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Clinical experience with the PLDL-1 (Pigmented Lesion Dye Laser) in the treatment of pigmented birthmarks: a preliminary report

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SUMMARY. **Twenty patients aged between 2 years and 17 years (mean 9 years) with pigmented birthmarks, mainly of the head and neck, were treated with the PLDL-1 laser (Pigmented Lesion Dye Laser—Candela Corporation, Wayland, Massachusetts, USA) which emits light with a wavelength of 510 nanometers and a pulse duration of 300 ± 50 nano-seconds.**

Nine patients (45%) showed excellent results after a test-patch was performed. Two patients (10%) showed some lightening of colour after initial test-patch. Six patients (30%) showed no improvement and 3 patients (15%) showed some hyperpigmentation at the test-patch sites which had not disappeared at 6 months follow-up.

There was no change in the clinical behaviour at 6 months follow-up and no evidence of scarring was encountered.

The first laser beam was generated by Maiman in 1960 using a ruby rod and a flashlamp.[1] Since then several different types of lasers have been developed to treat a variety of surgical and medical conditions. At the last count nine different types of lasers had been or are being used on the skin. DOPA-Melanin in melanosomes absorbs laser light at wavelengths greater than 350 nm.[2] This absorption spectrum superimposed on that of oxy-haemoglobin is shown in Figure 1. The argon laser (514 nm) and the ruby laser (694 nm) have been used to treat brown birthmarks,[3–5] with varying degrees of success. The picture is, however, changing all the time and a newer pigmented laser has been introduced, namely the PLDL-1 (Pigmented Lesion Dye Laser—Candela Corporation, Wayland, Massachusetts, USA).

We had use of such a laser for a period of 6 months and recount our clinical experience.

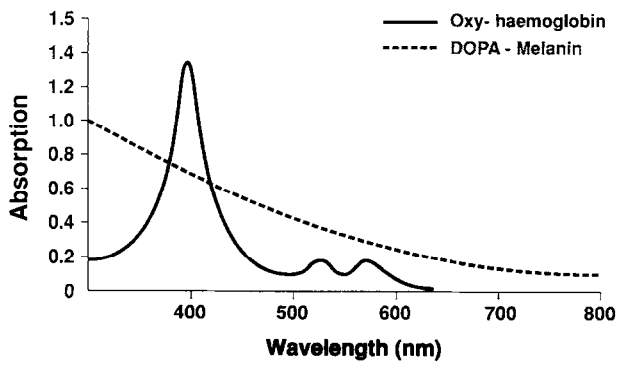

Fig. 1

Figure 1—Laser light absorption spectrum of Oxy-haemoglobin and DOPA-Melanin plotted against wavelength.

Patients and Methods

The PLDL-1 (Pigmented Lesion Dye Laser, Candela Corporation, Wayland, Massachusetts, USA) laser is a flashlamp excited, air-cooled dye laser that delivers a monochromatic green wavelength (510 nanometer) with a pulse duration of 300 ± 50 nanoseconds. The pulses are delivered through a handpiece with a 5 mm spot size. Energy density (fluence) available for the 5 mm spot size is between 2.0 and 4.0 Joules/cm^2 in increments of 0.25 Joules/cm^2.

Twenty patients with pigmented birthmarks referred to the South-East of Scotland Plastic Surgery and Laser Unit were counselled about the possibilities of laser therapy. Two or three test areas were then exposed to laser light at energy densities of 2.0 and 2.5 Joules/cm^2 (the results of which are summarised in Table 1). Documentation was by colour photography before and immediately after exposure to laser light, at 1 week, at 6 weeks and at 6 months follow-up.

Thirteen female and 7 male patients between the ages of 2 and 17 years (mean 9 years) were included. A histological diagnosis was only available on one patient, the rest of the diagnoses were made on clinical grounds. The three types of lesions thus treated were: café-au-lait macules (9 patients), pigmented linear naevi (4 patients) and congenital naevocellular naevi (7 patients).

Anatomically, 12 patients had lesions confined to the head and neck, 5 patients had lesions on the trunk and 3 patients had lesions on the limbs.

The test areas were assessed at 6 weeks and classed as successful if complete clearing of pigmentation had taken place (Fig. 3A). Test areas with less than complete clearance of pigmentation were repeated at this stage using 3.0 and 3.5 Joules/cm^2 and the same procedure followed as after the initial test area. No anaesthetic was required for any of the test areas and

Table 1 Clinical diagnosis and results of test-patches

Age	*Diagnosis*	*Site of lesion*	*Energy density J/cm²*	*Result of test-patch*
17	Café-au-lait macule	Cheek	2.0 and 2.5	Excellent
8	Café-au-lait macule	Forehead	2.0 and 2.5	Excellent
10	Café-au-lait macule	Both arms and back	2.0, 2.5, 3.0 and 3.5	Excellent at 3.5
14	Congenital naevocellular naevus	Chest	2.0 and 2.5	Poor—hyperpigmentation
5	Congenital naevocellular naevus	Forehead	2.0, 2.5, 3.0 and 3.5	Poor—partial clearing that repigmented
14	Congenital naevocellular naevus	Forehead and cheek	2.0, 2.5, 3.0, 3.5 and 4.0	Poor—partial clearing at 4.0
6	Pigmented linear naevus	Soles of feet	2.0, 2.5, 3.0 and 3.5	No effect
5	Pigmented linear naevus	Chin and neck	2.0, 2.5, 3.0 and 3.5	No effect
5	Congenital naevocellular naevus	Temple	2.0, 2.5, 3.0 and 3.5	Poor—initial clearing followed by hyperpigmentation
5	Café-au-lait macule	Both legs	2.0 and 2.5	Excellent
11	Café-au-lait macule	Nose and forehead	2.0, 2.5 and 2.75	Excellent
2	Café-au-lait macule	Neck and chin	2.0 and 2.5	Excellent
3	Café-au-lait macule	Cheek	2.0, 2.5 and 3.5	Excellent
7	Congenital naevocellular naevus	Neck	2.0 and 2.5	No effect
12	Linear pigmented naevus	Arm	2.0, 2.5, 3.0, 3.5 and 4.0	Some flattening, but no lightening of lesion
7	Linear pigmented naevus	Arm	2.0, 2.5, 3.0 and 3.5	No effect
9	Café-au-lait macule	Forehead	2.0, 2.5 and 3.0	Excellent
15	Congenital naevocellular naevus	Forehead	2.0, 2.5, 3.0 and 3.5	No effect
10	Café-au-lait macule	Temple	2.0 and 2.5	Excellent
12	Congenital naevocellular naevus	Neck	2.0, 2.5, 3.0, 3.5 and 4.0	Hyperpigmentation

most patients described the sensation as "like multiple little pin-pricks".

Patients with successful test areas were then treated using local anaesthetic cream applied 1 h prior to treatment. A general anaesthetic was required in two young children.

Clinical results

The clinical behaviour of the treated areas can be divided into three patterns.

In the first group, the treated area became grey-white in colour immediately after exposure to laser light (Fig. 4A). This lasted a few minutes and was then replaced by purpura which lasted anything up to 2 weeks before fading (Fig. 4B). Lesions that behaved in this fashion developed scab formation which dropped off at the end of the two week period revealing normal skin with complete clearing of pigmentation (Fig. 3A). Without exception all the café-au-lait macules behaved in this fashion and could therefore be treated. Treatment was performed at 6-weekly intervals and at each session the entire lesion was covered by laser pulses placed close together without overlap. These then faded, revealing a reticular pattern of untreated pigmentation. Follow-up treatment sessions then concentrated on untreated areas (Fig. 3B). At the time that our trial period with the laser came to an end no lesion had been completely cleared. At the time the number of treatments that had been administered to each patient ranged from 1–3. The average number of pulses per treatment session was 38.

The second clinical reaction noticed occurred almost exclusively in those patients with congenital naevocellular naevi. Exposure to laser light gave rise to immediate "disruption" of the pigmentation within a "punched-out lesion" (Fig. 5). In all cases partial clearing of the pigmentation occurred, but complete clearing could not be achieved despite using the maximum available energy density of 4.0 Joules/cm². At 6 months follow-up all these cases had repigmented and in one instance hyperpigmentation had taken place.

The third behaviour pattern was noticed predominantly in the pigmented linear naevi. These lesions showed little or no clinical change immediately after exposure to laser light and at subsequent follow-up one patient had developed hyperpigmentation which had not settled down at 6 months and the rest demonstrated no clinical change.

Discussion

Considerable clinical experience is often required to diagnose and treat brown birthmarks and a working knowledge of lasers and brown birthmarks is required. We have therefore devised a classification of brown birthmarks based upon the ease with which melanosomes can be targeted by laser light (Table 2 and Fig. 2).

1. Birthmarks due to an increase in the number of naevocytes

The most common example in this group is the congenital naevocellular naevus. It exhibits a great deal of variation as far as colour, hairiness and texture is concerned. The birthmark discolouration is due to melanin pigment both within and outside the naevo-

Table 2 Practical classification of pigmented birthmarks based on ease with which melanosomes can be targeted by laser light

1. *Increased number of naevocytes*
   a) The congenital Naevocellular Naevus
   b) The Mongolian Spot
   c) Naevus of Ota
2. *Increased melanin*
   a) Café-au-lait macule
   b) Naevus Spilus
   c) Becker's Naevus
3. *Normal naevocytes and melanin*
   a) Epidermal Naevus
   b) Sebaceous Naevus

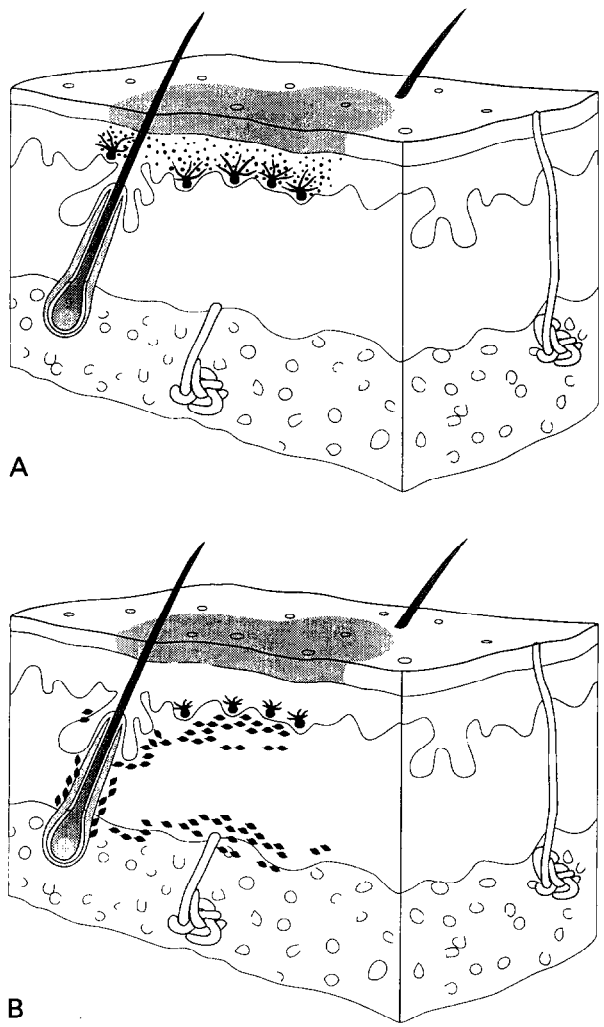

Fig. 2

Figure 2—(A) The superficial melanosomes in café-au-lait macules are well within the reach of the PLDL-1 laser light. (B) The deeper located naevocytes in congenital naevocellular naevi are beyond the reach of the PLDL-1 laser light and are therefore not affected and may in fact repigment the lesion.

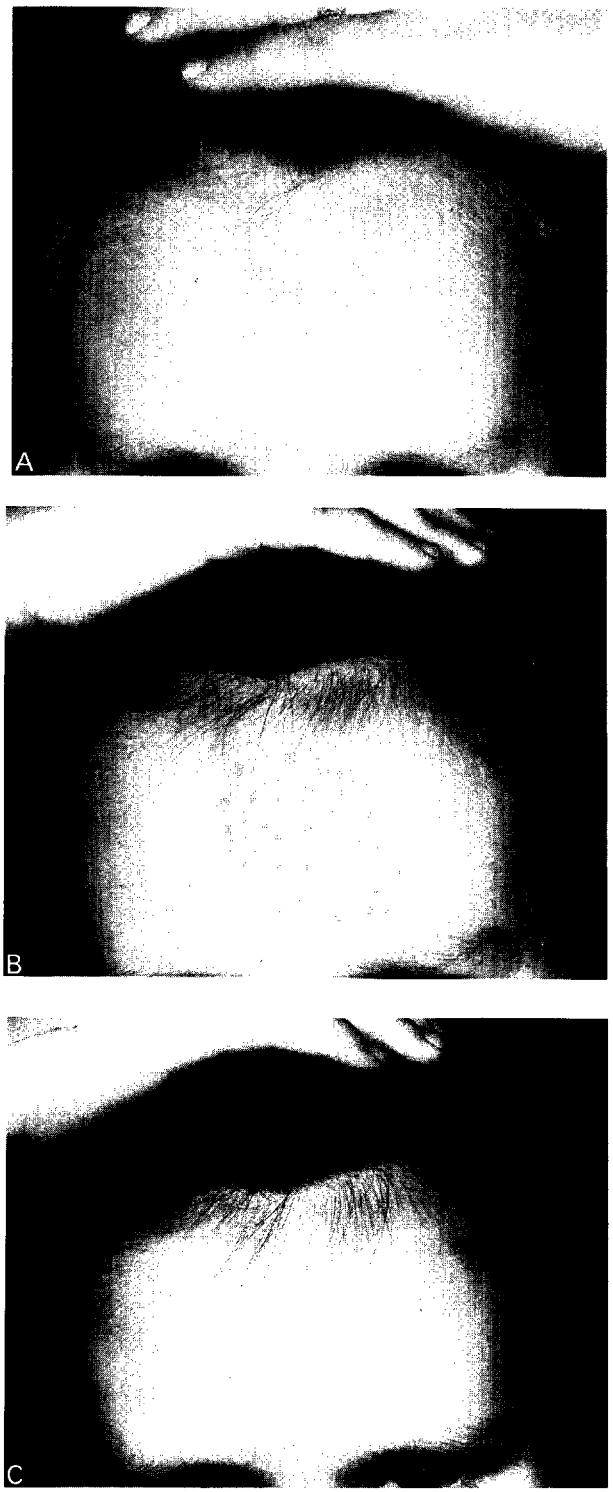

Fig. 3

Figure 3—(A) A successful test-patch in a café-au-lait macule. (B) The bruising seen after a treatment of the same café-au-lait macule. (C) The result after two complete treatment sessions.

cytes in both layers of the dermis and occasionally subcutaneous fat.

The Mongolian spot is due to the presence of naevocytes in the deeper layers of the dermis. It usually disappears during childhood.

The Naevus of Ota typically involves the periorbital area in Oriental patients. It is due to melanocytes in the reticular dermis and around the blood vessels and skin appendages. Its colour is therefore variable with hues ranging from black, blue-black, slate blue to purplish-brown.

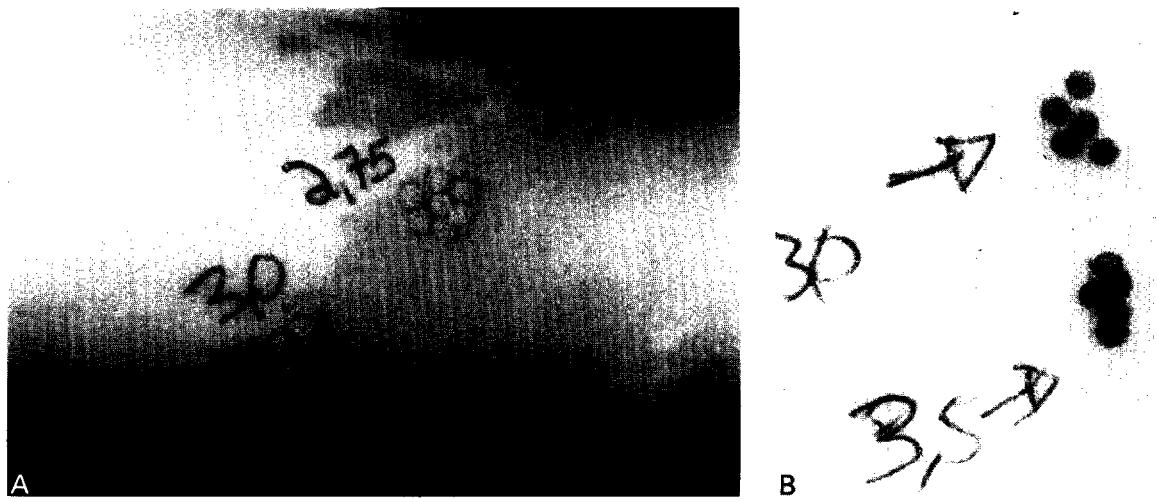

Fig. 4

Figure 4—(A, B) The immediate grey-white response seen in café-au-lait macules after exposure to laser light is replaced after a few minutes by purpura.

2. Birthmarks due to increased melanosomes

The most common lesion in this category is the café-au-lait macule, which may be a marker of systemic disease, for example, neurofibromatosis, but may occur in isolation. The discolouration is due to an increase in the number of melanosomes accompanied by a normal complement of melanocytes. The naevus of Spilus is essentially a café-au-lait mark containing darker macules or papules.

Becker's Naevus is a segmental macular pigmentation first appearing at the end of the first decade of life. Long and darkly pigmented hair may grow in these at puberty, making the lesion appear more conspicuous.

Fig. 5

Figure 5—The "punched out" reaction seen in congenital naevocellular naevi after exposure to laser light at 3.5 and 4.0 joules/cm.

3. Birthmarks with normal naevocytes and melanin

Here epidermal naevi and sebaceous naevi of Jadassohn are included. Epidermal naevi, also called linear naevi, are congenital birthmarks of the epidermis. They appear flat at birth, but become raised, verrucous and acquire a brown colour with age. There is no malignant potential and treatment has been centred on improving the cosmetic appearance.

Sebaceous naevi of Jadassohn are orange-yellow coloured congenital hamartomas of the sebaceous glands and are typically found on the face and scalp. It has been estimated that 10 to 20% of sebaceous naevi may develop basal cell carcinomas and laser therapy may not be appropriate.

The PLDL-1 Laser system works on the principle of selective photothermolysis as first described by Anderson and Parrish[2]. This means that by matching the wavelength and pulse duration to a specific target, in this case melanosomes, the green laser light will be maximally absorbed by the melanosomes and not by the surrounding dermis and epidermis.

The PLDL-1 Laser has a penetrating ability of 0.1–0.2 mm and therefore acts mainly on the superficial melanosomes and has little or no effect on naevocytes which may be deeper. The pigmented lesions most effectively treated were the café-au-lait macules, where discolouration is mainly due to superficial epidermal melanosomes (Fig. 2A).

In the congenital naevocellular naevi the reaction that occurs is not unlike that found in dermabrasion. It would appear that the first reaction is very encouraging, namely destruction of the superficial melanosomes in a "punched-out" lesion, but in some cases the colour returned, presumably because repigmentation takes place by undestroyed naevocytes present at a deeper level (Fig. 2B). In one case the initial clearing was followed by hyperpigmentation which had not settled down at 6 months follow-up. Hyperpigmentation is a well recognised complication of most cutaneous lasers. While the poor response in

congenital naevi was not unexpected and can be readily explained, the failure of pigmented epidermal naevi to show any response was disappointing. Perhaps the use of a laser with a longer wavelength (Ruby at 694 nm) and a higher power density is necessary before textured and deep lesions can be treated.

Our experience suggests that the PLDL-1 Laser is suitable to treat the superficial lightly stained café-au-lait macules only and it would appear that most of them can be cleared after several sessions with this particular laser (Fig. 3A–C). The concept of treating pigmented birthmarks is an exciting one, but at present this particular laser can only be recommended to treat the very superficial brown marks such as café-au-lait macules.

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