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Piezoelectricity in the human pineal gland

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Abstract

Melatonin secretion by the pineal gland has been reported to be affected by exposure to electromagnetic fields (EMFs). In an initial investigation to determine if calcifications commonly found in the pineal gland could respond to EMFs by a transducer mechanism, studies were conducted to ascertain if pineal tissues were piezoelectric. Second harmonic generation (SHG) measurements showed that pineal tissues contained noncentrosymmetric crystals, thus proving the presence of piezoelectricity. Both mulberry-like and faceted crystalline calcifications were observed by scanning electron microscopy (SEM). Some of the calcifications had compositions similar to that of hydroxyapatite; others contained a high concentration of aluminum.

Keywords: Aluminum; Calcification; Crystals; Electromagnetic fields; Scanning electron microscopy (SEM); Second harmonic generation (SHG)

1. Introduction

There is evidence that melatonin secretion by the pineal gland is affected by exposure to electromagnetic fields (EMFs) [1], but the mechanism by which the EMF is converted into intracellular second messengers that regulate melatonin gene expression is unknown. The pineal contains unusual calcified deposits that are chemically similar to bone mineral [2], and it occurred to us that the presence of calcifications and the sensitivity of the pineal to EMFs might be related.

Pineal calcifications occur in subjects of any age [3], but apparently in amounts that are relatively independent of age [4]. Neither the mechanism of formation nor the physiological significance of pineal calcifications are known [5]. There is microscopic evidence of an intimate association between the calcifications and cellular membranes [6]. Pineal calcifications have been given numerous names in the literature, including corpora arenacea, acervuli, psammoma bodies and brain sand [6].

Piezoelectricity is a third-rank tensorial property exhibited by members of the 20 noncentrosymmetric crystal point groups [7]. (In addition, a 21st point group 432 is also noncentrosymmetric but its members are not piezoelectric because of the presence of other elements of crystallographic symmetry.) In the direct piezoelectric effect, an elastic stress gives rise to a voltage; in the converse effect, an applied voltage results in elastic strain. If the pineal calcifications were piezoelectric, they could produce a surface charge distribution and a strain by virtue of the interaction of the direct and the converse piezoelectric effects whenever a subject was exposed to an appropriate EMF. In principle, either the electrical or mechanical changes could trigger intracellular second messengers that regulate the metabolism of pinealocytes.

The principal objective of this research was to determine whether the calcifications present in the human pineal gland were piezoelectric. The classical methods for measuring piezoelectricity [8,9] are not suitable for examination of specimens containing small piezoelectric crystals dispersed in a nonpiezoelectric material. Consequently, an alternative technique that would detect noncentrosymmetry was selected: second harmonic generation (SHG) [10,11].

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