OPTICAL PROPERTIES OF NORMAL HUMAN INTRACRANIAL TISSUES IN THE SPECTRAL RANGE OF 400 TO 2500 NM

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INTRODUCTION

Optical properties describe the physical interactions between electromagnetic radiation and matter dependent on the wavelength of the radiation. Incident power may be reflected, absorbed, scattered and/or transmitted. Reflection may consist of specular reflection and back scattering from inside the matter. The total amount of absorption and internal scattering may be expressed as extinction. According to the law of energy conservation, reflection, extinction and transmission add up to 1. For that reason, measuring optical properties of tissues must include at least two of these parameters or one of them must be excluded by the experimental design. Using a semi-infinite thickness of specimens, the influence of transmitted power may be neglected. According to the Kubelka-Munk-theory (Kubelka and Munk 1931, Kubelka 1948), the ratio of absorption and scattering can be calculated from reflection measurements assuming an ideally black background and a semi-infinite slice thickness (Blazek 1979). In reflection as well as in transmission measurements it has to be considered that the intensity of reflected and transmitted power depends on the solid angle of reflection or transmission (Hardy et al. 1956, Longini et al. 1968). This problem may be solved by using a two-beam spectral photometer with an integrating sphere as measuring instrument (Blazek 1975).

The knowledge of optical properties of normal intracranial tissues within a rather wide spectral range may influence the use of lasers as neurosurgical tools. It may be of some help for photodynamic therapy of brain tumors (Boggan et al. 1985, Cheng et al. 1986) as well as for in vivo measurements of cerebral blood flow and metabolism. The following contribution deals with the optical properties of normal brain tissue, meninges and arterial walls between 400 and 2500 nm measured with a two-beam spectral photometer using an integrating sphere as measuring instrument.
MATERIALS AND METHODS

A two-beam spectral photometer with an integrating sphere of 60 mm in diameter (UV/VIS/NIR-Spectrometer, Lambda 9; Perkin & Elmer, Überlingen, Germany) was used in order to measure spectral reflection and transmission. The measuring range extended from 400 to 2500 nm. The instrument provides a wavelength accuracy of ± 0.2 nm (UV/VIS) respectively ± 0.8 nm (NIR), a wavelength reproducibility of ± 0.05 nm (UV/VIS) resp. ± 0.2 nm (NIR), a photometrical accuracy of ± 0.003 E at 1E, and a photometrical reproducibility of ± 0.001 E. The measuring and reference beam are calibrated by aiming the beams at reflection standards made of barium sulfate. Calibration and zero adjustment are carried out automatically. A spectral band width of 2 nm and a scan speed of 960 nm/min were chosen. Measured data were recorded on-line with a plotter and simultaneously saved at a floppy disc. By this means, computer assisted data processing became possible. For statistical calculations a spectral band width of 10 nm was used.

The spectral reflectance expressed as a percentage of incident power was measured in tissue samples of at least 5 mm in thickness. This thickness seemed to be sufficient to meet the Kubelka-Munk theory (Kubelka and Munk 1931, Kubelka 1948) and to approximate the intraoperative use of lasers, in which a semi-infinite slice thickness usually has to be assumed. The tissue samples were mounted at slides made of quartz glass (Suprasil®). The ratio of spectral absorption and scattering was calculated according to the Kubelka-Munk theory as described earlier (Eggert and Blazek 1987).

![Reflection vs Wavelength](image)

**FIGURE 1.** Frontal gray matter: relative levels of reflection plotted against wavelength, means ± SD.