A new fixation device for the Leksell stereotaxic system

Technical note

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A device is presented that permits several applications for the Leksell stereotaxic system. The patient is fixed in this new system by means of a rectangular instrument that connects to the standard Leksell stereotaxic coordinate frame and maintains spatial orientation after the frame itself is removed. Specific uses for this device include stereotaxic radiosurgery and stereotaxic guidance during microsurgery. Other attractive features of this device are its capability of being precisely reapplied, its compatibility with both computerized tomography and magnetic resonance imaging, and the availability of an accessory device to adapt it for animal stereotaxis.

KEY WORDS • stereotaxic procedure • instrumentation • neuroimaging

Since its introduction nearly four decades ago, the Leksell stereotaxic instrument has been revised continuously to both enhance its versatility and accommodate new developments in neuroimaging. The impetus for the current modification was derived from the need to adapt the stereotaxic apparatus for use with the Leksell Gamma Unit, for microsurgery, and for conventional open surgery. The standard Leksell instrument is less suitable for these procedures because it provides somewhat limited access to the cranial vault. This restriction was circumvented by incorporating a downwardly suspended head-fixation device into the system. Similar to the standard Leksell instrument, this new design is compatible with computerized tomography (CT) and magnetic resonance imaging (MRI). Furthermore, it can be converted for use in animal stereotaxis by the attachment of a specially developed animal head-holder.

Description of Device and Technique

Apparatus

The system described here incorporates the standard Leksell coordinate frame with a new fixation instrument.* The fixation instrument is a rectangular device made of anodized aluminum and is insulated at each corner for compatibility with strong magnetic fields. This structure is fixed to the skull, encircling the lower aspect of the face anteriorly and the upper cervical spine posteriorly (Fig. 1). Fixation is provided by four fiber glass posts, each one holding a fiber glass pin which anchors the instrument to the patient's head using previously drilled holes in the outer table of the skull. The height of the fiber glass posts is adjustable and allows the position or angulation of the instrument to be varied. The standard Leksell coordinate frame can be attached to the upper surface of the instrument.

Target Localization

Whether the standard Leksell coordinate frame is attached to the patient's head directly or indirectly by means of the fixation instrument, the same basic principles apply when determining target coordinates from angiographic and CT studies. The only difference with the fixation instrument is that it, rather than the coordinate frame, attaches to the magnetic adapter which connects with the angiography or CT table.

Magnetic resonance imaging can also be used to determine stereotaxic coordinates. The standard Leksell coordinate frame and the fixation instrument described here are compatible with the strong magnetic fields associated with MRI. Prior to MRI, the standard metal feet of the fixation instrument are replaced by similar
but nonferrous feet. These connect the fixation instrument to the MRI adapter, in the same way as with the standard Leksell frame. The two coordinate indicator side plates used in CT localization are used with MRI; the established method of target coordinate determination is also the same. To permit localization from sagittal MRI, the MRI indicator includes a vertex plate (Fig. 2).

Because the fixation instrument is compatible with positron emission tomography, the system that is used for stereotaxic localization can also be used with all modern neuroimaging techniques. This versatility allows the fixation instrument to provide reproducible spatial orientation from one radiological examination to another and, as a consequence, comparisons can be made between identical tomographic sections or angiographic projections obtained at different times.

Uses for Fixation Instrument

Upon completion of target localization, the fixation instrument itself provides spatial orientation. Since the localization device (x-ray film, CT, or MRI) is now superfluous, it may be removed. Special sliding side rings can be attached to the fixation instrument, one on each side. They are adjusted to the predetermined Y and Z coordinates and connect with the entire range of Leksell instrumentation.

Leksell Radiosurgical Gamma Unit. Since the standard Leksell stereotaxic coordinate frame does not fit inside the presently available collimator helmets of the Leksell Gamma Unit, a halo type of metal ring or a Thermoplast helmet, either of which will fit into the collimator, must be applied separately. In contrast, the fixation instrument provides a system not only for coordinate determination but also for fixation during the radiosurgical treatment. This is accomplished by attaching two sliding bearings adjusted to the correct Y and Z coordinates to the sides of the instrument. The bearings are specifically designed to accommodate the two axis rods of the collimator helmet which, in addition to suspending the patient's head, are also used to set the X coordinate. When the patient's head is correctly positioned within the Gamma Unit, the fixation instrument rests outside the helmet and does not interfere with the available space inside. This arrangement has proved to be reliable and simple.

Use in Craniotomy. After target localization is completed and the coordinate indicator system has been removed, the fixation instrument can be used for stereotaxic guidance during an open craniotomy. The apparatus provides secure fixation of the head yet still permits extensive access to the cranial vault. If required, the anterior pins can be placed in the zygomas. The fixation instrument can be rigidly fastened to the operating table by means of a special attachment connected to the Mayfield head rest (Fig. 3 left). The adjustable side rings, which adapt the fixation instrument to the semicircular arc, and the instrument carrier are included in the prepared surgical field so that the sterilized arc can be connected and detached as needed during the operation. Once the brain is exposed, a stereotaxically positioned probe can guide both the cortical incision and subsequent deeper dissection. Alternatively, a laser beam can be utilized for this purpose. This system can also be used to stereotaxically guide dissection ...
under the microscope (Fig. 3 right). This is helpful when the incision in the brain is deep and purposely limited, such as in eloquent parts of the brain.

**Reaplication of Fixation Instrument**

Precise reaplication of the fixation instrument is possible. To reaply, the position of the four adjustable fiber glass posts on the instrument must first be recorded. Next, the instrument is removed by detaching it from all four posts. The position of the skull pins at the upper end of each post must not be changed if precise reaplication is to be achieved. When reaplaying the instrument, each post is separately fixed to the skull by inserting the attached pin into its respective drilled hole. In our experience, it has not been difficult to identify the original holes within 1 week of removal. Finally, after all four posts are fixed to the skull, the lower end of each is reconnected to the fixation instrument precisely in their previously recorded position.

This capacity to reaplay the frame is particularly helpful when several surgical procedures are needed. In such situations, repeat radiological studies and target localizations become unnecessary. Furthermore, it might not be necessary for the patient to have the surgical procedure performed on the same day as the target localization. This can be an advantage, for instance, when the target is localized by MRI, which can be particularly time-consuming.

**Animal Stereotaxis**

The attachment of a specially designed animal head-holder to the fixation instrument converts this system into one that can be used in stereotaxic experiments with animals (Fig. 4). The animal is secured by two pins fixed in the midline of its skull and two adjustable posts that support both of its zygomas. A third pin is placed between the animal's upper middle incisors. Stereotaxic localization with this system applies the same principles for coordinate determination as are applied to human stereotaxis with the Leksell instrument.

**Discussion**

In 1908, Horsley and Clarke introduced a stereotaxic technique which was later used extensively in animal experiments. Kirschner, who designed an instrument capable of placing radiofrequency lesions in the gasserian ganglion via the foramen ovale, was the first to perform a stereotaxic operation on man. However, it remained for Spiegel, et al. using a tool modeled on Horsley and Clarke's apparatus, to perform the first intracerebral stereotaxic operation. Soon thereafter, the first Leksell stereotaxic instrument was described. This initial Leksell instrument was revised repeatedly in attempts to overcome the limitations encountered during its daily use. With the development of microsurgery and radiosurgery another change was necessary, prompting the modification described in this report.

By providing the LekseU Gamma Unit with an integrated system for both stereotaxic coordinate determination and cranial fixation, the fixation instrument minimizes the risk of spacial dislocation either prior to
Leksell stereotaxic system fixation device

FIG. 4. A cat skull is shown fixed in the animal head-holder attached to the fixation instrument.

or during radiosurgical treatment. Also, in conjunction with the rest of the Leksell system, this device can be used either for conventional craniotomies or in microsurgery to stereotaxically guide the surgical approach. The feasibility of employing stereotaxic techniques to facilitate the surgical resection of deep arteriovenous malformations1,2,3,6 and tumors4,5,14 has been established. As recognized by these authors, stereotaxis allows neurosurgeons to approach some poorly accessible lesions safely. Because the exposure provided by stereotaxis is both limited and deep, the operating microscope is a natural adjunct, by virtue of its magnification and intense illumination. The precision offered by other modern neurosurgical tools, such as the laser and ultrasonic aspirator, can also be used to greater advantage by incorporating them into a stereotaxic system. The continued development of such tools has made "stereotaxic microsurgery" an increasingly important concept.

Recent advances in neuroradiology and other neurosciences have significantly widened the scope of stereotaxic intervention. At the same time, the limits of conventional neurosurgery have been extended by microsurgery. These recent advances could have isolated one neurosurgical field from another; however, as illustrated by the development of stereotaxic radiosurgery and by the coupling of microsurgery with stereotaxis, the different lines of development in neurosurgery are not mutually exclusive, but are logically compatible.

References


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This paper is dedicated to the memory of Dr. Lars Leksell.
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