EFFECT OF THE LASER BEAM ON THE SKIN*

Preliminary Report

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The first operating laser was developed by Maiman (1) in 1960. Since that time there has been considerable interest in the scientific and biological applications of this instrument. The laser (light amplification by stimulated emission of radiation) in brief, is an instrument which emits an intense, coherent, directional beam. Because of the fact that the beam is coherent and almost parallel, extremely small focal spots are made possible. The local energy density of irradiation which is attained is therefore extremely high. As yet, the upper limits of this power are not known. The laser may have as direct source of the emitted beam a crystal, gases, or even liquids. A semi-conductor of the gallium arsenide type as a junction diode now can produce essentially coherent light from electrical energy.

The instrument we used was a solid type containing a ruby crystal ¼″ x 2″, emitting a coherent light at 6943 A, a beam of 30 seconds of an arc, a pulse of 500 microseconds and an energy of 0.84 joules. Recently we have used a ruby laser with an output of more than 5 joules. (Maser Optics Inc.) This laser was mounted on an optical bench with an external lens system to focus the beam of light. Operating personnel wear B & L anti-laser protective glasses with 97 db attenuation at 6943 Å. It is essential that eye protection be used since severe eye damage may be produced by the laser beam even by reflection of the beam from specular surfaces. The filters in the protective glasses must be watched for fading and consequent reduction in protection. Operating personnel should have frequent eye examinations before starting to use the laser and at regular intervals thereafter.

At 4 KV power of the laser and with a single convex lens of 12 cm focal length, under the direction of Dr. Alan Freemond of the Department of Ophthalmology, eyes of nembutal-anesthetized rabbits with pupils dilated were exposed to the laser beam. No evident damage was produced in the eyes of albino rabbits. In the eyes of black rabbits, exposed to this same beam, severe and immediate eye damage resulted with extensive hemorrhage in the retina, retinal perforation and exposure of the sclera. After retinal photography, the eyes were enucleated and sectioned. Iris burns in addition to retinal burns were produced by the laser beam. These eye reactions are similar to those obtained by Zaret (2, 3).

Under the same conditions of operation of the laser, albino and colored rabbit skin and skin of Caucasian and Negro volunteers were exposed. White skin and white hairs of the rabbits showed no changes on gross examination or by examination with the skin microscope at 40 ×. Black hair showed charred areas with no evident change in the white skin underneath. The pigmented skin about the edge of the rabbit ear revealed a small, deep, charred through-and-through area with no effect on the finger of the individual holding the ear in the beam. Detailed sections were made of animal tissues exposed to the beam. Inflammatory reaction was evident in the tissues about the necrotic zone of the laser reaction. In the Negro skin, slight pricking was felt and a small 1.0 mm x 1.5 mm (average) area of white superficial scaling was observed at the impact of the laser beam. With the 5 joule laser more extensive changes were found. Surface photography of this at 40 × was done. The areas were excised and examined with routine and histochemical studies. The tissue destruction was superficial. There was inflammatory cellular response. Sulfhydryl stains showed no changes in keratin adjacent to impact area. The impact was represented by a superficial ulcer.

No lesions could be detected under similar conditions of exposure on Caucasian skin. In an effort to increase the absorption of the laser beam (4) the skin of Caucasian and Negro skin was covered with a blackish layer of soot from a glass slide held over a burning candle. In two Caucasian volunteers, the skin also was stripped by tape and the keratin removed only partially before rubbing in the soot. In skin of Negro patients, stripping was done also before exposure. Black oil crayons were used but were found less satisfactory. 90 per cent dihydroxyacetone in a hydrophilic base was also rubbed into the flexor surface of the forearms of Caucasian volunteers and twenty-four hours later this colored area was exposed to the laser beam. In all these experiments there was a clear white zone in the colored material at the small impact area of the laser beam. The reaction was more intense in the skin of Negro volunteers. Often a puff of smoke was observed at the impact area. These areas were examined under the skin microscope and no dark particles could be observed in this area. The skin surface was whitened and scaling. Dark hairs in the area were charred usually at the upper end. A

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patient with argyria was also exposed to the laser beam. There was no evident reaction in a deeply colored area of the chin. White skin covered with 10 per cent crude coal tar in vaseline base was also exposed. A reddish-brown spot at the impact area developed. This deposit could be wiped off. The skin underneath showed no change although the impact area was painful. Hairs in this area showed white charring at the top. It is evident then that dark color of the skin increases the absorption of the laser beam. With a lens of focal length of 12 mms. superficial burns were produced in baso-squamous papillomas of Caucasian patients. Light color may reflect and transmit the beam without causing any evident change. As control, a B-carbon rod and black cardboard and black carbon paper were exposed. A definite depression was produced in the carbon rod and a whitish area in the cardboard, and a through-and-through perforation of the carbon paper.

Also being studied are the effects of the laser beam on red cells, capillaries, old hemorrhage in the skin, pigmented nevi, pigmented basal cell carcinoma, tattoo marks, excised flaps of human and animal skin, and callosities colored with various pigments. In addition, lenses of shorter focal lengths and objectives of microscopes are being used to produce more intense local action. Some microscope lenses may be ruined by the laser beam (coating? cement?) (4). Measurements of red and infrared reflection and transmission through tissue are also to be made. Experiments have been done with fiber optics combined with laser beams to provide for deeper penetration into tissue and for visualization of deep structure of the skin. Finally, solid type lasers of higher energy values up to 60 joules have been leased for additional studies.

CONCLUSIONS

From preliminary studies, eye lesions of pigmented rabbits and skin lesions of pigmented areas of rabbits and man may be produced by the coherent beam of a ruby laser of only light power intensity. Dark color of the skin increases absorption of the laser beam. Eye protection of operating personnel is necessary.

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