

Microwave Thermotherapy — Technical and Clinical Aspects

J. Vrba, L. Oppl, J. H. Trefna, T. Drizdal, and R. Zajicek

Czech Technical University, Czech Republic

J. Kvěch and J. Kubeš

Institute of Radiation Oncology, Czech Republic

We would like to describe our new technical results dealing with microwave thermotherapy in the cancer treatment. Our research interest is to develop applicators for deep local heating and for intracavitary cancer treatment as well. Basic evaluation of clinical results is presented.

Deep Local and Regional Applicators

Microwave thermotherapy (hyperthermia) is being used for cancer treatment since early 80's in many countries around the world. Since 1981 we were interested in the local external applicators working at 434 MHz and 2450 MHz. These applicators were used here in Prague for the treatment of more than 500 patients with superficial or subcutaneous tumours (up to the depth of approximately 4 cm). Now, following new trends in this field, we continue our research in two important directions:

- deep local and regional applicators,
- intracavitary applicators.

For the deep local thermotherapy treatment we develop above all waveguide type applicators based on the principle of evanescent mode waveguide, which is our specific solution and original contribution to the theory of microwave hyperthermia applicators. This technology enable us:

- to design applicators with as small aperture as necessary also for the optimum frequency range for deep local and/or for regional thermotherapy treatment (the frequency band between 27 and 70 MHz).
- using our technology we need not to fill the applicator by dielectric (necessary for deep penetration into the biological tissue - i.e., up to 10 centimetres under the body surface).
- two to four of such applicators can be also used for regional treatment.

Waveguide type applicators are often used in the local external hyperthermia treatment of cancer and other modifications of microwave thermotherapy as they offer very advantageous properties, above all:

- depth of penetration of the EM energy approaching the ideal case of plane wave,
- low irradiation of the energy in the vicinity of the hyperthermia apparatus,
- very good impedance matching, i.e., perfect energy transfer to the biological tissue.

We have studied waveguide applicators heating pattern for the aperture excitation at above and at under the cutoff frequency. It has helped us to get analytical approximations of the electromagnetic field distribution in the treated area of the biological tissue. The most important results for the effective heating depth d can be characterised as follows:

- at high frequencies (above approx. 1000 MHz) the depth of effective heating d is above all a function of frequency f (skin effect),
- below approx. 100 MHz d is the dominantly function of the diameter D of applicator aperture ($d = 0.386D$).

Clinical Results

In the case of cancer treatment the long term statistics of clinical results can be described as follows:

Complete Response of Tumor53%
 Partial Response of the Tumor ...31%
 No Significant Response16%

which corresponds to results obtained also by other groups in Europe.

*This research is supported by Grant Agency of the Czech Republic, project: “Microwave Imaging for Biomedical Applications” (102/05/0959) and by the research program MSM6840770012 “Transdisciplinary Research in the Area of Biomedical Engineering II” of the CTU in Prague, sponsored by the Ministry of Education, Youth and Sports of the Czech Republic.