Propagation of microwave electromagnetic filed in live tissues

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Abstract

Effects of electromagnetic fields on living cells depend on the frequency. The purpose of this article is to show the influence of the microwaves and in particular the wave of the decimetre range beyond the human. The performed studies showed that more effective treatment we have, when the frequencies are very high in the range of 2-3 GHz. These frequencies and wavelengths are the most efficient and allowing for much deeper action and better controlability of intensity of the warming. Electromagnetic waves of this range are well defined optical properties and can guide and reflect. Studies were made with dipole antennas with hemispherical or semi-cylindrical reflectors of different sizes and in various locations. The achieved results are applied to observed the penetration of microwave electromagnetic fields in our body and its positive impact on the treatment of certain diseases.

1. Introduction

In microwave therapy, the patient is set in electromagnetic fields with frequencies a few GHz, which means that the wavelength is from 10 to 70 cm. The energy of microwaves, absorbed from the body tissues, is converted into heat, significantly more effective than the energy of longer wavelengths.

During the action of the variable electric field on the dielectric, the sign of polarization and orientation of the dipole, changing with the frequency of change of the sign on the field. At the high frequencies of electrical field, the polarizing molecules fail completely to change their spatial orientation and occur vibrations of the dipoles around neutral position. This process is associated with generate the heat.

2. Theoretical solution

At the frequencies above 500 kHz, the irritation of the current became so weak, that the patient can't feel anything. The electromagnetic oscillations with high frequencies are used for heating of living tissue by converting the electromagnetic energy of high frequency current or high frequency field in the heat. In these high frequencies, the currents even up to several amps do not cause irritation. Characteristic is that the heat is produced inside the body itself, where the applied energy is converted into thermal energy (heat endogenous), but the distribution of energy in the various methods is not uniform. By increasing the frequency of the alternating current is reduced the time to move of ions in one direction, consequently fewer ions accumulate at the border semi-permeable cell membranes and reduces irritation. At frequencies above 500 kHz do not get enough concentration of ions to be induced excitation. Even at these frequencies, the ions vibrate around a midpoint. Since there is no irritant effect, the current can be increased until we get a heat. The quantity of heat released from various tissues is inversely proportional to the conductivity of tissues.

Furthermore, since there is no irritant, this allowed larger current densities under the electrodes, thus reduces the contact resistance between electrode and skin. Table 1 gives the specific resistance of the major tissues of the body at frequencies in the range of 2-3 GHz. [2]

Specific Electrical Resistance of the tissues [Ω.m]	
Tissue	*Frequency in range 2-3 GHz*
Blood	0,65
Muscles	0,49
Internal Organs	0,4 - 0,8
Nerve Tissues	0,4 – 0,9
Fatty Tissues	8 -30

Table 1 Specific electrical resistance of the tissues in the human body

The heat q, release per unit time, per unit volume of homogeneous tissue for passing of high currents is:

$$q = k\frac{\Delta^2}{\sigma}$$

where: Δ - current density;

k - coefficient of proportionality;

σ - specific conductivity of the tissue through which currents passing.

The separated heat is determined by the geometrical parameters of the electrodes, how they were placed against the body, but the frequency, the electrical conductivity of tissues and their dielectric properties. Therefore, different tissues in specific for their frequencies will receive the maximum amount of heat.

The energy absorption of microwaves from the tissues of living tissues and converting it into heat shall result in energy losses in ion conduction and dielectric losses, associated with relaxation oscillations of the dipoles. The absorption of the ion conductivity does not depend on frequency in the range of microwaves.

The intensity of the microwaves as they pass through the environment, which absorbs reduces to an exponential law. The depth at which the intensity decreases called absorption half - width *h*. [1]

$$\frac{1}{2}J(0) = J(0)exp(-\alpha h),$$

Where:

$J(0)$ – the intensity of surface (x = 0).

α – absorption coefficient.

Absorption half - width is determined by the expression:

$$h = \frac{\ln 2}{\alpha}$$

We estimated that if we have wavelength 12 cm, absorption half – width will be 0,9 cm.

Upon irradiation of homogeneous tissues, the heat is distributed in depth by an exponential law. When they are exposed to microwave, the layers of different tissues obtained reflection from boundary surfaces, when the permittivity of the layers is different. This phenomenon changed the distribution of energy absorbed and deep heating of tissues. On the boundary surfaces between the layers of the different tissues, temperature peaks are obtained.

3. Basic components of the microwave therapy and irradiation of the different reflectors

The impact of the microwaves of a human's body can be achieved through dipole antennas with hemispherical or semi-cylindrical reflectors. They can be seen on Fig.1. Reflectors are placed directly on the area, which has to be heated, or at some distance from it. Reflectors can be closer or further away, so they can adjust their distance to the skin, which must be 2-10cm.

Figure 2 shows the microwave apparatus and its application (Fig. 3).

Figure 1. Different reflectors

Figure 2. Device for microwave therapy

Figure 3. Applied to the patient

4. Microwave therapies and the positive influence of them

One of the main and not quite resolved issues, in microwave therapy is the determination of energy, which is absorbed by the object. It was made a lot of researches, which showing that ultra-high frequency waves with a wavelength of 69 cm, i.e. the frequency is 433,92 MHz, are the most perspective. These waves have similar physiological action with the other high frequencies currents, but they penetrate to greater depths. The differences relate to absorption of electromagnetic energy and its distribution in different tissues. They have the least thermal effect of fat tissues, but their energy is distributed more evenly in tissues. Recently, ultra-high frequency waves have a good therapeutic effect in: transient disorders of cerebral circulation, stroke, vascular incidents in the central nervous system, chronic arterial insufficiency of lower extremities. Improves microcirculation, rheological properties of blood, detection of shunting, increased cell permeability. The conclusion is that the ultra-high frequency waves have a beneficial effect on the functional status of heart.

Improves tissue oxygen saturation and metabolic processes in cells.

In medicine is mainly used microwaves with wavelength 12.2 cm, 12.4 cm and 12.6 cm which are on the border with UHF. In practice, apparatus are used primarily, generating capacity to 200 W at 2450 MHz operating frequency, i.e. the wavelength is 12.2 cm.

The duration of procedures depends on the dosage, but they are weak - 0,36 W/cm^2, average - 0,56 W/cm^2 and strong - 1,5 W/cm^2. The duration of the procedures is from 5 to 10-20 min. In acute and sub-acute inflammatory processes are used weak doses. These doses are recommended and low exposure areas vascularised or near such (ovaries, eyes). Irrespective of different coefficients of reflection of the individual tissues, centimeter waves are absorbed significantly (40-75 %). They are penetrated to a depth of 5-6 cm. The next Figure 4 shows the distribution of heat in the UHF and microwaves in various tissues.

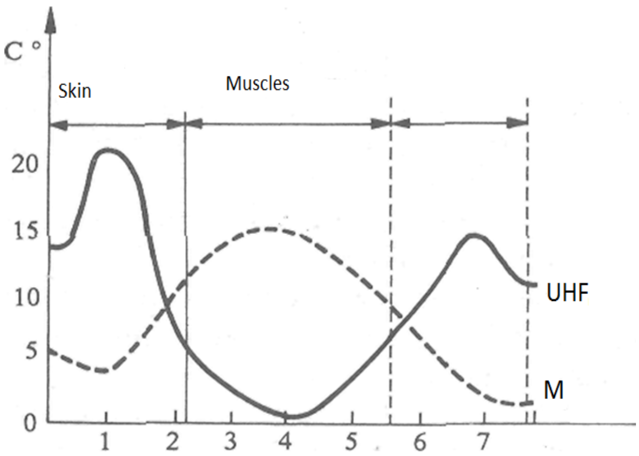

Figure 4. The difference between UHF and microwaves

The different design of reflectors for directing of the microwaves amended distribution of heat. Figure 5 shows the distribution of heat, perpendicular to the axis of irradiation with hemispherical (Figure 5a) and semi-cylindrical reflector (Figure 5b).

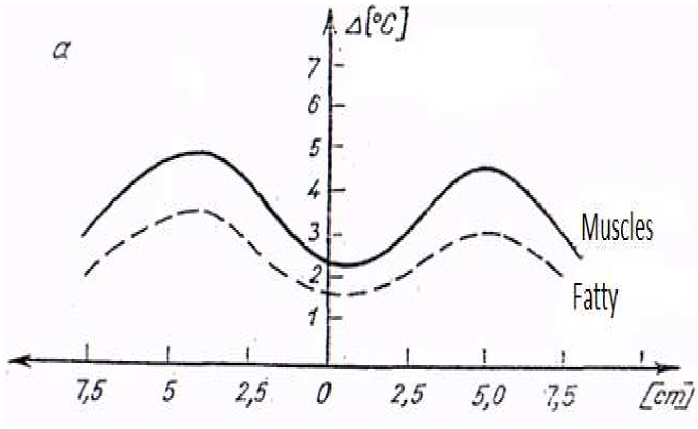

Figure 5a. Irradiation with hemispherical reflector

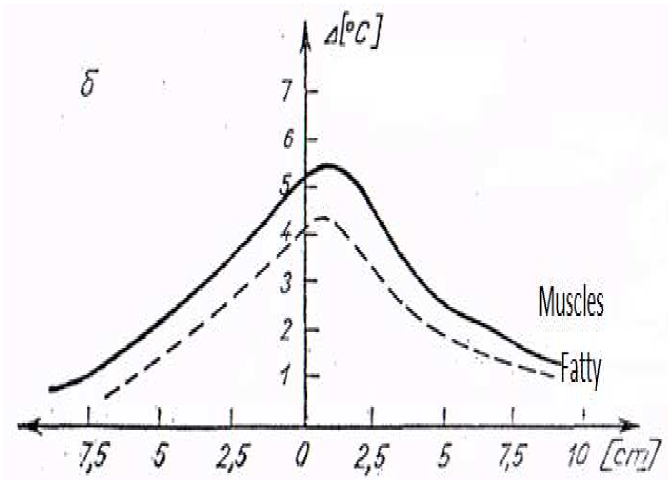

Figure 5b. Irradiation with semi-cylindrical reflector

Figure 6 is shown schematically, the extent of absorption of electromagnetic energy of the electromagnetic energy in our body depth with different methods of high-heat treatment. Observe that the capacitor field, where the wavelength is 11,12 cm (Figure 6a) heating occurs deeper underlying tissues. In inductive heating electrode receives the muscles (Figure 6b). The same distribution is observed and with longer decimeter waves, where the wavelength is 69 cm, it can be seen in the Figure 6d. The scope of ultra-high frequency waves, the longer waves have greater depth effect of the shorter (Figure 6c). In ultra-high frequency waves through the radiator, representing a symmetric vibrator and reflector, achieves much higher warming of the deeper tissues (Figure 6e). [5]

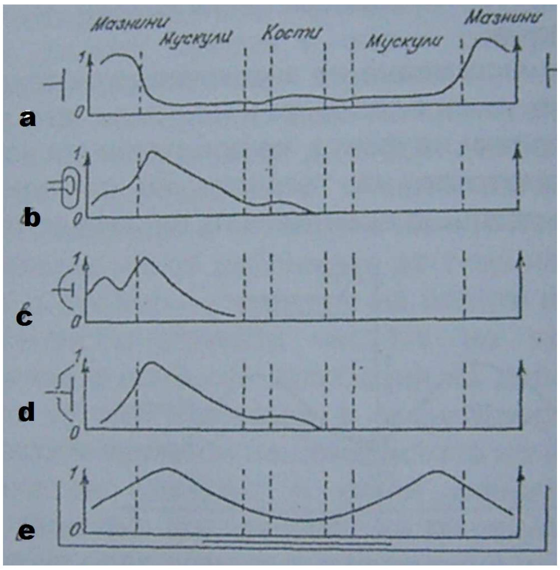

Figure 6. The extent of absorption of electromagnetic energy of the electromagnetic energy in our body depth with different methods of high-heat treatment.

Skin and subcutis absorbs less microwave energy, allowing to penetrate without much loss to the muscles and the blood tissue, unlike the electromagnetic waves used in the UHF field. Microwaves at low doses appear to be particularly beneficial on vascular permeability in inflammation and allergic conditions. They also raise redox processes in the tissues. In small doses increases the protein content and phosphorylase activity in skeletal muscle.

5. Conclusion

1. Describes the change of the field from the location and the different size of reflector and heat generation in the body.
2. Positive effect of the microwave therapies in our bodies

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Note: *Publication of the this paper is on the base of financial support of contract No. 122ПД0009-07 of Scientific- Research Centre of Technical University- Sofia*