

Intraoperative imaging with the *neuromate*[®] Frameless Gen II stereotactic robot

Optimal hardware and software integration of the *neuromate** robot with the 2D and 3D imaging mechanisms ensures safer and more reliable implantation procedures than working in a nonrobotic way.

Perioperative control of brain implantation procedures is an important safety requirement for surgeons. The Renishaw Mayfield *neuromate** stereotactic robot and its associated image-based planning software reduce the risks associated with frame bending, errors in calculation or dialling of trajectories into a stereotactic frame. However, electrode bending or displacement after replacement of micro/macro electrodes or closure of the burr hole remain a possibility. Intraoperative imaging devices based on X-rays provide the ability to verify electrode implantations in a matter of seconds.



DBS implantation procedure in Bordeaux with the neuromate*, Medtronic O-arm®, Elekta Leksell® frame and Cross Hair Kit

Medtronic O-arm[®] 2D and 3D imaging device

The Medtronic O-arm[®] intraoperative imaging device, although initially developed for spine surgery, lends itself very well to cranial surgery as well. It provides reduced radiation dose, and increased geometric accuracy compared to a standard CT scanner, at the expense of contrast resolution¹. Therefore, it is particularly adapted to stereotactic neurosurgery, when fused to high field MRI images. The device has a large internal diameter ring so there is no obstruction of the surgical field. The O-arm[®] can be positioned and draped before the patient enters the room, and remains in place during the entire procedure.

The 3D field of view of the O-arm[®] is limited to a cylindrical volume of 20 cm (diameter) \times 15 cm (length) ³. Therefore, the device does not lend itself to 3D registration with the frame's CT localizer box ². However, 2D registration with the X-ray localizers, as well as 3D anatomical fusion, can be achieved with high accuracy using the robot's software.

The team who pioneered the use of the O-arm[®] for DBS (deep brain stimulation) electrode implantation in France noted that "fixing the stereotactic frame to the floor of the operative room would limit uncontrolled movements of the frame during surgery" ². The *neuromate*'s* solid base provides this very sturdy mechanical fixation.

Intraoperative fluoroscopy devices

The *neuromate*^{*} can be used in conjunction with standard intraoperative fluoroscopy ("C-arm") devices. These devices cannot be used for registration or stereotactic imaging because of their high geometric distortion ⁴. However, they can be used to check the reproducibility of implant placement, for example with the Elekta Leksell[®] Cross Hair Kit or a similar device.

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O-arm® 3D image showing electrode deflection during DBS lead revision surgery (left) and fusion with pre-operative MRI showing location of previous lead (right)

Stereotactic X-ray systems

In the example below, the *neuromate** robot is used with the longrange X-ray system invented by Jean Talairach in Paris. Two X-ray sources are mounted to one wall and the ceiling – at a distance of 3.5 m to 5 m from the patient, depending on the size of the operating room. Fiducial plates and flat panel detectors are mounted onto the robot base to provide anteroposterior and lateral images with minimal conical deformation ⁵. The robot's software supports the registration of the 2D images and their co-registration with 3D imaging modalities such as MRI.

NOTE: The *neuromate** robot and software also support other stereotactic frames.



Stereotactic 2D X-ray image pair obtained with the O-arm[®]. The images are registered in the software using the visible fiducial points. This operation registers the patient to the neuromate* robot.

Trademarks

 $\ensuremath{\mathsf{O}}\xspace$ are a registered trademark of Medtronic Inc.

Leksell[®] is a registered trademark of Elekta Instrument AB.

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

For worldwide contact details, please visit our main web site at www.renishaw.com/contact

References

- ¹ Colombo PE, Moscato A, Pierelli A, Cardinale F, Torresin A. Medtronic O-arm: image quality and radiation dose assessment in 3D imaging. In: 2nd Meeting Of Intraoperative Imaging Society, Istanbul, Turkey, Jun 14-17, 2009.
- ² Caire F, Gantois C, Torny F, et al. Intraoperative use of the Medtronic O-arm for deep brain stimulation procedures. Stereotactic and functional neurosurgery. 2010;88(2):109-114.
- ³ Medtronic O-arm[®] product data sheet 9670866 Rev. 3. For detailed information regarding the Medtronic O-arm[®], refer to Medtronic documentation.
- ⁴ Henderson JM, Hill BC. Fluoroscopic registration and localization for image-guided cranial neurosurgical procedures: a feasibility study. Stereotactic and functional neurosurgery. 2008;86(5):271-7.
- ⁵ Benabid AL, Chabardès S, Seigneuret E, Hoffmann D, Le Bas J. The Talairach Stereotactic System. In: Textbook of Stereotactic and Functional Neurosurgery. Springer; 2009.

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