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RESEARCH PAPER

Effect of polarized light in the healing process of pressure ulcers

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Effect of polarized light in the healing process of pressure ulcers

A trial was conducted to examine the effect of polarized light on pressure ulcers of 1st, 2nd and 3rd grades. Patients with two pressure ulcers, one of which received the polarized light therapy (experimental ulcer) and the other acting as control, were included in the study. The experimental ulcers received treatments for 2 weeks consisting a 5 min therapy session each day, excluding weekends, for 10 days. Experimental and control ulcers were assessed as they appeared on admission and reassessed at the end of each week. Fifty-five patients aged 37–85 years (67.1 ± 11.9 years were studied. Pressure ulcers of 1st, 2nd and 3rd grades receiving extra treatment with polarized light had increased values of epithelial tissue between the first and second assessments of 0–30.9% and between the second and third assessments of 30.9–21.7%. Values of the control pressure ulcers were, respectively, from 0 to 5.5% and from 5.5% to 3.1%. The mean pink/white colour values of the experimental ulcers, between the first and second measurements increased significantly compared with the control ulcers ($P=0.021$) and also increased significantly between the second and third measurements ($P=0.003$). The mean values of 'no and minimal exudate' of the experimental ulcers increased significantly between first and second measurements compared with the control ulcers ($P=0.001$), and similarly, significantly between the second and third measurements ($P=0.002$). Mean surface areas of the experimental ulcers decreased significantly between the first and second measurements from 2.84 to 2.54 cm^2 ($P \leq 0.001$) and between the first and third measurements from 2.84 to 2.26 cm^2 ($P \leq 0.001$). Mean surface areas of the control ulcers decreased between the first and second measurements

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from 2.10 to 2.08 cm^2 ($P \leq 0.42$) and between the first and third measurements from 2.10 to 2.04 cm^2 ($P \leq 0.007$). Pressure ulcers subjected to extra treatment with polarized light in the early stages (first to third measurements) showed improvement in the healing process than the control ulcers.

Key words: epithelial tissue, exudate, polarized light, pressure ulcers, red/pink ulcers, ulcer surface area.

INTRODUCTION

In ancient times, the sun was venerated as a source of life in various cultures. In 1817, Hieronymus Hess of Basel used photocoagulation of a human eye in order to destroy it. It was a historic time when Gerhard Meyer Schwickerath used the modern ophthalmic photocoagulation therapy in 1949.[1] In 1903, Finsen was awarded one of the earliest Nobel Prizes in Medicine for his 'Finsen light therapy' for infectious diseases, especially lupus vulgaris.[2] In the 1930s and 1940s, the medical profession promoted sunbathing as beneficial for children, and from that basis, the popularity of sun-tanning emerged. In 1970, a melanoma epidemic began to be noticed and the role of ultraviolet light in the pathogenesis of melanoma was highlighted.[2] However, light therapy is a common form of therapy for some diseases such as hyperbilirubinaemia of newborns and psoriasis.[3,4] Psoriasis 'clears' in patients undergoing phototherapy or photochemotherapy. Another popular type of therapy is low-power laser therapy.[5] It has been suggested that low-power laser beams cause biostimulation, a photochemical response to laser light inducing biochemical alternations in cells.[5,6]

Polarized light

The Hungarian scientist Mester is one of the pioneers with large experimental and clinical experience in the use of biostimulating effect of laser beams.[6,7] A hypothetical model based on experimental facts to explain this effect was proposed. The substance of that model showed that polarized light reorders the polar heads of the lipid bilayer (being near transition phase) in the cell membrane. The change of the polar heads of the lipid bilayer in the cell membrane has influenced all processes closely connected with it. Another interesting finding pointed out that while the incoherent irradiation of a thermal light source (630 nm) was ineffective, the result of irradiation by polarized light showed about equal effectiveness (80%) of helium neon (HeNe) polarized laser light.[8,9] This phenomenon indicates that biostimulation might also be produced by a polarized thermal light source. Mester and Fenyo similarly suggested that a source of incoherent light emitting polarized rays would induce biostimulative effects in living cells similar to low-level lasers.[6–9] This means that lamps emitting polarized light and low laser light, when used as wound treatment, both cause the phenomenon of biostimulation.

Other clinical studies have also shown saturation character and proved to be nearly independent of wavelength (649–458 nm). Several experiments in wound mice with polarized light showed a stimulating and healing effect.[6] Kubasova[10] used human embryo fibroblast cell cultures to examine the effect of HeNe laser polarized light on the cell membrane. This study showed that 4 J/cm^2 was effective for irradiation and the duration of exposure was 7 min.

Mester's former student, Ribari, first used HeNe laser for the epithelization of perforated tympanic membrane and treatment of postoperative fistulas of the neck and the mastoid, and he was successful in obtaining a biostimulating effect. The biostimulating effect of low-level laser treatment conveys anti-inflammatory, analgesic, antioedematous effects on tissues and could be the basis for wound healing.[5]

Sommer and Francle supported that lower-energy densities evoke a significant biostimulation in human tissue.[11] They introduced a new laser beam distribution system for medical application, that is, low-energy densities applied with high-energy lasers in combination with laser beam diverging lenses. They found that this system is effective for biostimulating human tissue and also has a moderate price. The lamp emitting polarized light used in the present study was also chosen because we assumed that it has a similar biostimulating effect with low laser polarized light, it is easy to use and has a moderate price.

So far, researchers have used polarized light of several types of low-laser as a therapy of several wounds, but no data have been reported with a light source emitting polarized rays on pressure ulcers. Electronic databases, including Medline and Cinahl, were searched up to 1999 for this subject without success.

The problematic healing of pressure ulcers and Mester's and col. positive view of biostimulation was a motivation for the present study in which the following

question was addressed. What is the clinical effect of polarized light (emitted from a lamp) on non-necrotic pressure ulcers?[6–10]

METHODS

Subjects

The sample consisted of 55 patients who were admitted in four hospitals of the Athens major area over the last 2 years. The following markers were used for assessing the effect of polarized light: (i) the presentation and increase of epithelial tissue on pressure ulcers surface; (ii) the increase of bright red/pink colour; and (iii) the presence and increase of ulcers with no exudate and the decrease of pressure ulcers surface area.[12–14] Inclusion criteria included the following: (i) pressure ulcers of 1st, 2nd and 3rd grades; (ii) pressure ulcers on the buttocks, trochanters, sacrum, shoulders and legs; (iii) each patient had to have two pressure ulcers, one of which received the polarized therapy (experimental) and the other acting as control; and (iv) the larger ulcer of each patient was chosen as the experimental ulcer. Exclusion criteria included the following: (i) presence of skin necrosis on the ulcers; (ii) previous or planned surgical excision of the pressure ulcer; and (iii) patients in palliative care (in very poor clinical status). Data were collected on a specially designed assessment chart.

The hospitals' ethics committees approved the study, and all patients selected gave their written consent. The study also involved close collaboration between researchers, doctors and nursing staff in the management of each patient.

Fifty-five experimental pressure ulcers received treatments for 1 week. Of these, 23 were excluded after the end of the week because the ulcers had healed. The remaining 32 patients received polarized light treatment for a second week. The treatment consisted of a 5 min therapy session each day on weekdays.

Materials

Energies delivered were typically 4 J/cm^2 per min, degree of polarization of >95% using a 20 W Bioptron electrical lamp.[9] At the end of each week, experimental and control ulcers were reassessed and a detailed report was completed.[15]

Methods

The trial compared the use of polarized light therapy to the typical therapy of each hospital. Hospital therapies are very similar. Details requested included age, sex, date of assessment and reassessment, and all personal characteristics related to pressure ulcer formation were recorded.

All patients were treated in accordance within hospital guidelines, which include turning the subjects every 2–3 hours, provision of electric pressure relieving overlay and a 30° lateral side-lying position given to avoid friction and shearing forces. Concerning the ulcers, these were of 1st, 2nd and 3rd grades without necrotic tissue; thus, the concentration was on two essential components of cleaning and dressing. Typically, the cleaning solution of choice was 0.9% sodium chloride and the dressing was chosen to match ulcer stage.

A simple and unambiguous pressure ulcer grading system was introduced in order to increase rater reliability and reduce dependence on pictures of pressure ulcers.[14] Particular consideration was given to ulcer tissue destruction, colour changes, quantity of exudate produced and the reduction of ulcer surface area. These markers were used as the best way of measuring improvement or deterioration.

All ulcers were assessed using the Torrance scale to describe the ulcers' tissue destruction, where 1st grade = persistent erythema of the skin; 2nd grade = blister formation or superficial subcutaneous ulcer; 3rd grade = deep subcutaneous ulcer-ulceration progress through the dermis.[14]

Colour was assessed as follows: 'pink/white' was indicative of epithelialization, 'beefy' red or bright red was indicative of granulation, and 'creamy' yellow or yellow 'white' was indicative of slough.[16]

The quantity of exudate produced showed improvement or deterioration in the condition of ulcers.[17] Too much exudate indicated deterioration while a minimal amount was indicative of wound healing. Exudate level was determined using a four-point scale of none, minimal, moderate and severe/high.[16,17]

Wound surface area was measured by tracing the border of the ulcer on plastic film. The area from these tracings was measured with a polar planimeter (model number 317 E; HAFF planimeters, West Germany). The precision of this instrument is within 1 mm, and the observers's good eyesight and a steady hand plays a decisive role.[2,18] In order to minimize errors, measurements have been made by the same researcher.

The statistical analysis was completed using the statistical package SPSS and the statistical methods χ^2, binomial exact test for matched pair and ANOVA for any differences

Table 1 Patient characteristics

Characteristic	Status	*n*	%
Activity	Ambulatory	0	0
	Can walk with help	3	5.4
	Uses wheelchair	7	12.4
	Bed bound	45	81.8
Mobility	Full	0	0
	Limited	10	18.1
	Very limited	45	81.8
Urine incontinence	Never	0	0
	Occasional	13	23.6
	Frequent	6	10.9
	Catheter	36	64.6
Fecal incontinence	Never	30	54.5
	Occasional	21	38.1
	Frequent	4	7.2
Disease	Hip fracture – left or right	16	29
	Stroke syndrome	11	20
	Frail elderly	15	27.2
	Other	13	23.6

Table 2 Tissue type changes of pressure ulcers through three assessments

Cases	*n* (%)		
	Experimental ulcers		
Tissue type	1st day	7th day	15th day
Epithelial tissue	0	17 (30.9)	7 (21.7)
Epidermis and dermis	16 (28.6)	10 (18.20)	10 (31.0)
Epidermis and dermis and subcutaneous fat	39 (71.40)	28 (50.9)	15 (47.3)
Total	55 (100)	55 (100)	32 (100)
	Control ulcers		
Epithelial tissue	0	3 (5.5)	1 (3.1)
Epidermis and dermis	17 (30.9)	13 (24.1)	10 (31.3)
Epidermis and dermis and subcutaneous fat	38 (69.1)	39 (70.4)	21 (65.6)
Total	55 (100%)	55 (100)	32 (100)

within experimental ulcers as well as between experimental and control ulcers.

RESULTS

Fifty-five patients aged 37–85 years (67.1 ± 11.9 years) were studied. The subjects' characteristics related to pressure ulcer formation and baseline assessments are presented in Table 1.

Of the 55 subjects, 23 of the subjects' ulcers responded satisfactorily to the applied treatment with polarized light having been healed at the end of the first week. These data are discussed hereafter.

The sample of 55 pressure ulcers of 1st, 2nd and 3rd grades that received polarized light had increased values of the following markers between the first and second assessments (days 1 and 7): (i) epithelial tissue increased from 0 to 30.9%; (ii) bright red/pink colour from 1.8 to 24.1%; and (iii) ulcers with no exudate from 1.8% to 29.1%. Between the second and third assessments (days 7 and 15; $n = 32$), epithelial tissue increased from 30.9% to 21.7%, bright red/pink colour increased from 24.1 to 34.3%, and ulcers with no exudate increased from 29.1 to 37.5%. Results from all assessments are presented in Tables 2–4. Values of the control pressure ulcers were as follows. Between the first and second assessments, epithelial tissue increased from 0 to 5.5%, bright red/pink colour increased from 3.6 to 9%, and ulcers with no exudate increased from 6.8 to 7.3%. Between the second and third assessments, epithelial tissue decreased from 5.5 to 3.1%, bright red/pink colour decreased from 9% to 6.2%, and no exudate increased from 7.3 to 9.3%.

In order to estimate the *P*-value of the colour, the binomial exact test for matched pairs was used to analyse the data. The pink colour was chosen as a wound-healing indicator. The mean pink/white colour values of the experimental ulcers between first and second measurements increased significantly compared with the control ulcers ($P = 0.021$). The mean pink/white colour values of the experimental ulcers between the second and third measurements also increased significantly compared with the control ulcers ($P = 0.003$).

In order to increase the number of observations and obtain a reliable *P*-value, we joined the 'no exudate cases' with the 'minimal exudate cases', assuming that both indicated wound improvement (healing). The mean values of 'no and minimal exudate' of the experimental ulcers increased significantly between the first and second mea-

surements compared with the control ulcers ($P=0.001$). The mean values of 'no and minimal exudate' of the experimental ulcers also increased significantly between the second and third measurements compared with the control ulcers ($P=0.002$).

The surface area mean values were normally distributed at the first measurements (on admission), but these values changed not uniformly during therapy; thus, the distribution was negatively skewed on the second and third assessments. Logarithmic transformation was done in order to obtain a curve close to normal. Once the distribution had been normal, the paired *t*-test was used to analyse the data for surface area. Mean surface values of the experimental ulcers decreased significantly between the first and second measurements from 2.84 to 2.54 cm^2 ($P \leq 0.001$) and between the first and third measurements from 2.84 to 2.26 cm^2 ($P \leq 0.001$). Mean surface values of the control ulcers decreased between the first and second measurements from 2.10 to 2.08 cm^2 ($P \leq 0.42$) and between the first and third measurements from 2.10 to 2.04 cm^2 ($P \leq 0.007$). The data indicate that both ulcers (experimental and control) had surface area reductions but there was a significant difference between the reductions in favour of the experimental ulcers (larger; Table 5).

Table 3 Pressure ulcers colour changes

Pink, white and bright red cases			
	1st day $n=55$	7th day $n=55$	15th day $n=32$
Experimental ulcers	1 (1.8%)	13 (24.1%)	11 (34.3%)
Control ulcers	2 (3.6%)	5 (9%)	2 (6.2%)

DISCUSSION

The problems identified within Table 1, uses of wheelchair, bedbound patients and other disorders, are contributing factors in the formation of pressure ulcers and delayed wound healing. However, despite the presence of these factors, granulation tissue in the cavity and epithelialization around the edges provide evidence that the wounds were normally progressing through the stages of healing. Further, 23 ulcers in very early stages were covered with epithelial tissue and were judged healed at the end of 5 days. In addition, as the study was designed to establish relevant parameters of wound healing (taking patients with two pressure ulcers each), the successful epithelial cover surpassed the effect of other confounders such as incontinence, mobility, medication, disease and other factors.

A number of studies have assessed the healing process of wounds treated by low-level laser light, but controversies appeared between them as some were unable to show a beneficial effect.[19,20] Controversies might be accounted for from the different criteria, from the variety of appearance of the ulcers and from the various predisposing factors in cases like frail patients etc. However, some studies indicated that light therapy could be of great benefit in the treatment of chronic wounds even if the design of these studies was entirely different from the present study.[5–11]

The mean pink/white colour values of the experimental ulcers between measurements increased significantly

Table 4 Quantity of exudate produced over time on ulcer surface area

	Experimental ulcers			Control ulcers		
Quantity of exudate	1st day $n=55$	7th day $n=55$	15th day $n=32$	1st day $n=55$	7th day $n=55$	15th day $n=32$
Number of exudate cases (%)	1 (1.8)	16 (29.1)	12 (37.5)	1 (6.8)	4 (7.3)	3 (9.3)
Minimal cases (%)	11 (20)	19 (34.5)	9 (28.1)	11 (20)	9 (16.3)	8 (25)
Moderate cases (%)	22 (40)	10 (18.2)	9 (28.1)	22 (40)	18 (32.7)	5 (15.7)
Severe cases (%)	21 (38.1)	10 (18.2)	2 (6.3)	21 (38.1)	24 (43.7)	16 (50)
Total	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)

Table 5 Mean and SE of the reduction in pressure ulcer surface area (cm^2) between measurements in logarithmic scale

		Experimental ulcers		Control ulcers	
n	Measurements	Mean surface area (cm^2)	SE (±)	Mean surface area (cm^2)	SE (±)
55	1st day	2.84	±0.122	2.10	±0.117
55	7th day	2.54	±0.127	2.08	±0.121
32	15th day	2.26	±0.198	2.04	±0.173

compared with the control ulcers ($P=0.021$ and $P=0.003$, respectively). This phenomenon is pointed out from many researchers as a strong marker of healing progress because it is an indicator of epithelialization.[11–13]

An important result for researchers studying wound healing was that of minimizing exudate. In the present study, mean values of 'no and minimal exudate' of the experimental ulcers increased significantly between measurements compared with the control ulcers ($P=0.001$ and $P=0.002$, respectively). This was also accepted by Banks[21] and Holman.[22]

The last and most clinically obvious point suggesting improved healing in wounds is the surface area reduction, which also indicated a significant decrease between measurements in the experimental ulcers compared with the control ulcers (Table 5).[13,14,18]

Light therapy is very beneficial, particularly for superficial wounds. Ferrell's findings are very similar to the findings of the present study.[18] They concluded that more superficial ulcers rather than deep ulcers were healed in a given period. Ferrell described a randomized trial of low-air-loss beds for treatment of pressure ulcers compared with a basic foam mattress, concluding that there was a threefold increase in the speed of wound healing compared with use of foam mattresses.[18] There are many devices available including low-level laser therapy devices, gel-foam mattresses, full-gel mattresses and special beds such as low-air-loss beds. 'Diapulse' is another device with pulsed high frequency, high-peak power electromagnetic energy used to heal pressure ulcers. According to Itoh's study, when Diapulse was added to conventional treatment, all 2nd grade ulcers were healed within 1–6 weeks.[23] Haalboom, in his study, supported that the grading of devices for quality marks for antipressure ulcers effect is difficult.[24] Further, the Agency for Health Care Policy and Research concluded that although there is evidence that pressure-reducing devices can decrease the incidence of pressure ulcers, there is no evidence to suggest that one type of device is more effective than any other.[25] Of course, there are many factors to be taken into account if a researcher wants to compare devices. The cost of the device, the cost analysis of treating pressure ulcers, the great heterogeneity of subject and quality of nursing care have a vital role to play.

Another result of the present study that should be stressed is that the overall agreement between the various indicators of the experimental ulcers increased or decreased together depending on the cause of healing. This confirmed the improvement of the healing progress in the experimental ulcers.

It must be said that in the present study, only pressure ulcers with the criteria of responsiveness at onset were included. The largest difference of the surface reduction appeared in ulcers of 1st and 2nd grades in which their entire surface area was covered with pink/white tissue, whereas the control group had no similar change.

Overall, this was a satisfactory experience because by improving healing, the deterioration of the ulcers was avoided, infections were controlled, comfort restored and the patients' quality of life improved. Considering the economics of use of the lamp emitting polarized light, it is not an expensive device compared with other types of similar device.

CONCLUSION

This trial demonstrated the effectiveness of polarized light therapy in healing 1st, 2nd and 3rd grade pressure ulcers. When polarized light treatment was added to conventional ulcer therapy, rapid changes in appearance and size with complete healing in half of the cases and accelerated partial healing in the remaining cases appeared within 1–2 weeks.

Limitations

This study focused on the healing process of early stages of pressure ulcers. Additional research would provide

useful information for 4th and 5th grades of ulcer in association with improved nutritional intake. In addition, it would be interesting to see how patients progressed to healing with different products for wound treatment. The lamp-emitting polarized light is not expensive, and evaluation of the cost comparing it to other devices or other products might be useful.

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