# HELICAL ANTENNA FOR MEDICAL APPLICATIONS.

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## INTRODUCTION.

An increased interest for thermotherapy using microwaves has been observed in the last decade. A large number of devices have been designed and tested in order to produce therapeutic heating for medical applications and more particularly microwave hyperthermia (for the treatment of tumors having different sizes and located in various places of the human body). Among these devices, we have been interested in the study of interstitial coaxial applicators and more particularly of endocavitary applicators. They are generally used in urology for the heating of tumors or for the improvement of medical treatments like radiotherapy or chemotherapy. In this paper, we present the theoretical study and the experimental verifications concerning a generation of applicators of helical type. They have been designed as to reduce the heating zone along the cable in order to avoid possible thermal necrosis.

## MATERIAL AND METHODS.

The microwave antenna is realized from a flexible coaxial cable of 50 Ω characteristic impedance. Previous antennas [1] were realized by removing the outer conductor of the cable on a length h. The improvement consists in making a double helical antenna [2]: the first helix is the inner conducter which is rolled up around the teflon sheath. The second helix is soldered at the outer conductor and is rolled up around the cable (figure 1). The thermotherapy system consists of a microwave generator (heating frequency 915 MHz and maximum power 100 W) and a microwave radiometer centered around 3 GHz for the measurement of the temperatures.

In order to take into account the heterogeneousness of the volume surrounding the antenna, but also the exact shape of tissues and applicator, a complete 3D model based on the wellknown FDTD method [3] has been developed. With this model, it is possible to know how the electromagnetic energy is deposited inside lossy media and, so to obtain the specific absorbtion rate (SAR). We can also determine the matching of the applicator inside the surrounding media at the heating frequency, but also in the radiometric frequency bandwidth. The heating pattern is then deduced from the resolution of the bioheat transfer equation.

As to verify the theoretical results, experimental measurements have been carried out on phantom model of human tissues (polyacrylamide gel). First, the return loss ($S_{11}$ parameter) has been measured as a function of frequency by means of a network analyser HP 8510 in order to obtain the level of adaptation of the applicator at the heating frequency and in the radiometric bandwidth. The next part of the experiment consists in the determination of the energy distribution. The method is based on the temperature increase in a polyacrylamide gel, induced by microwave power for a short time (about one minute) in order to avoid thermal conduction phenomena inside the gel. The thermal performances of the applicator are obtained from temperatures measurement on a polyacrylamide gel after a heating session of about forty five minutes using an automatic experimental system.

## RESULTS AND DISCUSSION.

The comparison between theoretical results and experimental measurements concerning the $S_{11}$ parameter as a function of frequency is shown on figure 2 : we can observe that the matching is quite good. The reflection coefficient is below -10 dB at the heating frequency, that is to say that at least 90 % of the incident power is delivered to the surrounding media.

The theoretical normalized power deposition diagram obtained with this applicator is presented in figure 3. We can observe a maximum of power behind the junction plane of the two helix (the junction plane is the plane where the two helix begin). The 40 % isopower line spreads on a length nearly equal to the total antenna length. A succession of power peaks appears in the vicinity of each metallic element corresponding to the helix. If we compare these results to the ones obtained with the previous urethral antenna, we can observe that the maximum of the SAR extends in the front of the junction plane of the applicator . So, we can conclude that the power deposition spreads on a less extensive zone for the helical applicator.

The experimental thermal pattern obtained for the helical applicator is given on Figure 4. As expected, the area delimited by the 40% isothermal line is smaller for the helical applicator and spreads on a shorter length. Moreover, this area is located in the front of the junction plane for the helical antenna when this area is nearly symmetrical with respect to this junction plane for the previous urethral antenna. So, in clinical situations, this more confined power deposition allows to avoid possible thermal necrosis near the bladder and the urethra junction.

## CONCLUSION.

We have studied a new kind of endocavitary applicator of helical type. The theoretical results (obtained from the FDTD method) and confirmed by experimental measurements show clearly an improvement of the power deposition along the coaxial cable, which will make possible to avoid potential burns near the bladder neck. We want to associate to this work the BRUKER company which has developed this applicator.

## REFERENCES.

[1] J.C. CAMART, J.J. FABRE, B. PREVOST, J. PRIBETICH, M. CHIVE « *Coaxial antennas array for 915 MHz interstitial hyperthermia : design and modelisation-power deposition and heating pattern-phase array.* » IEEE Trans. on Microwaves Theory and Tech., Vol.MTT-40, n°12, pp 2243-2250, December 1992.

[2] Patent Bruker 27-11066, N° registration 93-12 472 (France)

[3] K.S. *YEE « Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media.* » IEEE Trans. on Antennas and Propagation, Vol.AP-14, n°3, pp 302-307, May 1966.

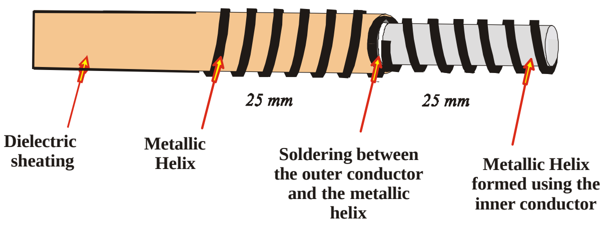

Figure 1 : Scheme of the helical applicator.

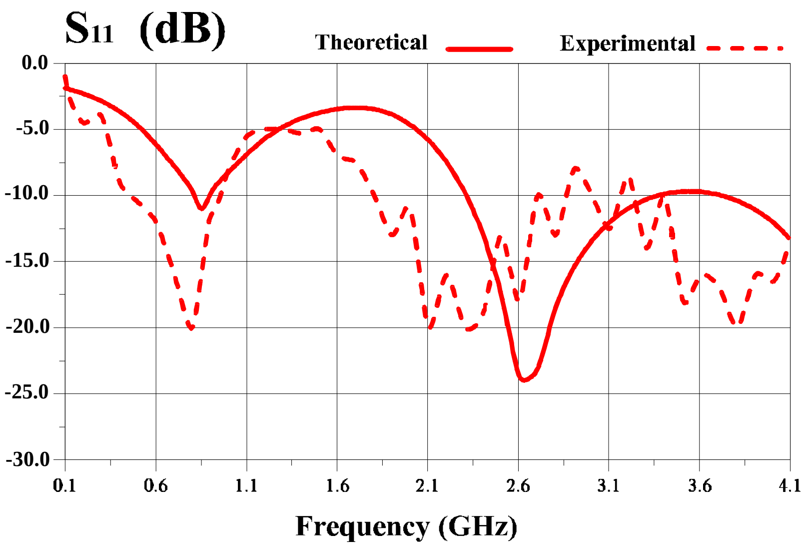

Figure 2 : Comparison between experimental measurements (dotted line) and theoretical results (full line) for the reflection coefficient ($S_{11}$ parameter) as a function of frequency obtained for the helical applicator dived in a polyacrylamid gel.

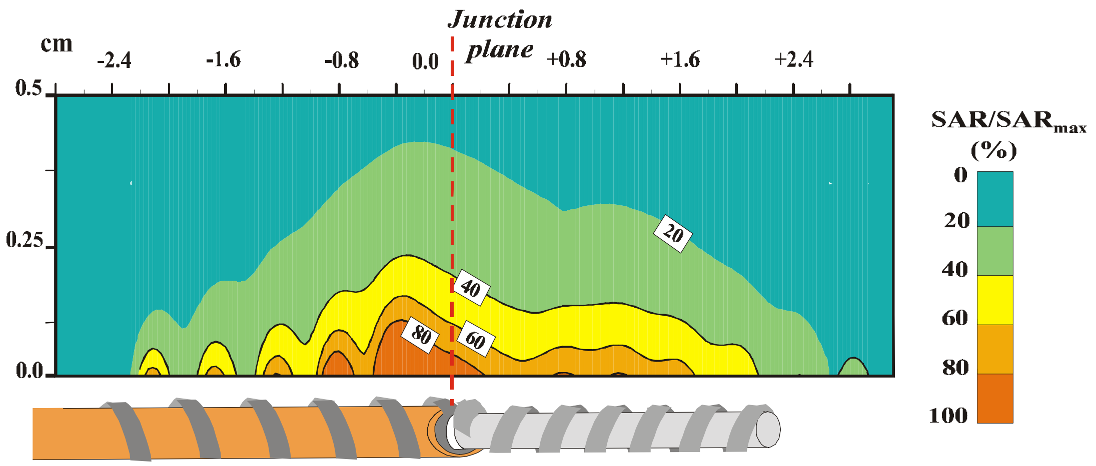

Figure 3 :Theoretical normalized SAR for the helical applicator.

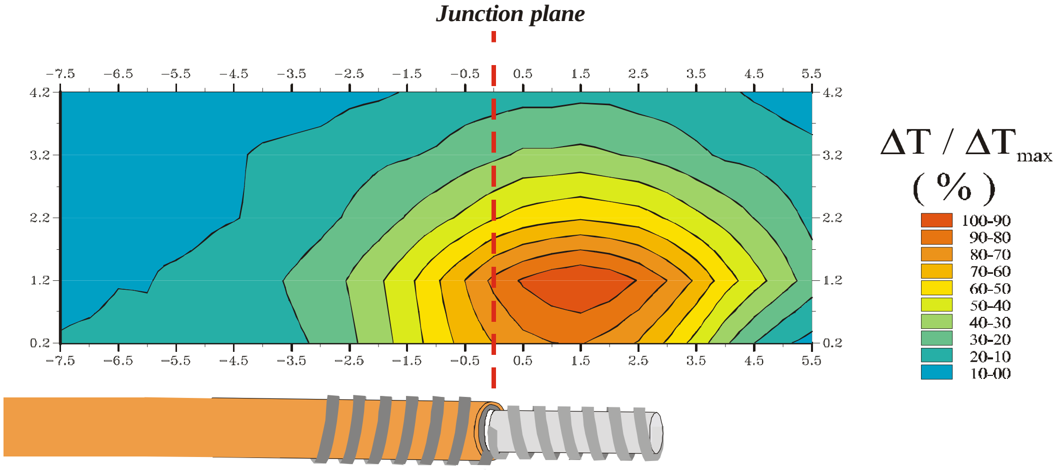

Figure 4 : Experimental thermal patterns for the helical applicator.