>29-36 (29)</td>
<td>1</td>
</tr>
<tr>
<td>Neck</td>
<td>2</td>
<td>18-30</td>
<td>2/2</td>
<td>16-48 (32)</td>
<td>0</td>
</tr>
<tr>
<td>Chest</td>
<td>5</td>
<td>11-35</td>
<td>2/2</td>
<td>16-168 (73)</td>
<td>0</td>
</tr>
<tr>
<td>Back</td>
<td>1</td>
<td>85</td>
<td>1/0</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Arm</td>
<td>1</td>
<td>39</td>
<td>0/1</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Leg</td>
<td>4</td>
<td>21-42</td>
<td>2/4</td>
<td>16-50 (35)</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>34</td>
<td>0.5-54</td>
<td>12/22</td>
<td>16-168 (47)</td>
<td>2</td>
</tr>
</tbody>
</table>

**TABLE I**

**Study Population**

resulting in a light-gray or ash-white discoloration of the irradiated site, thereby indicating the desired threshold response. Subsequent treatment fluences were adjusted according to individual clinical response.

Photographs were obtained and assessments of lesional color and/or textural changes made at each visit. No general or intralosomal anesthesia was used; however, topical 30% lidocaine cream was used under occlusion for 30 minutes in patients under 14 years of age to reduce the snapping sensation experienced with each laser impact. Laser treatments were continued every 6 to 8 weeks until the lesional skin color was indistinguishable from that of the normal surrounding skin (Figs. 1 through 4).

Patients were instructed to apply antibiotic ointment daily and to avoid cosmetic application to the laser-treated sites for 1 week following each treatment. Contact sports were prohibited during the 1-week healing phase. Avoidance of ultraviolet light and regular sunscreen use were advised between treatment sessions.

**RESULTS**

The café-au-lait birthmarks required an average of 8.4 (range 4 to 14) laser treatments at an average fluence of 2.71 J/cm² for total clearance (Table I). All patients were able to return immediately to their usual work or school activities. Side effects were minimal, with transient hyperpigmentation lasting an average of 8 weeks seen in 5 patients. Continued laser treatment of these patients was suspended until the transient postinflammatory hyperpigmentation resolved spontaneously. No hypopigmentation, textural changes, or scarring was seen in laser-irradiated skin. In addition, no lesional recurrences were observed 1 year following the final laser treatment.

**DISCUSSION**

The concept of producing specific, thermally mediated injury to a particular target in the skin, such as pigment-containing cells, using brief and selectively absorbed laser pulses is termed selective photothermolysis—a theory first described by Anderson and Parrish in the early 1980s. In general, melanosomal alter-
Fig. 2. A 15-year-old boy with a café-au-lait birthmark (above) showing 50 percent lightening after a single 510-nm laser treatment at 2.5 J/cm² (center). An additional five laser treatments achieved complete clearance (below).

Infections have been shown to be qualitatively similar at a wide range of wavelengths but differ in threshold dose and depth of penetration into the dermis. Shorter wavelengths of light require less energy to damage the epidermal pigment cell, while longer wavelengths are capable of deeper (dermal) penetration.

Sherwood et al. identified 504 nm as the wavelength producing the most specific injury to pigment-containing cells in the epidermis with the fewest side effects when compared with several longer wavelengths. The specificity of injury to pigmented cells was found to be further enhanced by using a pulse duration that corresponded to the 1-μs thermal relaxation time of the targeted melanosomes. Pigment cells are selectively destroyed presumably as a result of either extreme temperature gradients created within melanosomes or from shockwave/cavitation damage that results from rapid thermal expansion.

This study demonstrates the effective removal of extensive café-au-lait birthmarks by the 510-nm pulsed dye laser. The average number of laser treatments required for lesional clearance in this study, however, was greater than that reported previously. A possible explanation for this could be the extensive nature of the lesions included, with the obvious increased pigment cell population conceivably slowing down the rate of pigment clearance by macrophages. In addition, prior studies did not always treat café-au-lait spots in their entirety, thereby implying that fewer laser sessions were necessary to achieve complete lesional lightening.
The absence of lesional recurrences within the first year following treatment was indeed encouraging. Perhaps it was the complete removal of pigment marking this study’s endpoint that permitted little, if any, pigment proliferation and, therefore, eliminated the risk of recurrence.

Fortunately, the hyperpigmentation observed in 15 percent of the lesions was transient in nature. It has been reported by others, however, to persist for years following laser irradiation. Prolonged hyperpigmentation may be due to the use of suprathreshold energy fluences causing basement membrane disruption, pigmentary incontinence, and engulfment of pigment by macrophages, leading to overlying skin pigmentation. In contrast, subthreshold energy fluences also have been shown to result in pigment stimulation. By localizing the injury induced by the laser to the pigmented cells at the dermal-epidermal junction, the likelihood of pigmentary incontinence and, therefore, permanent hyperpigmentation should be reduced. The use of the short 510-nm wavelength in this laser system limited absorption to the epidermis and took advantage of the enhanced absorption of melanin at this wavelength.

The excellent results obtained in this study support the high degree of specificity of the 510-nm laser and the proper determination of energy densities used. The absence of recurrences noted at the 1-year follow-up examination is highly suggestive of permanent lesional eradication.

In conclusion, patients of all ages suffering from disfiguring café-au-lait birthmarks that have been treated traditionally with extensive surgery and reconstruction can now be treated with little risk of adverse sequelae or recurrences by means of the 510-nm pulsed dye laser. The selectivity of this laser for superficial pigmentation was such that no permanent abnormal changes in skin color or texture were observed in the laser-irradiated skin.

**ADDENDUM**

Following completion of this study, four patients with café-au-lait birthmarks presenting for laser treatment did not show the excellent clinical responses reported in this study despite the use of identical treatment parameters as described herein. It is worth noting that the average age of the 4 patients was 38 years, as compared to 21 years in the study. Perhaps the discrepancy in responses seen can be explained by age differences, with pediatric patients showing improvement faster than adults. On that assumption, when the original study data are analyzed separating those patients younger than 18 years of age from adults, the pediatric age group (mean age = 9.8 years) required an average of 8.0 laser treatments for clearance, as compared to 8.9 treatments for the adult age group (mean age = 33.6 years). Given the close response rates, age may not be as important as...
some other unknown factor (i.e., lesion, hormonal influence, or histologic variations). Obviously, more research is needed to explain the differences observed. It remains clear, however, that while the 510 nm pulsed dye laser can effectively treat many café-au-lait birthmarks without adverse sequelae, there remains a subset of patients who do not respond to treatment.

Tina Alster, M.D.
2311 M Street, N.W.
Suite 200
Washington, D.C. 20037

REFERENCES