

EFFECTS OF MICROWAVE AND MILLIMETER WAVE RADIATION ON THE EYE

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1. Introduction

Exposure of the eye to microwave radiation can lead to intraocular temperature increase sufficient to damage tissues. The eye of mammalian species does not efficiently remove heat. Within the anterior segment of the eye, active thermal transport is not known to occur. Conduction through the sclera and convection from the surface of the cornea is the primary avenue for heat dissipation which is poor compared to many other tissues in the body. The anterior segment can be closer to ambient temperature than the posterior segment. On the other hand, a primary avenue of heat dissipation in the posterior segment of the eye is bloodflow through the choroidal vascular system which lies just inside the sclera. It is thought to act as a heat sink and maintain a stable thermal environment for rod and cone cell metabolism in the retina [1, 2, 3]. Bloodflow throughout the retina may also serve to maintain a stable thermal environment for the photoreceptors. Many investigators have postulated that the poor heat dissipation capability from within the anterior segment of the eye of humans and other animals may lead to heat buildup and subsequent thermal damage [4]. For many, this has implied that the eye is sensitive to heating and especially sensitive to heat deposited within the anterior segment of the eye by deeper penetrating microwaves. Early investigations of microwave produced eye damage focused on the production of cataracts. In the past several years, new studies have investigated microwave effects on the retina, iris vasculature, and corneal endothelium.

At the much shorter wavelengths of millimeter waves, damage to the eye may occur near the radiated surface such as the cornea [5, 6]. Absorption of energy from this portion of the spectrum occurs within less than a millimeter resulting in very high specific absorption rates and rapid temperature increases. Few studies have been conducted at millimeter wavelengths to evaluate either acute exposure effects, or to

determine if changes occur with prolonged exposures. This paper presents a short summary of many of the reported ocular effects of microwave and millimeter wave radiation.

2. Cataract Formation

Much of the early laboratory research on microwave damage to the eye was conducted at 6 GHz and below [7, 8]. The research focused mainly on acute exposure damage to the lens. The lens lies just behind the iris and pupil of the eye in the anterior segment. The lens can become cloudy or opaque due to injury, aging, or disease. Opacification resulting from microwave irradiation was usually found localized in the posterior portion of the lens capsule, but at higher frequencies (above 6 GHz) they were localized in the anterior portion of the lens. Most of the early research was carried out in the lower portion of the microwave spectrum (at 2.45 GHz) and demonstrated a high dose response relationship between microwave exposure and cataract induction [7]. For example, Carpenter and Van Ummersen [9] irradiated anesthetized rabbits at 2.45 GHz and showed a decreasing threshold for cataractogenesis from 4 minute exposure at 400 mW/cm² to 40 minutes at 80 mW/cm². Guy et al. [10] repeated some of the earlier research and found essentially the same threshold for cataract production in rabbits exposed with a near field applicator at 2.45 GHz. At minimum, they determined that 150 mW/cm² was required for 100 min. to produce a cataract. The maximum specific absorption rate (SAR) associated with cataract production was 138 W/kg. Kramar et al., [11] found nearly the same threshold (180 mW/cm² for 140 min.) for rabbits exposed to 2.45 GHz radiation. Interestingly, they found that exposures even higher in power density (500 mW/cm² for 60 min.) could not produce a similar cataract in rhesus monkeys. This was attributed to poor absorption by the monkey skull due to shape and the more recessed eye sockets that found on the rabbit. It is important to note that at the power densities and exposure durations used in these studies, far field exposure would be lethal for the exposed animal long before a cataract could be formed [7].

3. Retinal and Corneal Damage

Research and clinical findings over the past 10 years have indicated that absorption of microwave radiation at power densities much lower than induce cataracts can cause damage to the retina. A recent report of an accidental overexposure described retinal damage [12]. The authors presented a case report of retinal damage resulting from microwave exposure of a 44-yr-old male who received two 15-min accidental exposures to 30-W, 6-GHz CW microwave radiation while inspecting a 3.2-m satellite transmitter dish. He developed facial erythema, bilateral foreign body sensation, and blurred vision. When given an ophthalmologic examination 5 days later, the subject had corrected visual acuity of 20/20 in the right eye and 20/25 in the left. A slit lamp examination showed superficial eyelid erythema, bilateral superficial punctate