RENISHAW apply innovation[™]

Robotic applications in stereotactic procedures are synonymous with speed, safety and efficiency provided a rigorous methodology is followed.

Professor Serge Blond and his team at Northern France's leading university hospital put the Renishaw neuromate[®] Frameless Gen II stereotactic robot to regular use for many stereotactic interventions.

"Robotic stereotactic neurosurgery is particularly appealing to neurosurgeons because it establishes excellent conditions for the procedure and makes it possible to free oneself from the use of a stereotactic frame, when used in frameless mode. The reliability and safety of this technique requires a stereotactic approach: a function or a lesion must be initially localised within a thoroughly identified brain environment," says Serge Blond, Professor at the Lille University Hospital, and President of the French Club of Functional and Stereotactic Neurosurgery. Prof. Blond leads one of the most active centres of functional and stereotactic neurosurgery in France. He has been using the neuromate* image-guided stereotactic system since 1999 1.

Stereotaxy provides access to brain areas that cannot be safely approached with conventional neurosurgical techniques (where the anatomy can be clearly seen). Stereotactic neurosurgery requires specialised training to develop not only operating techniques, but also a deep understanding of brain anatomy and physiology, that can be compared with the individual clinical data of the patient. Mastery of the methodology, combined with a rigorous technical approach, ensures an optimal result: the execution of the stereotactic procedure must neither cause new functional perturbations, nor aggravate clinical signs related to the causal pathology.

Trained by stereotaxy pioneer Prof. Jean Talairach at Sainte-Anne Hospital in Paris, Prof. Blond upholds a rigorous, detail-oriented approach, allowing the introduction of technological advances in a completely safe manner. "The *neuromate** is used in a manner that entirely respects the tenets of the stereotactic methodology. The capabilities of this robotic system allow us to operate much faster, enabling us to support a considerable increase in the indications of functional as well as tumour stereotaxy, while maintaining surgical precision."



Insertion of the biopsy needle through the depth sensor-equipped tool guide mounted on the $neuromate^{\star} \mbox{ arm}$



Biopsy sample

neuromate* used in stereotactic biopsy

The objective of stereotactic biopsies is to reliably collect samples that are sufficient for histological diagnosis while limiting the inherent risks of any surgical procedure. The stereotactic approach is an obvious choice when confronted with brain tumours developing in functional or deep-seated areas that are sometimes revealed by the smallest of clinical signs. As with conventional neurosurgical procedures, even when guided by neuronavigation, there are dangers. It is absolutely essential not to worsen the clinical symptoms or cause novel neurological or neurocognitive deficits.

The *neuromate** is in daily use in Lille for stereotactic biopsies, removing the necessity of using a stereotactic frame. "The frameless registration system frees up surgical space and expands possible trajectories whatever the head orientation. This considerable increase in working space provides a huge advantage. allowing access to lesions with high efficiency and safety." Prof. Blond has presented, in international conferences, series of biopsies performed within highly functional regions of the brain, such as the pineal region or the brain stem, with a high success rate and much reduced morbidity and mortality ^{2, 3}. Out of 80 consecutive brainstem biopsies, diagnostic yield was obtained in 96% of patients and modified the choice of treatment modality in 29% of patients ⁴. "With its accuracy, the neuromate* allows approaches that we would not be prepared to undertake with a traditional frame," says Prof. Blond.



Prof. Blond planning a biopsy procedure

Diagnostic MRI provides insight into the characteristics of a lesion, to be compared with the clinical situation of the patient. This comparative analysis enables a choice between a direct surgical approach, usually with a neuronavigation procedure, or a stereotactic exploration. In the latter case, a novel MRI dataset is acquired after the skull implantation of a fiducial marker, in a sequence tailored to the lesional characteristics, after ensuring precise calibration of the scanner. This examination is used to define the target and stereotactic trajectory taking into account the clinical state of the patient, the functional environment and vascular constraints.

The procedure takes place under general anaesthesia, with the patient's head immobilized in the head holder mounted on the neuromate* base. Frameless registration is performed in a matter of minutes, and the robot moves along the predefined trajectory. A laser mounted on the robot arm pinpoints the trepanation site. The laser is then replaced with a drill guide providing a firm support for the electric burr. After the dura mater is coagulated, a guillotine biopsy needle (Sedan needle) is mounted and progressively introduced into the brain along the predefined trajectory by the neurosurgeon. The position of the needle tip is displayed in real time onto the *neuromate** navigation station, thanks to a depth sensor on the robot arm. Several layered biopsy samples are obtained along the trajectory, taking into account the region of interest to obtain sufficient sampling.



Trajectory planning



Real-time probe tip position feedback on the *neuromate** navigation station. A tumour of the pineal region is shown in purple.

neuromate* in functional procedures

Prof. Blond's team use a stereotactic frame in conjunction with the frameless localizer for several applications of deep brain stimulation involving initial insertion of recording and stimulation microelectrodes, followed by implantation of permanent electrodes. The neuromate* is used in combination with a custom long-range digital X-ray system to provide constant verification of the trajectories and electrode positioning throughout the procedure. Professor Blond explains, "In this context, the use of the frameless localization system frees us from the time constraints of MRI, as it can be acquired one or several days in advance of the stereotactic procedure. This provides a substantial time saving on the day of the stereotactic electrode implantation." The fiducial marker is implanted under local anaesthesia days before the surgery, allowing the neuroradiology department to perform the MRI acquisition in optimal conditions depending on availability. The data is then transmitted to the planning station of the neuromate* so that the neurosurgeons can perform a surgical plan taking into account individual and statistical data. The intervention is performed under the "asleep - awake - asleep" principle: the initial and final parts of the surgery are performed under general anaesthesia, while perioperative electrophysiological explorations are performed on a conscious patient, and coupled with a meticulous clinical evaluation allowing a precise definition of the stereotactic target (thalamic, subthalamic nucleus, pallidal stimulation). The *neuromate** base provides a firm support for the stereotactic frame, which is particularly valuable for patients suffering from severe tremor.



Catheter implantation for cysts

For cystic craniopharyngiomas and other intracerebral expansive cystic lesions, Prof. Blond sometimes resorts to endocavitary irradiation, a technique consisting in the injection of a colloidal rhenium-186 solution. The objective is to progressively reduce the secreting ability of the cyst walls and obtain their retraction, thus reducing the mass effect on neighbouring structures. A catheter is first implanted within the cavity along a double oblique approach, and connected to an access port placed under the scalp. The content of the cyst is drained. Subsequently, a small quantity of rhenium is injected through the access port. Controls performed with a gamma camera ensure the absence of leakage into the ventricular system or basal cisterns. If tightness is confirmed, a therapeutic dose is injected, and then removed after five days. An article published in Neurosurgery concludes that this method "is a safe and effective procedure with a tumour control rate greater than 70%. Stereotactic methodology notably reduced the risk of leakage 5."

Foetal cell grafts for neurodegenerative diseases

Lille participates in an international trial for foetal cell grafts for Huntington's disease. This experimental protocol provides hope for treatments that control this devastating condition. Foetal cells are implanted through six trajectories on each side of the brain, into the striatum (caudate nucleus and putamen.) Prof. Blond's was one of two teams who used the *neuromate** for all grafting procedures, in frameless mode. "The procedure was greatly facilitated by the *neuromate**. It brings about considerable advantages when several trajectories are executed: reduced manipulations of mechanical elements, computerized image-based definition of the targets and trajectories, and a considerable reduction of the procedure time."

A bright future

"The *neuromate** has a bright future in the context of stereotactic neurosurgery." Prof. Blond considers the extension of the indications of deep brain stimulation to psychosurgery and the treatment of pain and certain refractory epilepsies. He believes that "interstitial drug delivery (such as chemotherapy), viral vectors or antibodies requiring precise positioning and multiple trajectories will be facilitated in centres mastering the most advanced tools and techniques of the stereotactic methodology."

NOTE: The *neuromate*^{*} stereotactic robot system is CE marked and cleared for sale in the USA.

References

(1) BlondS, TouzetG, ReynsN, DantasS, PruvoJ. [Clinical applications of stereotactic methodology]. Annales françaises d'anesthésie et de réanimation. 2002;21(2): 162-9.

(2) Haegelen C, Touzet G, Reyns N, et al. Robotic stereotactic biopsies in the management of brain stem lesions: about a first series of 15 patients. In: Abstracts of the Proceedings of the XVIIth Congress of the European Society for Stereotactic and Functional Neurosurgery (ESSFN). Montreux; 2006.

(3) Lefranc M, Touzet G, Reyns N, et al. [Current role of stereotactic biopsies for pineal region tumours. A retrospective series of 87 patients]. In: Marseille Neurosurgery 2009 Joint Annual Meeting (EANS-SNFC). Marseille; 2009.

(4) Dellaretti M, Reis BL, Touzet G, et al. Brainstem biopsies in adults: review of 80 consecutive cases. Arquivos brasileiros de neurocirurgia. 2009;28(4):139-142.

(5) Derrey S, Blond S, Reyns N, et al. Management of cystic craniopharyngiomas with stereotactic endocavitary irradiation using colloidal186 Re: a retrospective study of 48 consecutive patients. Neurosurgery. 2008;63(6):1045-52.

* In the USA the *neuromate*[®] is known as the *neuromate*[®] Frameless Gen II stereotactic robot.

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