Medical Application of N2 Laser to Treatment for Dermatomycosis

Medical Application of N_2 Laser to Treatment for Dermatomycosis

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Abstract—**The influence of N_2 laser irradiation on eumycetes and the practical effect of the irradiation on the lesion of tinea pedis have been studied experimentally. It has been confirmed that the sterilizing effect of N_2 laser may be used successfully for the medical treatment for dermatomycosis.**

Today the laser has found widespread application in medicine from diagnostics to therapeutics [1]–[3]. In dermatology, the ruby laser has been used successfully for the removal of the nevus [4], [5], but the ultraviolet laser has not yet been used for such medical treatment. The nitrogen gas laser of 3371 Å (N_2 laser), which is the most popular ultraviolet laser [6], has a sterilizing effect and a suitable penetration into the skin. It can then be expected that the N_2 laser is applied to the treatment for the superficial dermatophytosis.

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This communication deals with the influence of N_2 laser irradiation on eumycetes (*Saccharomyces cerevisiae*, *Microsporum canis*, and *Trichophyton rubrum*) and the practical effect of the irradiation on the lesions of tinea pedis.

Quantitative study on the effect of N_2 laser irradiation on eumycetes was done using *S. cerevisiae* of haploid strain (T55a). The cells were sown on the nutrient agar medium at the density of about 10^4 cells/cm^2. After the N_2 laser irradiation, cell shape and cell number were followed by microscopic observation. *M. canis* and *T. rubrum* which are representatives of dermatophyte were also planted on Sabrouraud's nutrient agar medium. In these cases the degree of growth of hypha and the morphological change in cells were observed with a phase-contrast microscope or the naked eye. All experiments were carried out at a temperature of 25°C. The N_2 laser is a transversely excited nitrogen laser that has been designed and constructed in our laboratory using ceramic capacitors [7]. The laser was operated at a repetition of 10 Hz throughout this experiment. The peak power is approximately 400 kW, pulsewidth 5 ns, and beam cross section 20×5 mm^2. By the use of a fused quartz lens (focal length of 70 mm) the laser beam was out-focused for the irradiation on to the nutrient agar (area of 8×2 mm^2 or so) or focused for the irradiation on to the lesions of skin.

Fig. 1(a) shows the dose-response of survival in *S. cerevisiae*. It is seen that the survival ratio decreases almost exponentially with dose of the laser light. The effect of near ultraviolet light (3000–3800 Å) on some bacteria have been investigated by

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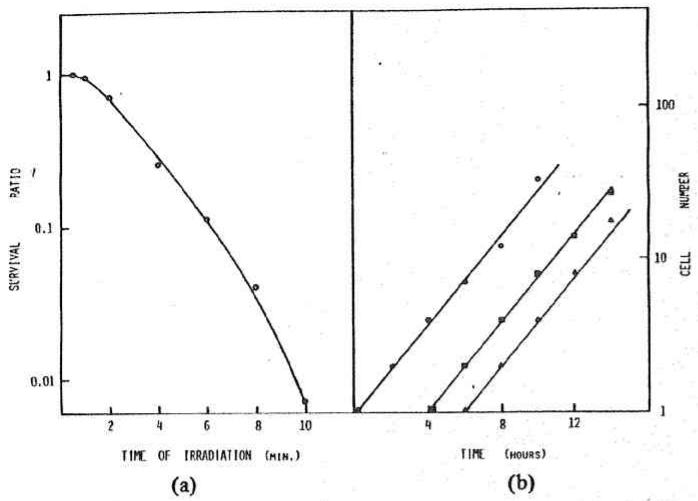

Fig. 1. Survival and growth behavior of yeast under N_2 laser irradiation. (a) Survival ratio against dose (in time). The lethality was measured at 24 h after the irradiation. (b) Growth curve for various doses (in time); circle–control, square–2 min irradiation, triangle–4 min irradiation.

other researchers [8], [9] using conventional light sources. This feature agrees approximately with their results. In Fig. 1(b) the course of cell division of the survivors is shown in comparison with that of the control. It is noted that the greater the dose the longer the time neccessary for the first division to take place, whereas once the first division has occurred, subsequent divisions proceed with the same division time as that of the control. A similar result is shown in the experiment made by Jagger and co-workers [10] who have studied the division delay in *Escherichia coli* caused by irradiation with near UV light from a mercury lamp. According to their consideration it is supposed that the damage induced by N_2 laser irradiation is also nongenetic and the lethal effect is mainly due to the damage in the metabolic system. Fig. 2(a) shows the inhibition in multiplication of *M. canis* induced by 5 min irradiation with N_2 laser. It is seen that the cells in the irradiated portion are completely killed by the dose. Fig. 2(b) shows a microscopic view of the nonirradiated portion. Fig. 2(c) shows the irradiated portion microscopically. In this case many vacuoles are observed in the cells of hyphae and conidia, which indicates the occurrence of degeneration. Fig. 2(d) shows the hyphae of *T. rubrum* before irradiation and Fig. 2(e) shows them after irradiation. As in the case of *M. canis* the degeneration of the cells is clearly noticed. Practical application of N_2 laser to medical treatment was carried out on vesicular lesions of the feet of the present authors suffering with tinea pedis. By virtue of about 10 s/mm^2 irradiation, itchiness ceased within about 12 h after the irradiation and the vesicles almost completely disappeared in about 2 days. At the instant of the irradiation very faint pain was felt due to heat generation. Therefore, in addition to the UV effect, the thermal effect may play a part in killing dermatophytes in epidermis. In order to make clear the penetration of the N_2 laser into skin, a biopsy was done. A biopsy specimen was taken from a irradiation lesion 24 h after N_2 laser exposure. The condition of the irradiation is the same with the abovementioned one. Microscopically, necrosis of the epidermis was observed as shown in Fig. 3.

In conclusion, at the present stage of experiments, it seems that the lethal effect of the N_2 laser irradiation is not essentially different from that of black light. But a few experiments on the effect of the N_2 laser irradiation on the affected parts suggest that N_2 laser treatment combined with medical therapy will become one of the powerful methods for the treatment of the superficial dermatophytosis. Further experiments on the effects are now continuing.

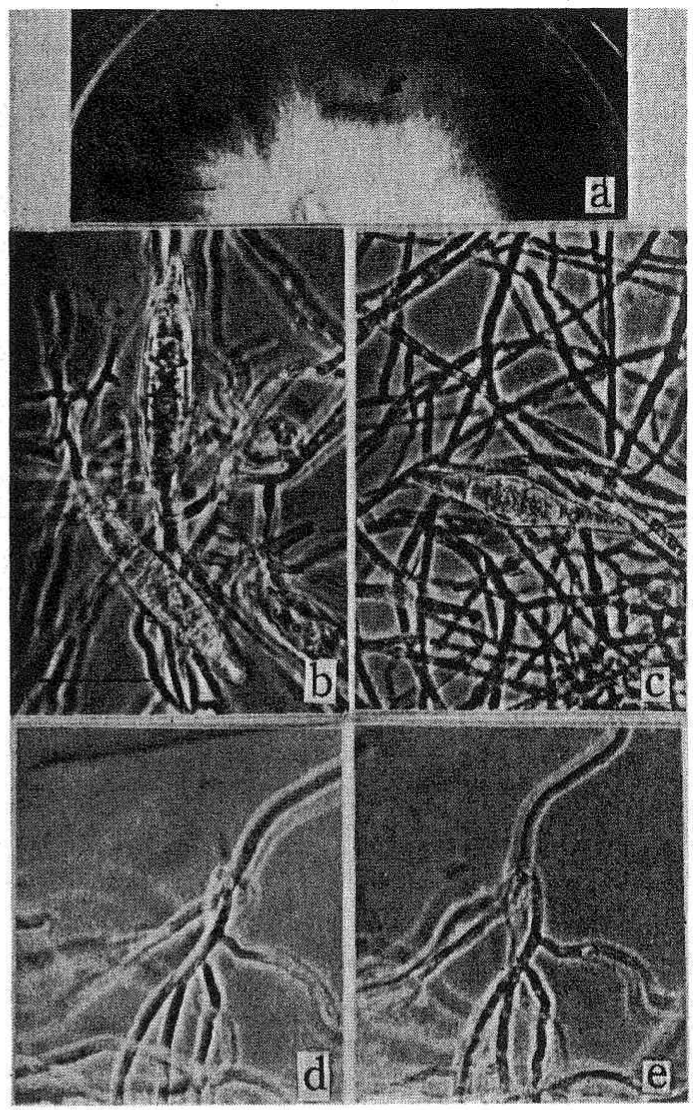

Fig. 2. N_2 laser effect on *M. canis* and *T. rubrum*. (a) Lethal region (arrow) in *M. canis* under 5 min irradiation. (b) Nonirradiated portion (*M. canis*). Conidia and hyphae germinate and proliferate vigorously. (c) Hyphae and conidia of *M. canis* under 5 min irradiation. Hyphae and conidia are degenerated. (d) Hyphae of *T. rubrum* before the irradiation. (e) The same as (d) but under 5 min irradiation. Photographs in Figs. 1 and 2 were taken 1 day after the irradiation by phase-contrast microscopy. Bar in (a) is 10 mm and the one in (b) is 50 μm. Scale in (c)–(e) is the same as (b).

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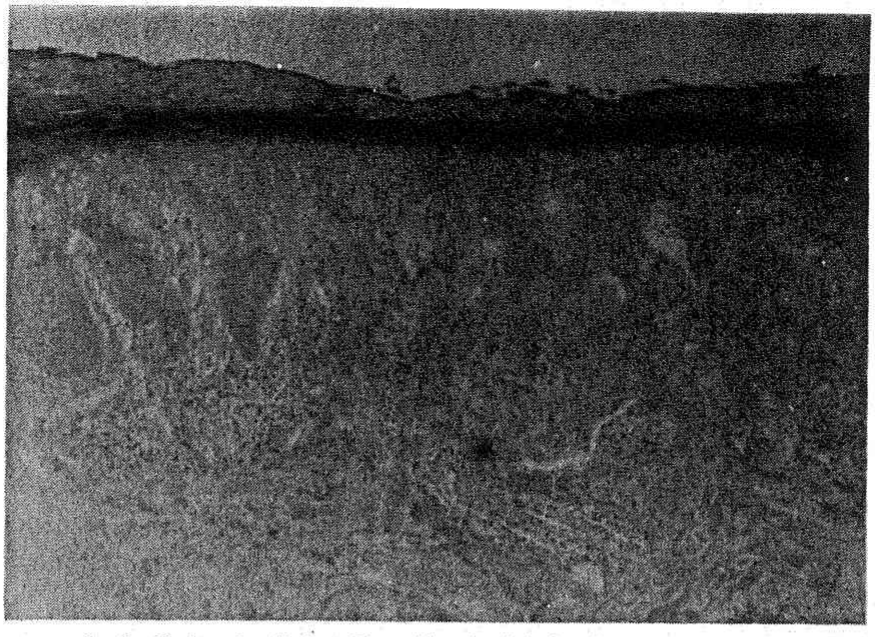

Fig. 3. Skin changes under the N_2 laser irradiation. The epidermis of the irradiation area shows necrosis (on the right-hand side of the picture). Nuclei of epidermis have disappeared and the epidermis is homogeneous (magnification = 60×).

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Correction to "Biomedical Engineering Education: Enrollment, Courses, Degrees, and Employment"

In the above paper,[1] the University of Illinois at Chicago Circle was inadvertently omitted, in a listing of accredited undergraduate biomedical engineering programs. This university offers an ABET/ECPD accredited undergraduate program in engineering science with an option in biomedical engineering.

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