

Frameless Stereotactic for Deep Brain Stimulation Placement: Operative Technique

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Deep brain stimulation (DBS) has been shown to be a safe and effective method for the treatment of refractory Parkinson's disease and other movement disorders. Traditionally, frame-based stereotactic have been the standard technique commonly used for DBS surgery. With the development of image-guided neurosurgical systems, frameless stereotactic has been increasingly used for tumor resection or biopsy without the use of stereotactic frame. Frameless stereotactic for functional surgery has been recently developed with the accuracy comparable to frame-based stereotactic surgery. The authors report the surgical technique of frameless functional stereotactic for the treatment of movement disorders.

Keywords: *Frameless stereotactic, Functional neurosurgery, Deep brain stimulation, Parkinson's disease, Dystonia*

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Deep brain stimulation (DBS) has been shown to be an effective method for the treatment for movement disorders such as Parkinson's disease and dystonia^(1,2). The traditional surgical approach to implanting the leads for a DBS procedure involves attaching a stereotactic head frame to the patient. The head frame allows surgeons to accurately guide the leads to a specific target in the brain.

Considerable experience has now accrued with image guidance systems⁽³⁻⁶⁾. With the advent of computer technology and imaging, the use of frameless stereotactic systems for real-time intraoperative guidance is becoming standard for neurosurgical procedures such as tumor resection or biopsy. However, frameless stereotactic had little been used on the functional neurosurgery because the perception that frame-based technique has more accuracy required for functional surgery. Recently, frameless stereotactic has been used for functional neurosurgical procedures and

demonstrated localization accuracies similar to frame-based technique in the laboratory and clinical use⁽⁷⁻¹¹⁾.

The authors report operative technique of frameless stereotactic for DBS placement.

Material and Method

On the day prior to surgery, the authors place the small stainless steel fiducials on the patient's head. Usually, the authors use 5 fiducials, 2 at the front, 2 at the back and 1 at the posterior midline to cover the entire head (Fig. 1, 2). Under local anesthetic, the fiducial is screwed into the skull by a battery-powered or a manual screwdriver.

After fiducial placement, 1 mm thick computed tomography (CT) slices are taken. The scan must be at least 2.8 cm above the head to encompass the entire head and all fiducials. Surgical planning is carried out using the neuronavigation system (StealthStation Treon, Medtronic Louisville, CO, USA) on the day prior to surgery. CT imaging with fiducials in place are fused with magnetic resonance imaging (MRI) performed several days or weeks before surgery. The targets and entry points are planned the same as usual (Fig. 3, 4).

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Fig. 1 Photograph comparing the large pins of frame-based stereotactic and small fiducials for frameless stereotactic surgery



Fig. 2 Placement of the fiducials under local anesthetic

Surgical technique

On the day of surgery, the patient can be brought to the operating room at the time scheduled. The patient's head is immobilized with the passive headrest (Navigus PH-2500) attached to the Mayfield adaptor (Fig. 5, 6). The cervical collar helps to restrain the patient and can be removed after the trajectory alignment is finished. The non-sterile initial registration is performed by attaching the image-guided reference frame to the patient by a head-strap (Fig. 7). The registration is performed as standard practice and the entry point is located and marked.

The patient is prepped and draped in standard sterile fashion. A small incision is made at the entry point and a small drill is used to mark the entry point for accurate burr-hole placement. The incision is then extended with enough space to accept the base of the platform (Nexframe #DB-1040, Image-guided Neurologics, Melbourne, FL, USA). A 14 mm burr-hole is made centered over the previous drilled entry point. The lead anchor or Stimloc base is mounted over the burr hole. The Nexframe base is then positioned over the Stimloc base and attached to the skull using 3 self-tapping screws. It is important that there is no movement between the platform and the skull.

The reference arc (passive spinal reference frame) is attached to the reference bracket. The registration is performed with the reference probe (passive planar probe) (Fig. 8). After the registration, the system accuracy is checked again by pointing each fiducial with registration probe. The guidance probe (guide-frame-DT) is verified at this time before the next step (Fig. 9).

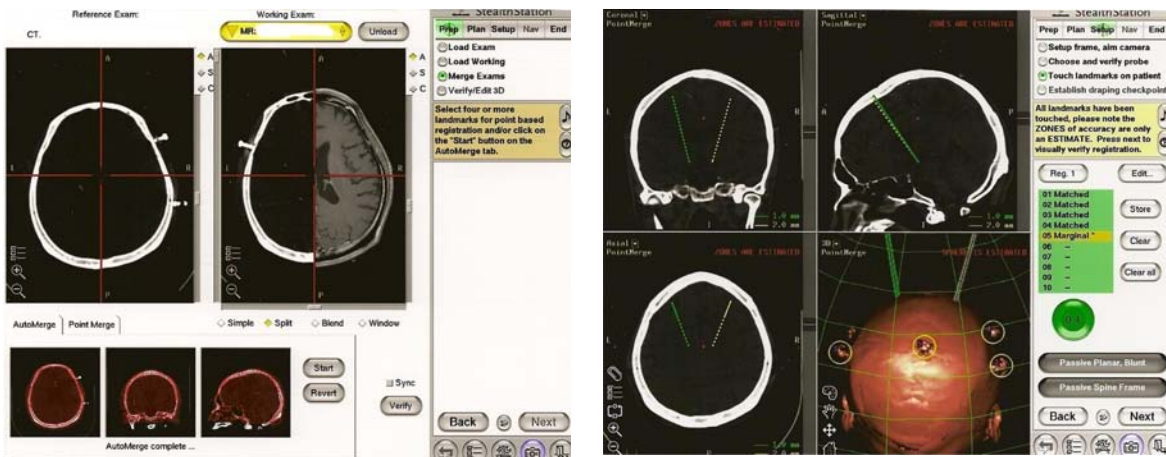


Fig. 3, 4 Surgical planning shows fusion of CT imaging and MRI imaging, entry point and target point



Fig. 5 Passive headrest attached to the Mayfield adaptor

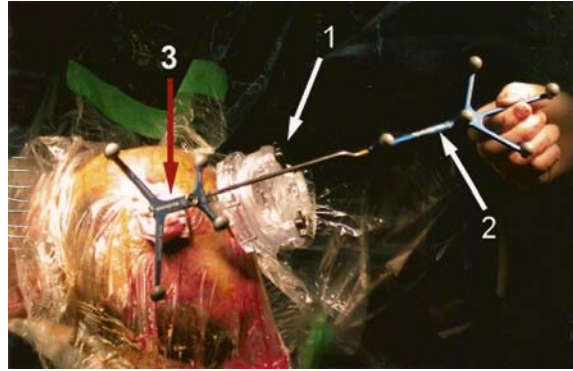


Fig. 8 Sterile registration 1-Trajectory guide platform (Nexframe), 2-Passive planar probe, 3-Passive spinal reference frame



Fig. 6 Patients can move their heads on the headrest during operation. This was comfortable during the long operation especially in dystonia patient

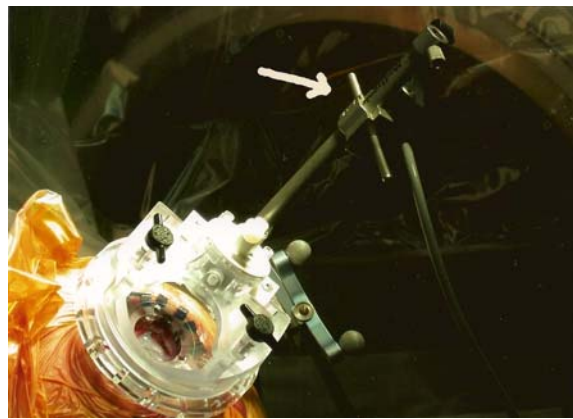


Fig. 9 Guideframe-DT (arrow) is attached to the Nexframe tower

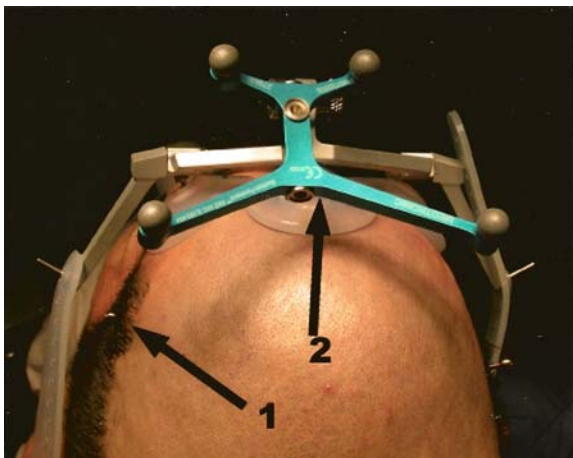


Fig. 7 Nonsterile registration 1-Fiducial, 2-Reference frame

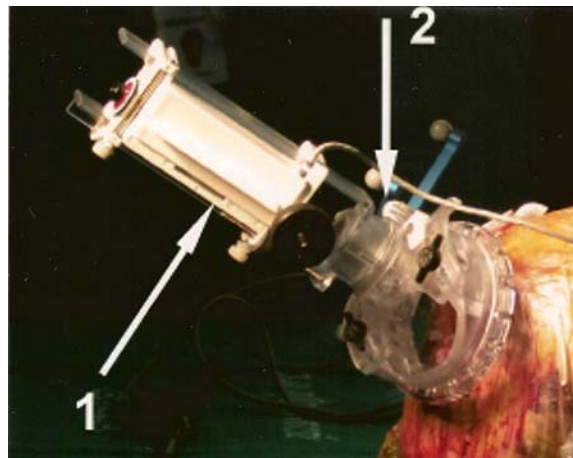


Fig. 10 Nexdrive in conjunction with Nexframe 1-Microdrive, 2- Multi-lumen adapter

The Dura is then opened and a cortical incision is made. Gelfoam is placed and fibrin glue is used to prevent CSF leakage and minimize the brain shift. The Nexdrive alignment adapter is attached to the Nexframe tower. The guideframe-DT is then attached to the alignment adapter. The guidance probe is adjusted to align to the target by sweep and rotate the tower and the surgeon watches the computer screen until the alignment to the target is achieved and then the locking screws are locked. The guidance probe is removed and the depth to the target is obtained by image guided system. The 3 mm offset alignment is sometimes used to avoid a cortical vessel.

The Nexdrive alignment adapter is removed and the Nexdrive multilumen adapter is replaced. The Z-stage on the microdrive (Nexdrive # MI-1000) is set to the desired depth based on imaged guide system and mounted on the adapter (Fig. 10). Gelfoam is removed and the guide tube with stylet is inserted. The stylet is removed and then the microelectrode spacer tube is inserted. The microelectrode collet is attached to the microdrive and microelectrode is inserted then tightens the microelectrode collet screws.

Microelectrode is introduced via the microelectrode recording (MER) knob manually. The position of the microelectrode can be read from the MER scale (1 mm increments) and MER index scale (10 micron increments) or from the digital display unit.

After the final target has been defined by microelectrode recording, the microelectrode and spacer cannula are removed. The DBS lead is inserted into the DBS bracket/measuring tube and adjusting the depth with the desired electrode at the end of the measuring tube and then secure the electrode with a thumbscrew. The measuring tube is removed from the DBS bracket. The electrode then is inserted into the outer cannula. After determining the final target by macrostimulation, the outer cannula is retracted. DBS lead is captured by StimLoc cam and locked in place. The cannula, DBS stylet, Nexdrive and Nexframe tower are removed. The remainder of the procedure is performed as the traditional DBS surgery.

Discussion

Recently, the development of instrumentation (Nexframe) for frameless functional surgery has provided a high degree of stability and accuracy. The results indicated that the frameless technique might meet or even exceed what is achievable with a conventional stereotactic frame⁽⁷⁻¹¹⁾. Frameless techniques for DBS placement offer several advantages over frame-based

stereotactic techniques. Patients are much more comfortable and they can move their heads during the long operative procedure compared with the application of the stereotactic frame. Surgeon can perform the operative planning the day prior to surgery thus decreasing the operating time. Surgery can be performed on one side, keeping the fiducials in place, and performing surgery on another site on a separate day, in case unexpected events happen, instead of applying the stereotactic frame again.

The authors describe frameless stereotactic technique for DBS placement for the treatment of movement disorders. The authors have performed frameless stereotactic DBS surgery first in Asia since August 2005 (Medtronic Thailand, personal communication). Until now, the authors have performed frameless stereotactic DBS surgery in nine cases, six for Parkinson's disease and three for dystonia. The outcome of this technique will be reported in the future. The frameless technique may be used as another option to frame-based techniques in functional surgery.

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วิธีการผ่าตัดใส่อ็ล็กโทรดเพื่อกระตุ้นสมองส่วนลึกโดยไม่ใช้กรอบยึดศีรษะ

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การกระตุ้นสมองส่วนลึกเพื่อรักษาโรคพาร์กินสันและการเคลื่อนไหวผิดปกติอื่น ๆ เป็นวิธีที่ได้รับการยอมรับว่าได้ผลและปลอดภัยในปัจจุบัน โดยปกติการผ่าตัดจะใช้กรอบยึดศีรษะเพื่อหาตำแหน่งในการใส่อ็ล็กโทรด ในปัจจุบันมีการพัฒนาการผ่าตัดทางประสาทศัลยศาสตร์โดยการใช้คอมพิวเตอร์นำวิถีทำให้ไม่ต้องใช้กรอบยึดศีรษะเพื่อบอกตำแหน่งซึ่งเป็นที่นิยมในการผ่าตัดเนื้องอก หรือ การตัดชิ้นเนื้อเพื่อการวินิจฉัย

การผ่าตัดโดยไม่ใช้กรอบยึดศีรษะได้พัฒนาให้มีความแม่นยำมากขึ้นเทียบเท่าการผ่าตัดโดยใช้กรอบยึดศีรษะ และสามารถนำมาใช้ในการผ่าตัดการเคลื่อนไหวผิดปกติซึ่งต้องการความแม่นยำสูง รายงานนี้นำเสนอวิธีการผ่าตัดใส่อ็ล็กโทรดเพื่อกระตุ้นสมองส่วนลึกโดยไม่ใช้กรอบยึดศีรษะ