British Journal of Dermatology (1988) **119,** 691–696.

311 nm UVB phototherapy—an effective treatment for psoriasis

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Accepted for publication 9 May 1988

SUMMARY

Fifty two psoriatic patients were treated with a new experimental fluorescent lamp (Philips TL-01) emitting a narrow band at 311 ± 2 nm (UVB) which had the advantage of a reduction in burning and carcinogenic wavelengths when compared with conventional broad band UVB therapy. Results of the '311' treated group when compared with broad band UVB therapy revealed a similar percentage of patients achieving a satisfactory response with fewer burning episodes and an increase in duration of remission.

Phototherapy with UVB and psoralen photochemotherapy (PUVA) are well established treatment modalities for psoriasis.[1–3] Initially, both may give equally satisfactory results,[4–6] but the duration of remission obtained with PUVA is superior to that obtained with UVB.[4] PUVA is contraindicated in pregnancy, and some patients may experience severe nausea or pruritus, especially with 8-methoxypsoralen (8-MOP).[7] The main concern lies with its potential carcinogenicity; both 8-MOP and 5-MOP plus UVA are known to be carcinogenic in animals.[8] Multicentre co-operative retrospective studies in psoriatic patients treated with PUVA have produced differing results;[9–11] where an increased risk of non-melanoma skin cancer did occur, in addition to other factors such as previous treatments with arsenic or X-rays, it was related to the cumulative UVA dose and possibly also to the treatment schedules used. Until such time as derivatives such as pyridopsoralen, which theoretically have less carcinogenic potential,[12] become available for routine therapy, the use of PUVA should be restricted to severe forms of psoriasis which are resistant to topical treatment. The use of conventional broad band UVB phototherapy with a source such as the Philips TL40W/12 (waveband 280–350 nm) is often limited by burning[2] and the potential risk of carcinogenesis.[13,14] Monochromator studies by Parrish and Jaenicke[15] demonstrated that the action spectrum for phototherapy of psoriasis differs from that for UV-erythema. Wavelengths of 290 nm and below are erythemogenic but not therapeutic, even at dosages of 50 times the minimal erythema dose (MED). The therapeutic wavelengths are, therefore, > 290 nm. Moreover, Fischer *et al.* have shown that a narrow waveband at 313 nm is particularly effective for clearing psoriasis, with a reduced capacity for

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producing erythema.[16] Van Weelden and van der Leun[17] proposed that it would be desirable to develop a radiation source for UV-phototherapy which excluded the shorter erythemogenic wavelengths. Since the action spectrum for UV-carcinogenesis is thought to parallel that for erythema,[18,19] such a source would also have the theoretical advantage of being less carcinogenic than the conventional broad band source.

An experimental fluorescent lamp (Philips TL-01) has been developed with a phosphor which produces a peak narrow band emission at 311 nm (± 2 nm) and a minor peak at 305 nm (Fig. 1). Two pilot studies of the efficacy of the TL-01 lamp in the treatment of psoriasis vulgaris have been performed.[20] First, in nine patients with widespread, symmetrical psoriasis, one half of the body was treated with radiation from conventional broad band UVB using TL-12 lamps, while the other half was treated with the new TL-01 lamps, the treatment schedule being the same for each lamp type so that a slight erythema was elicited after each treatment. In the second, a comparison of whole body treatment was made in eight patients using the two types of lamps. In both studies results obtained with the TL-01 '311' lamps were significantly better than those obtained with the broad band TL-12 lamps. The authors also showed that the TL-01 lamps were significantly less carcinogenic for mice than the TL-12 lamps.

As part of an intended multi-centre trial we have studied the efficacy of these new lamps in the treatment of psoriasis in our department, comparing the results obtained with those from a trial using the conventional broad band Philips TL-12 lamps.

METHODS

During the period January to August 1986, 52 patients with extensive psoriasis (> 20% body surface area involved) were treated. In order to assess the efficacy of therapy, patients were subdivided clinically into three groups; plaque, plaque/guttate, and guttate psoriasis. Patients with a history of photo-aggravated psoriasis or previous cutaneous malignancy were excluded. Topical therapy during the study was restricted to 50:50 liquid paraffin:white soft paraffin or emulsifying ointment emollient. Phototherapy was given in an upright irradiation cabinet, 2 m high × 1·4 m × 1·2 m, containing initially 22 of the new '311' fluorescent tube lamps (Philips TL-01) arranged to provide whole body exposure with an average irradiance of 1·07 mW/cm^2 measured with a calibrated UVB meter. During the course of the study the irradiance was

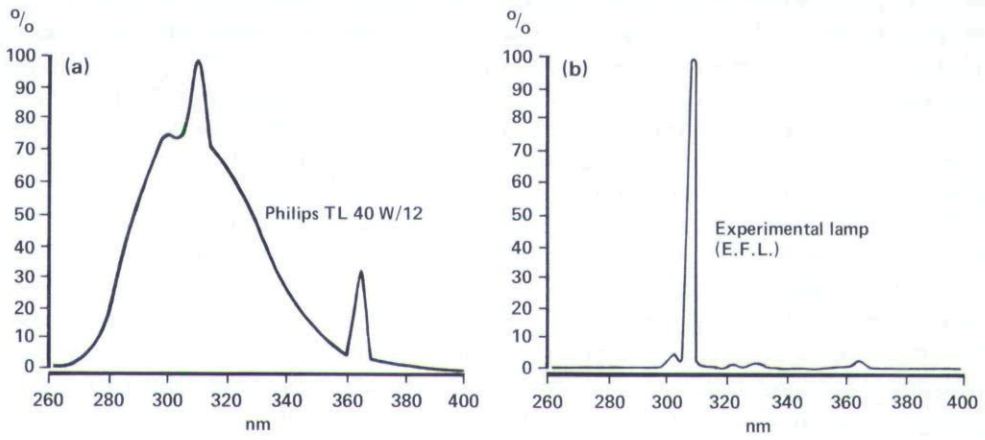

FIGURE 1. Relative spectral energy distribution of (a) the Philips TL40W/12 lamp and (b) the Phillips TL-01 lamp.

increased to 2·09 mW/cm^2 by placing reflecting foil behind the lamp fittings and by increasing the number of tubes to 49. This made it possible to reduce the treatment exposure time and so increase the availability of the cubicle to patients.

Prior to therapy, the MED for the TL-01 lamps was determined in each patient using a range of dosages established empirically during a pilot study. The final testing schedule required each patient to be seated at a distance of 20 cm from six tubes; six sites on the back, or, in a few cases where there was insufficient lesion-free skin, on the arm, were irradiated with a graded series of exposures from 50–1500 mJ/cm^2 (irradiation time 19 s–9 min 30 s). Using this schedule we found the average MED for patients with skin type II to be 500 mJ/cm^2 (range 100–1250).

Treatment was given thrice, or in five cases twice, weekly, the initial exposure dose being 70% of the MED. Subsequent exposures were increased by 40%, the aim being to achieve a mild erythema response after each treatment. The exposure schedule was adjusted if severe erythema or burning occurred, with burning being defined as severe, painful erythema (Table 1).

Patients were assessed weekly and any adverse reactions recorded. Once a satisfactory state, defined as clearing of lesions with or without minimal residual activity, was achieved, patients then received six further treatments at the same exposure dose. Once patients stopped therapy they were reviewed every 2 weeks for 8 weeks, and thereafter monthly. A relapse of psoriasis was defined as a degree of skin involvement of 50% or more of that recorded at the time of entry into the study.

RESULTS

Results of treatment in the three clinical groups are shown in Table 2. A satisfactory response was obtained in 92% of the plaque psoriasis group and in 100% of patients in the plaque/guttate and guttate groups. The mean duration of therapy (6·6 weeks) and the mean total cumulative dose (18·4 J/cm^2) were similar in each group. The incidence of burning episodes was 10%. One year after cessation of therapy, 38% of the patients remained in remission. Those patients who relapsed did so after an average of 12 weeks (range 2–52 weeks).

Comparison with conventional UVB therapy

In a previous study, 25 psoriatic patients were treated by conventional UVB phototherapy (Philips TL40W/12 lamps; irradiance 1·5 mW/cm^2) initially using the same inclusion criteria, treatment schedule and assessment criteria as in the present study.[4] However, because there were problems of burning, patients were treated twice rather than thrice weekly. Table 3 shows the comparison of results of the conventionally treated and the '311' treated groups. Both the

TABLE 1. Phototherapy schedule

Stage	
1	MED determination
2	First treatment: 70% of MED
3	Dose increments thrice weekly:
	If not erythema: dose increased by 40%
	If slight erythema: dose increased by 20%
	If more than slight erythema: same dose
	If mild burn: dose decreased by 50%
	If severe burn: dose omitted

TABLE 2. Results of UVB phototherapy with Phillips TL-01 lamps in 52 patients with psoriasis. Values are means and ranges

Type of psoriasis		Satisfactory results: Duration of treatment (weeks)	Satisfactory results: Cumulative dose (J/cm^2)	Total treatment course: Duration (weeks)	Total treatment course: Cumulative dose (J/cm^2)
Plaque	($n=17$)	4·7 (2·6–9·3)	11·8 (3·4–26·0)	6·7 (5·3–12·3)	18·1 (9·9–41·5)
Guttate	($n=20$)	4·3 (1·6–7·0)	9·9 (2·6–17·8)	6·6 (3·0–9·3)	18·3 (3·8–25·6)
Plaque/guttate	($n=15$)	3·8 (2·3–5·3)	8·5 (2·2–19·8)	6·6 (4·0–11·0)	19·0 (10·6–38·1)

time taken to achieve a satisfactory response and the total duration of therapy are significantly less in the '311' treated group; the total cumulative exposure dose was of the same order of magnitude in each group. Despite the twice weekly treatment schedule, the incidence of burning in the conventionally treated group was still relatively high at 28%. In the '311' UV treated group, 38% of the patients remained in remission for a year compared with the results of conventional broad band UVB where only 5% were still in remission after this length of time.

DISCUSSION

In discussing the action spectrum for UV-therapy of psoriasis and the lamps available for this treatment, Fischer *et al.*[16] emphasized the importance of separating the burning and possible Koebner effects of the shorter wavelengths in the UVB from the therapeutic effects of the longer wavelengths around 313 nm. This approach was well supported by phototherapy action spectrum studies of Parrish and Jaenicke.[15] Moreover, a successful practical application of the hypothesis is apparent in the results of Schothorst *et al.*[21] using the Sylvania UV-6 lamp, the emission of which has a much reduced component below 310 nm compared with that of the conventional broad band UVB lamps, and of the apparently natural selective ultraviolet phototherapy at the Dead Sea.[22] Diffey and Farr have developed this concept in the form of a 'Phototherapy Index' applied to the various lamps currently used for therapy of psoriasis, the higher the index for a given end point of therapy, the less the limitation of therapy by erythema and burning.[23] The calculated index for the TL-12 lamp was 1·3 while that for the '311' TL-01 lamp was 2·8. This predicted superiority in therapeutic efficacy is borne out by the results of both the original studies by van der Leun and van Weelden[20] and by the results reported here.

We recognize the limitations of comparing results of studies which took place at different times, but still think the comparison of the previous treatment with conventional broad band

TABLE 3. Comparison of the results of '311' and conventional UVB phototherapy. Values are means and ranges

	Satisfactory results: Duration of treatment (weeks)	Satisfactory results: Cumulative dose (J/cm^2)	Total treatment course: Duration (weeks)	Total treatment course: Cumulative dose (J/cm^2)
311: ($n=52$)	4·3 (2–9)	10 (3–26)	6·6 (3–12)	18 (4–42)
Conventional: TL40W 12 ($n=25$)	10·6 (3–26)	9 (7–16)	22·0 (8–43)	19 (5–41)

UVB and the narrow band '311' is valid and of interest. With the TL-12 lamps and an aggressive, thrice weekly treatment schedule, patient compliance was poor due to burning. Even with the twice weekly schedule, the incidence of burning episodes was relatively high at 28%.

In contrast, with the TL-01 lamps the incidence of burning was only 10%, allowing continued thrice weekly therapy and thereby an average total treatment course of only 6·6 weeks. Twenty-two weeks was required for the TL-12 lamps to produce the same overall mean total exposure dose of 18–19 J/cm^2 which produced a satisfactory result with both lamp types. One disadvantage of the narrow band TL-01 lamps is the relatively long exposure time required, especially when considering the reported success of less aggressive, daily exposure regimens with conventional broad band UVB sources.[24,25] However, this problem may in part be overcome by increasing the number of lamps in the cabinet. A thrice weekly schedule may be preferred to daily exposures for patients with work commitments and travelling expenses to consider. Moreover, if as reported by Fischer *et al.*[16] psoriasis is cleared with exposure doses of 0·5 MED rather than the aggressive regimen used in our study, exposure times will again be reduced.

Thus, our work has shown the '311' lamp to be at least as effective for treating psoriasis as the broad band TL-12 source, with some clinical advantages. It is of interest to put this result in the context of the work of Parrish[26] which has shown that simultaneous or subsequent exposure to shorter wavelength radiation not only lessens the therapeutic effect of longer wavelength UVB, but also may obviate it completely. Without maintenance treatment, the remission obtained with the TL40W12 lamps was disappointing, only eight patients of the 25 treated continuing to be satisfactory for longer than 8 weeks. With the TL-01 lamps, of the 38% who remained in remission for a year or more, one-third were patients in the plaque psoriasis group. Normally, we would expect treatment with PUVA to be required for such a result and although the number of subjects in the present study was small, the remission times do appear to be very similar to those obtained with PUVA.[27]

Over the past few years, knowledge that the retinoids have an anti-cancer effect[28] has stimulated workers to study these drugs in combination with both UVB[29] and PUVA.[30,31] These combinations have proved successful in the treatment of psoriasis with a significant reduction in the mean total exposure dose. The experimental finding that the new TL-01 lamp also carries less risk in terms of UV-carcinogenesis is very encouraging in itself and the study of its use in combination with one of the oral retinoids would be of considerable interest.

ACKNOWLEDGMENTS

We would like to thank Sister Margaret Bell and her nursing staff, and Mrs Davina Watson and her technical staff, for invaluable help in this study.

REFERENCES

1 Wolff K, Fitzpatrick TB, Parrish JA. Photochemotherapy for psoriasis with orally administered methoxsalen. *Arch Dermatol* 1976; **112:** 943–50.

2 Boer I, Schothorst AA, Suurmond D. UV-B phototherapy of psoriasis. *Dermatologica* 1980; **161:** 250–8.

3 Le Vine, MJ, Parrish JA. Outpatient phototherapy of psoriasis. *Arch Dermatol* 1980; **116:** 552–4.

4 Kenicer KJA, Lakshmipathi T, Addo HA *et al.* An assessment of the effect of photochemotherapy (PUVA) and UVB phototherapy in the treatment of psoriasis. *Br J Dermatol* 1981; **105:** 629–39.

5 Boer J, Hermans J, Schothorst AA, Suurmond D. Comparison of phototherapy (UV-B) and photochemotherapy (PUVA) for clearing and maintenance therapy of psoriasis. *Arch Dermatol* 1984; **120:** 52–7.

6 Van Weelden H, Young E, van der Leun JC. Therapy of psoriasis: comparison of photochemotherapy and several variants of phototherapy. *Br J Dermatol* 1980; **103:** 1–9.

7 Hönigsmann H, Jaschke E, Gschnait F. 5-methoxypsoralen (Bergapten) in photochemotherapy of psoriasis. *Br J Dermatol* 1979; **101:** 369–78.
8 Young AR, Magnus IA, Davies AC, Smith NP. A comparison of the phototumorigenic potential of 8-MOP and 5-MOP in hairless albino mice exposed to solar simulator radiation. *Br J Dermatol* 1982; **108:** 507–18.
9 Henseler T, Christopher E, Hönigsmann H, Wolff K *et al.* Skin tumours in the European PUVA study. *J Am Acad Dermatol* 1987; **16:** 108–16.
10 Stern RS, Laird N, Melski J *et al.* Cutaneous squamous cell carcinoma in patients treated with PUVA. *N Engl J Med* 1984; **310:** 1156–61.
11 Lassus A, Reunala J, Idanpaa-Heikkila T. PUVA treatment and skin cancer; a follow-up study. *Acta Derm Venereol (Stockh)* 1981; **61:** 141–5.
12 Blais J, Vigny P, Moron J, Bisagni E. Spectroscopic properties and photoreactivity with DNA of new monofunctional pyridopsoralens. *Photochem Photobiol* 1984; **39:** 145–50.
13 Larko O. Phototherapy of psoriasis—clinical aspects and risk evaluation. *Acta Dermatovenereol (Stockh)* 1982; Suppl. 103).
14 Slaper H, Schothorst AA, van der Leun JC. Risk evaluation of UVB therapy for psoriasis: Comparison of calculated risk for UVB therapy and observed risk in PUVA-treated patients. *Photodermatol* 1986; **3:** 271–83.
15 Parrish JA, Jaenicke KF. Action spectrum for phototherapy of psoriasis. *J Invest Dermatol* 1981; **76:** 359–62.
16 Fischer T, Alsins J, Berne B. Ultraviolet action spectrum and evaluation of ultraviolet lamps for psoriasis healing. *Int J Dermatol* 1984; **23:** 633–7.
17 Van Weelden H, van der Leun JC. Improving the effectiveness of phototherapy for psoriasis. *Br J Dermatol* 1984; **111:** 484 (Abs).
18 Cole CA, Forbes PD, Davies RE. An action spectrum for photocarcinogenesis. *Photochem Photobiol* 1986; **43:** 275–84.
19 Sterenborg HJCM, van der Leun JC. Action spectrum for tumorigenesis by ultraviolet radiation. In: *Human Exposure to Ultraviolet Radiation; Risks and Regulations* (Passchier WF, Bosnajakovic BFM, eds). Excerpta Medica, Int. Congr. Ser. 1987; **744:** 173–90.
20 van der Leun JC, Van Weelden H. UVB phototherapy; principles, radiation sources, regimens. *Curr Probl Dermatol* 1986; **15:** 39–51.
21 Schothorst AA, Boer J, Suurmond D, Kenter CA. Application of controlled high dose rates in UVB phototherapy for psoriasis. *Br J Dermatol* 1984; **110:** 81–7.
22 Abels DJ, Kattan-Byron J. Psoriasis treatment at the Dead Sea: A natural selective ultraviolet phototherapy. *J Am Acad Dermatol* 1985; **12:** 639–43.
23 Diffey B, Farr P. An appraisal of ultraviolet lamps used for the phototherapy of psoriasis. *Br J Dermatol* 1987; **117:** 49–56.
24 Halprin KM, Comerford BA, Taylor JR. Constant low-dose ultraviolet light therapy for psoriasis. *J Am Acad Dermatol* 1982; **7:** 614–19.
25 Ellis LD, Wolff JM, Garloff J, Eaglstien WH. Comparison of suberythemagenic and maximally aggressive ultraviolet B therapy for psoriasis. *J Am Acad Dermatol* 1984; **11:** 105–10.
26 Parrish JA. Phototherapy of psoriasis and other skin diseases. In: *The Science of Photomedicine* (Regan and Parrish, eds) New York and London, Plenum Press, 1982; 511–31.
27 Johnson BE, Green C, Lakshmipathi T, Ferguson J. Ultraviolet radiation phototherapy for psoriasis. The use of a new narrow band UVB fluorescent lamp. *Proc 2nd Eur Photobiol Congr, Padua, Italy*, September 1987, Plenum Publishing (In press).
28 Weeks CE, Slaga TJ, Henning H *et al.* Inhibition of phorbol ester-induced tumour promotion in mice by vitamin A analogue and anti-inflammatory steroid. *J Natl Cancer Instit* 1979; **63:** 401–6.
29 Orfanos CE, Steigleder GK, Pullmann H. Oral retinoid and UVB radiation; a new alternative treatment for psoriasis on an outpatient basis. *Acta Derm Venerol (Stockh)* 1979; **59:** 241–4.
30 Lauharanta T, Juvakoski T, Lassus A. A clinical evaluation of the effects of an aromatic retinoid (Tigason) combination of retinoid and PUVA, and PUVA alone in severe psoriasis. *Br J Dermatol* 1981; **104:** 325–32.
31 Fritsch P, Hönigsmann H, Jaschke E, Wolff, K. Augmentation of oral methoxsalen photochemotherapy with an oral retinoic acid derivative. *J Invest Dermatol* 1978; **70:** 178–82.

Since this paper was submitted, a detailed report of the original study has been published:

Van Weelden H, Baart de la Faille H, Young E, van der Leun JC. A new development in UVB phototherapy of psoriasis. *Br J Dermatol* 1988; **119:** 11–19.