Modern Problems in Ophthalmology
Editor: E. B. Streiff, Lausanne
Publishers: S. Karger, Basel
Reprint (Printed in Switzerland)

Mod. Probl. Ophthal., vol. 20, pp. 169–173 (Karger, Basel 1979)

Comparison of Temperature Measurements and Fundus Reflectometry in Laser Coagulation[1]

V.-P. Gabel, R. Birngruber, W. Weinberg, R. McCord and F. Hillenkamp

Augenklinik der Universität München, München, Gesellschaft für Strahlen- und Umweltforschung, Neuherberg, and Institut für Biophysik der Universität Frankfurt, Frankfurt/Main

In light coagulation, thermal parameters play an important role for the biological reaction. Therefore, we measured the temperature increase and the whitening of the coagulation site simultaneously during the coagulation.

Microthermocouples [1] were developed as shown in figure 1. The diameter of the tip ranges between 5 and 10 μm, the response time of this element is in the region of 1 msec. We designed a technique to insert this thermocouple into the globe through a trepanation at the pars plana (fig. 2). The tip is advanced by a step motor and can be positioned exactly by a micromanipulater anywhere within the posterior pole. Coagulation of 500 μm in diameter were set in rabbit eyes with an argon laser coagulator using a slitlamp contact lens arrangement. The temperature in the center of the lesion at the interface between the PE and retina is monitored during and after the coagulation (fig. 3).

To demonstrate our method, figure 4 shows a typical temperature course during a weak coagulation. The light reflected from the coagulation site is monitored simultaneously with the temperature. The details of this technique have been reported in a paper at the 1976 Gonin Meeting in Lausanne by *Birngruber et al.* [2].

The upper curve of figure 4 shows the temperature course as a function of time, the lower curve shows the corresponding course of the reflected light. In this case, the temperature increases by about 35 °C, but no change of the reflected light can be observed. This indicates that the

[1] This work was supported by the Herrmann Wacker Fond.

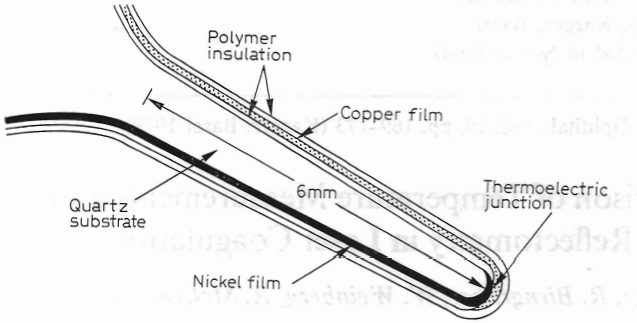


Fig. 1. Shematic cross-section of probe (not to scale).

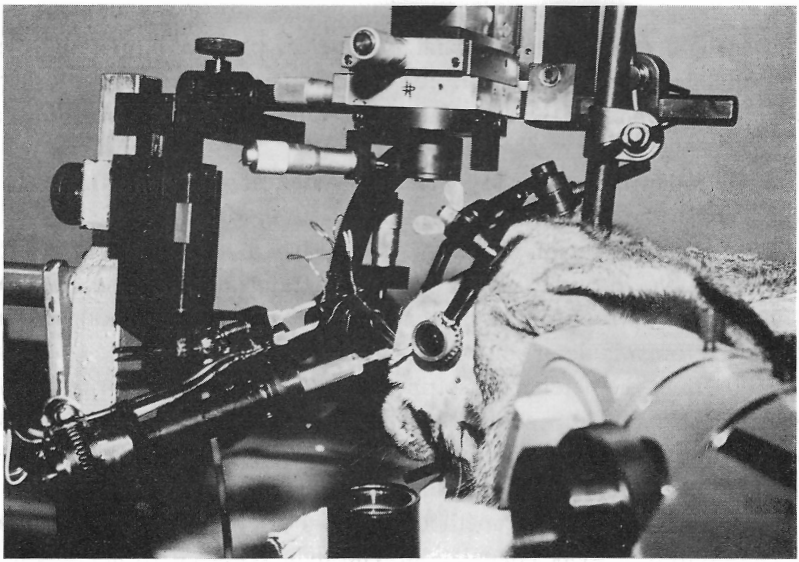
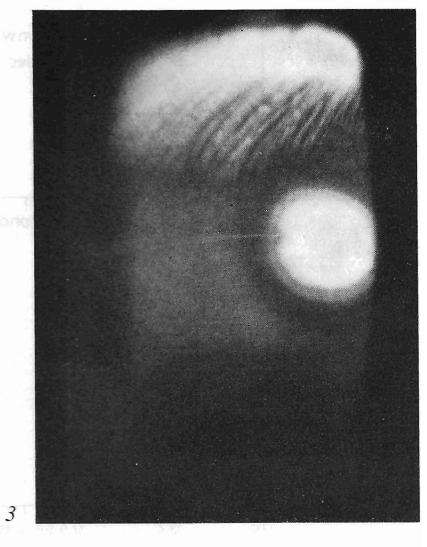
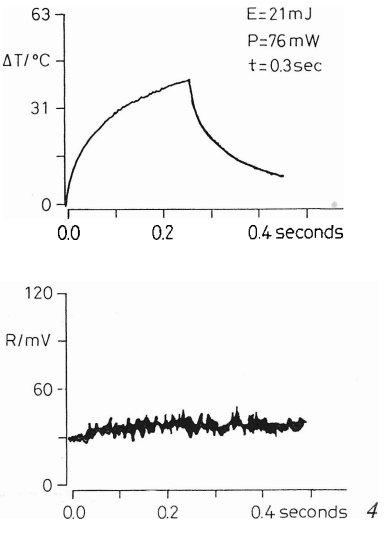


Fig. 2. Experimental set-up.

coagulation is below the level of ophthalmoscopic visibility. The combination of fundus reflectometry and temperature measurements during the exposure can help to answer some questions in clinical light coagulation. For example, in creation comparable clinical lesions, this combination can demonstrate the correlation between temperature and energy for dif-





3 4

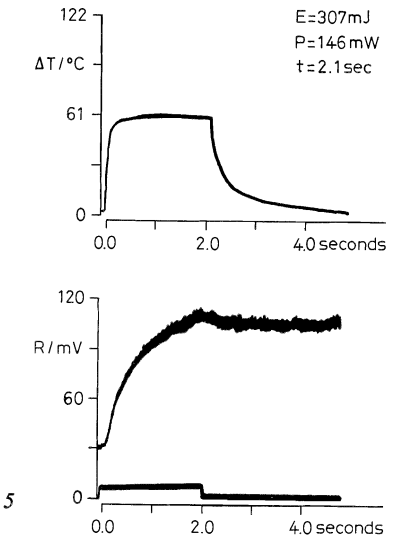
Fig. 3. Thermocouple placed on coagulation in the fundus of rabbit eye.

Fig. 4. Temperature profile (upper diagram) and reflectogram (lower diagram) of a weak, ophthalmoscopically non-visible coagulation.

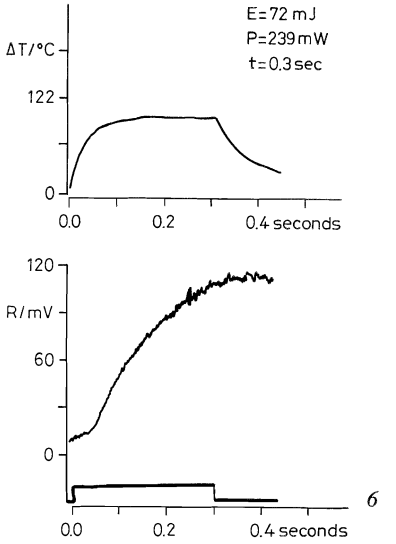
ferent exposure times. For this purpose lesions were produced with exposure time between 0.3 and 2 sec. The whitening was monitored; energy and/or exposure time were chosen to render equal changes in reflected light for all exposures. This means that the coagulation would appear the same under visual observation.

The results are demonstrated in figures 5 and 6. A coagulation with an exposure time of 2.1 sec and a total energy of 307 mJ corresponding to a power of 146 mW is shown in figure 5. The temperature increases by about 60 °C, and results in a typical clinical coagulation. The marked increase in reflected light demonstrates this fact. For an exposure time of 300 msec, the corresponding diagrams are shown in figure 6. Using an energy of 72 mJ, it was possible to produce a coagulation with the same ophthalmoscopic appearance as demonstrated by nearly the same increase of reflected light at the end of the coagulation. On the other hand, the temperature rises by about as much as 90 °C in this case.

Comparing the parameters of these two coagulations we can conclude: The energy necessary for a clinical coagulation using an exposure time of 2.1 sec is 307 mJ, and the resulting rise of temperature will be



5



6

Fig. 5. Temperature profile (upper diagram) and reflectogram (lower diagram) of a typical clinical coagulation with a long time exposure.

Fig. 6. Temperature profile (upper diagram) and reflectogram (lower diagram) of a clinical coagulation, which has the ophthalmoscopically identical appearance as the coagulation shown in figure 5.

about 60 °C. Whereas, in the case of the short exposure time of 300 msec, the energy for the same type of lesion is only 72 mJ, but the temperature rises by 90 °C. In other words, when we reduce the exposure time by a factor of 7, the temperature increases only by factor of 1.5 to produce a comparable lesion. This reflects a rather complicated dependence of the damage mechanism on temperature and period of the temperature elevation.

In summary, short exposure times in light coagulation help to avoid unnecessary thermal load of the eye by saving a great amount of energy. On the other hand, the danger of unwanted mechanical effects, such as hemorrhages, increase likewise with short exposure times due to a faster rise of the tissue to a higher final temperature. We therefore recommend exposure times in the range of 100–300 msec, which are a good compromise between reducing the energy and obtaining a sufficient therapeutic spectrum.

References

1 McCord, R. C.; Weinberg, W., and Hillenkamp, F.: Microminiature thermoelectric sensors for dynamic temperature measurements in laser irradiated tissue. Adv. biomed. Technol. *20:* suppl., pp. 171–172 (1975).

2 Birngruber, R.; Gabel, H. P., and Hillenkamp, F.: Fundus reflectometry: a step towards optimization of the retina photocoagulation. Mod. Probl. Ophthal., vol. 18, pp. 383–390 (Karger, Basel 1977).

Priv. Doz. Dr. med. habil. V.-P. Gabel, Augenklinik der Universität München, Mathildenstrasse 8, D–8000 München 2 (FRG)