Synchrotron radiation: a new tool for the study and the treatment of central nervous system diseases

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Synchrotron radiation facilities are large scale laboratories where extremely intense and highly collimated X-ray beams are made available to researchers for a wide range of applications, among which biology and medicine are constantly increasing of imporance.

These applications are particularly advanced at the European Synchrotron Radiation Facility (ESRF, Grenoble, France) where intense nanometric or homogeneous broad beams are also used to study, analyze and treat pathologies of the central nervous system (CNS).

An endstation, the ID17 biomedical beamline, is fully dedicated to preclinical and clinical studies; research made in house or carried out by the users‘ community focusses on developing novel brain cancer treatments and innovative techniques in radiation therapy and stereotactic radiosurgery. These developments make profit of specific properties of synchrotron radiation like coherence, monochromaticity and high intensity, that make it possible to applying techniques like microbeam radiation therapy (MRT).

The intense, quasi monochromatic beam available at ID17 allowed to develop combined chemo- radio-therapies which exploit the local X-ray dose enhancement achievable by irradiating a tumour previously loaded with a high-Z (chemotherapic) drug. The remarkable curing effect of these combined therapies shown in preclinical tests has paved the way of the clinical application of the novel therapy; in parallel, new optimized drugs-radiation protocols are under preclinical evaluation.

MRT uses multienergy arrays of microscopic beams (from 25 to 600 microns) delivered with submillimetric precision to the CNS. Doses up to hundreds of Grays, delivered in a fraction of a second, can be very well tolerated by the CNS in mammals as shown in several preclinical trials. The potential application of MRT in the treatment of cancers of the CNS is presently under evaluation in veterinarial trials.

MRT has also been applied to obtain the radiosurgical equivalent of multiple subpial transections. Cortical columns are the basic functional units of brain computation. Synchrotron microbeams can generate cortical transections disconnecting adjacent columns and modulating abnormal columnar processing. The hypothesis was verified in epilectic rats. Microradiosurgical transections induced seizure control while motor function was not affected. Also the ability of microbeams to generate hippocampal transections has been recently investigated. This original approach offers an interesting new way to study the hippocampal function and to develop novel treatment avenues for mesiotemporal epilepsy.

More recently, X-ray microbeams have been used to explore the electrophysiological behaviour of neurons contained inside the microbeam-transected primary sensory cortex in experimental models of chronic pain, a widespread invalidating neurological disorder currently orphan of effective medical and surgical treatments. Selected pioneering results of these new research avenues will be presented.