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Promotion of wound healing by irradiation with polarised light

Clinical experience with Evolite therapy

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The treatment of poorly healing wounds continues to be a problem in clinical practice. Low-energy laser light was first successfully applied over 10 years ago. After it was recognised that the physical property of polarisation of the light must be responsible for the "biostimulation", the very much more simply obtained polarised light was introduced in clinical trials.

The investigations by Mester's research group into the action of laser beams on biological systems describe various effects. Among them, the healing of artificial skin defects in mice could be accelerated by the application of low-energy irradiation (7, 8). In rat studies, the tensile strength of clamped skin wounds showed significant improvement with laser application (6). This effect was confirmed for laser irradiation by the studies of Hutschenreiter et al in 1980 (4). However, laser and red-light irradiation led to no acceleration in wound healing in these trials in rats and also to no significant change in cell patterning in the wounds during the various phases of healing. More extensive experience of wound treatment in man was published in 1976 (9). This report

also contains a more detailed bibliography on laser applications in medicine.

Activated collagen production, fibroblast activation, and increased cell division, identifiable as raised thymidine incorporation, have been regarded as the factors responsible for promoting wound healing (10). In addition, an immunosuppressant effect of laser irradiation on human lymphocytes could be demonstrated, but this also applies in about the same degree to linear polarised incoherent light of the same wavelength (11).

Theoretical and experimental principles

The following physical properties of the laser distinguish it from "normal" light:

Monochromaticism (light of a single wavelength), coherence (oscillation of equal amplitude), the possibility of producing an extremely high-energy beam, and polarisation (oscillation in a single plane).

By analogy, the observations that linear polarised incoherent light has a laser-like effect (11), that the effect on wound healing was largely independent of the wavelength and that low-energy laser irradiation showed such an effect, permit the conclusion that polarisation of light is the significant property for promoting wound healing (3,13).

A hypothetical physical model of laser stimulation has been developed, according to which polarised light con-

ceivably influences the cell membrane, which could explain the "biostimulation" produced (5).

The first clinical observations with the application of polarised light (incoherent, at various wavelengths) were made in Budapest in 1981 (3,2). On the basis of experience with lasers, a light energy of 4 joules/cm² was applied. The apparatus employed emitted polarised light with a wavelength of about 500-800 nm.

We began our first clinical trials with one such apparatus in May 1982. The range of indications for its application was based on experience with laser therapy and covered leg ulcers, decubital ulcers, skin defects before and after grafting, secondary- and delayed-healing wounds, and amputation stumps and defects, especially in diabetics.

Since the light cone of the apparatus used initially was very bright, due to its spectrum, the spectrum of a more advanced apparatus employing a different polarisation method was extended into the infra-red range. This was done without appreciably altering the incident energy at the surface, by selecting a greater distance between the light source and the wound. The distance of 5 cm, required with the original model to achieve a surface energy of 4 joules/cm², proved difficult to maintain in practice, and the brightness of the original light cone was very strongly blinding. The distance of 20 cm between apparatus and wound necessary with the

new model is very much easier to manage, and the light is not blinding due to its longer mean wavelength. The Evolite (R) light source* now employed has a power density of 0.163 j/s per cm^2 at 20 cm distance between lens (light emission point) and wound surface.

At an exposure time of 30 s, this produces an incident energy of 4.89 j/cm^2 on the wound surface. The apparatus emits a linear-polarised light beam of electromagnetic waves in the spectral range, from 500 to 3000 nm, and thus contains no ultra-violet component.

Following our first positive impressions in clinical application, we became interested in experimental studies on the influence of polarised light on cell cultures and in animal models. Such studies were being performed in Budapest and some are still incomplete or not yet published. While irradiation with non-polarised light produces no difference from controls, Evolite irradiation of fibroblast cultures is distinguished, in contrast, by positive effects on growth and metabolism (12). In animal models, whereas the healing process in deep excised burn wounds ran the same course under normal light irradiation and in controls, Evolite- and also laser-irradiated wounds showed a significantly improved healing tendency (1).

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*Manufacturer: AMS, Auerbach/Opf.

Distributor: Firma Kranth, Hamburg.

We ourselves have studied the influence of polarised light on bacterial cultures (Staph. aureus, Proteus). Various irradiation times produced no changes in the bacterial growth of the cultures, in either the positive or the negative sense.

Clinical application

Wounds in over 200 patients have so far been treated with the Evolite apparatus in our present clinic. They form a mixed patient population of all age groups, but consist mainly of older patients with a poor wound-healing tendency associated with diabetes, generalised arterio-sclerosis, hypertension and obesity.

In individual cases, the Evolite irradiation was applied for the indications already noted above. The wounds were cleaned of necrotic tissue and secretions, ready for treatment. The wound surface was then irradiated once daily with a vertically-applied light beam, over the whole surface, an area of 4-5 cm^2 being covered by the light cone for 30 s. The wound margins with fresh epithelium were included in the irradiated area. This gave total irradiation times of half to several minutes, depending on the size of the wound surface in each case. A timing clock in the apparatus gives a signal every 30 s. Simple muslin-gauze dressings were then applied to still-secreting wounds, plain gauze being used under the dressings only with some dry wounds and fresh trans-plants. If the dressings became purulent, Nebacetin or Refobacin powder was sprinkled on thinly, according to bacterial sensitivity testing.

Results

In general, the following effects on the wounds could be established:

- Acceleration of the formation of granulation tissue even in poorly perfused areas associated with arterial (occlusive disease) and venous (PTS = post-thrombotic syndrome) ulcers, decubital ulcers, and defects following diabetic gangrene, where it is known that scarcely any granulation tissue forms on conventional therapy.
- Quicker cleaning and secondary closure over granulation tissue in infected wounds and those left open for therapeutic reasons, e.g. infected laparotomy wounds, pilonidal sinus, amputation stumps, and also in old patients, carcinoma cases, and other unfavourable conditions.
- Promotion of epithelialisation of the wound margin and from the smallest epithelial rests. Following skin grafting, epithelial growth can be observed after a few days, even on wounds which generally accept grafts only with difficulty.
- Rapid regression of moist wound secretion.
- Pain relief.
- Positive effects also observed with oedema and suture-track inflammation in otherwise primary-healing wounds, and cosmetic result more favourable.
- Immediately after treatment, almost all wounds even in poorly perfused areas showed a markedly fresh red colour, which can be explained by immediate capillary dilatation.
- A negatively-assessed tendency is drying out of fresh fatty tissue in the exposed subcutaneous layer,

although the irradiation dosage described produced no warming of the tissue; the surface temperature rises by only 0.3 - 0.5°C during the 30 s exposure.

The three case histories described below may serve as representative, demonstrating the many favourable results.

- In an 80-year-old female patient with subtotal popliteal stenosis and generalised arteriosclerosis, a therapy-resistant ulcer of the right lower leg had been present for months. Figure 1 shows the defect, which had been treated unsuccessfully with various ointments, paraffin gauze etc. After 14 days' Evolite irradiation, fresh granulations and epithelialisation from the margin are already developing (Fig. 1b). The Reverdin graft then performed was further irradiated from the second postoperative day, and this led to complete healing of the defect (Fig. 1c).

- In a 74-year-old female patient with severe diabetes mellitus and congestive heart failure, extensive diabetic gangrene developed in the line of the 2nd to 4th toes, extending to the midfoot.
  There was no occlusive arterial disease of the larger vessels. Evolite therapy followed operative treatment of the wound and piecemeal removal of further necrotic tissue. Figure 2 shows the condition after several days' treatment. After just three weeks, the defect showed a definite tendency to epithelialisation and

good granulation with progressive wound shrinkage (Fig. 2b). Thereafter, with the aid of several Reverdin flaps, the defect finally healed completely within the next two months (Fig.2c).

- An 83-year-old female patient with severely impaired arterial perfusion and mild diabetes mellitus developed gangrene of the forefoot, which necessitated amputation in the line of the first metatarsal in the mid-foot region. The infection could be limited by antibiotic treatment. With piecemeal removal of necrotic tissue, Evolite irradiation was performed in extremely unfavourable circumstances (extensive complete occlusion of the upper and lower leg arteries on the left side), accompanied in this case by simultaneous application of an antibiotic powder (Fig.3a). Good granulation was nevertheless obtained under irradiation (Fig.3b), and the defect could be finally closed by grafting of the largest wound area (Fig. 3c). The patient was then able to walk once again.

Discussion

The effect of wound irradiation with linear polarised incoherent light in promoting wound healing depends primarily, in our experience, on non-specific activation of fibroblasts, capillary blood vessels and epithelia. An immunosuppressant effect, which has also been confirmed for laser irradiation, probably plays an important part in this (11). Our results make it possible to identify

grades of efficacy in different types of wound. The most impressive improvements were in secondary healing of infected wounds, followed by defects associated with diabetic gangrene. Equally good results can be reported in the treatment of lower leg ulcers, even those with arterial causes responding well. The procedure has become routine with us in the early treatment (from the 2nd day) of fresh skin transplants, using Reverdin or Thiersch grafts.

With decubital ulcers it is necessary to differentiate fresh superficial defects, which responded well with rapid epithelial regeneration, from deep defects which first required extensive surgical treatment of necrotic tissue before success could be achieved. It would be irrational to expect "biostimulation" of necrotic tissue in such cases. In the healing phase, however, excellent acceleration of healing was to be seen. Our experience of burn wounds is too limited, owing to the small number of cases, for us to be able to confirm a truely positive effect. At the same time, almost the same healing progress was observed on both sides in a case of bilateral burns of the hands, in which one hand was treated conventionally, i.e. with baths and Refobacin cream, the other with bathing, wound drying and Evolite irradiation.

We have not extended Evolite irradiation to wounds healing primarily, apart from the above-mentioned cases of wound

oedema and suture-track infection, and can therefore make no statement about improved tensile strength, which is to be expected on the basis of laser studies (6, 4). The improvement of tensile strength in wounds healing primarily has also been confirmed recently for polarised light by a study performed in China, in which the direction of polarisation in relation to the wound axis is said to play a part (13).

The negative, fat-cell damaging influence of Evolite irradiation is the sole undesired side effect. This can, however, be readily eliminated by removal of superficially-arising necrotic tissue. In individual cases we also observed some "resistance" during several weeks' therapy, i.e no further progress took place after the wound initially responded well. This occurred with several decubital ulcers and in individual lower-leg ulcers, in the latter often before final healing.

Particularly impressive in the positive sense, on the other hand, were several cases who could be discharged from in-patient treatment after extensive healing, because their progress did not justify keeping them in the clinic for further treatment. Conventional therapy from the family doctor then rapidly led to deterioration in the state of the wound, which subsequently healed under renewed Evolite therapy, which we restarted on an out-patient basis.

In addition to the positive chances of healing therapy-

resistant wounds and the acceleration of wound healing, the savings on costly ointments and extensive dressings may also be significant.

The amount of time which needs to be devoted to wound care is quite similar to that with conventional therapy. In our experience, Evolite treatment of wounds can be generally recommended for the indications given.

Summary

Clinical experience is reported in the treatment of intransigent wounds with polarised light of defined energy content. Acceleration of granulation formation and epithelialisation, and reduction of both wound secretion and wound pain were observed. On theoretical grounds, an influence on the cell membrane and an immunosuppressive effect are worthy of consideration. The main indications for application are secondarily-healing wounds, defects following diabetic gangrene, leg ulcers of arterial and venous origin, and fresh skin grafts.

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Fig. 1a: Female patient A. Sch. 80 years old. Superinfected leg ulcer associated with occlusive arterial disease.

Fig. 1b: After 14 days Evolite irradiation and some antibiotic powder.

Fig. 1c: Reverdin graft healed under Evolite irradiation.

Fig. 2a: Female patient E. P. 74 years old. Diabetic gangrene of forefoot, partial amputation, condition after removal of necrotic tissue. Treatment with granulation-inducing ointments.

Fig. 2b: Three weeks later, rapid wound shrinkage and early epithelialisation with Evolite irradiation.

Fig. 2c: After another nine weeks, with Reverdin graft meanwhile, complete healing.

Fig. 3a: Female patient M. K. 83 years old. Combination of diabetes with severe arterial occlusive disease. Mid- foot amputation in line of first metatarsal.

Fig. 3b: After three weeks' Evolite irradiation, clean granulation and definite wound shrinkage.

Fig. 3c: Well-healed Reverdin graft in the largest wound area under early Evolite irradiation. In anterior part of wound, connective tissue still present.