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BRIEF COMMUNICATION

A Microdrive Positioning Adapter for Chronic Single Unit Recording

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ALDRIDGE, J. W., S. GILMAN AND D. JONES. *A microdrive positioning adapter for chronic single unit recording.* PHYSIOL BEHAV 44(6) 821–823, 1988.—A new micropositioner design for use in chronic, transdural single unit recording studies is presented. The adapter is used to position an electrode microdrive assembly to any desired location within a surgically implanted recording chamber. The adapter uses a radial positioning technique that requires few moving parts. In comparison with the X-Y slide manipulator it replaces, it is more durable, it provides access to a larger brain area, and it attaches more securely. In addition, provision can be made to mount a second microdrive, permitting two electrodes to be manipulated independently.

Micropositioner   Single unit recording   Micromanipulator   Chronic recording   Neuronal recording   Conscious animals

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FOR chronic transdural single unit recording studies, electrodes are typically manipulated to the recording site in the brain with a mechanical or hydraulic microdrive (3, 4, 6). The depth, or Z-axis, control of the electrode is provided by the microdrive, which is positioned within the X-Y plane of the recording chamber by an attached micropositioner carrying the microdrive. Many microdrives and micropositioners to accomplish these tasks have been devised (1–3, 5, 7, 8). For several years we have used a commercially available hydraulic microdrive and X-Y slide micropositioner (Kopf). Unfortunately, the micropositioner used with the Kopf hydraulic microdrive was no longer manufactured. Requiring a replacement for it, we designed a micropositioner based on the radial positioning technique (4). The new design requires only one sliding element, making it simple and more robust than the slide type X-Y micropositioner. Based on our experience with chronic recording, several new design features were implemented to enhance the utility of this device.

METHOD AND RESULTS

The micropositioner consists of three main components (Fig. 1). The base of the micropositioner is the main structural element. A horizontal saw cut extending halfway through the base (Fig. 1) divides the base into upper and lower parts. The bottom part of the base is machined to fit the recording chamber closely and has a vertical cut on one side spanned by a machine screw (Fig. 1) for clamping the base on the recording chamber. On the top part of the micropositioner base, machined guides carry the sliding micropositioner element. The slide is positioned by a worm screw in the base of the micropositioner (Fig. 1). A belleville washer, selected to provide secure clamping without binding, and a machine screw hold the slide in its guides.

The electrode microdrive is attached to the micropositioner by inserting its electrode guide into the guide shaft and fixing it with a set screw (Fig. 1). The zero or home position on the micropositioner slide scale has the center of the guide shaft, that is, the electrode axis, in the center of the chamber. The worm screw adjustment can move the slide one millimeter in four rotations and can easily be set to within 0.1 mm of the desired location by noting the scale and screw rotation. In this way the electrode can be positioned to any radial distance from 0 to 7 mm from the center of the recording chamber.

The microdrive guide shaft in this radial adapter was made considerably deeper (8 vs. 3 mm) than the shaft in the original X-Y adapter. A long shaft greatly facilitates

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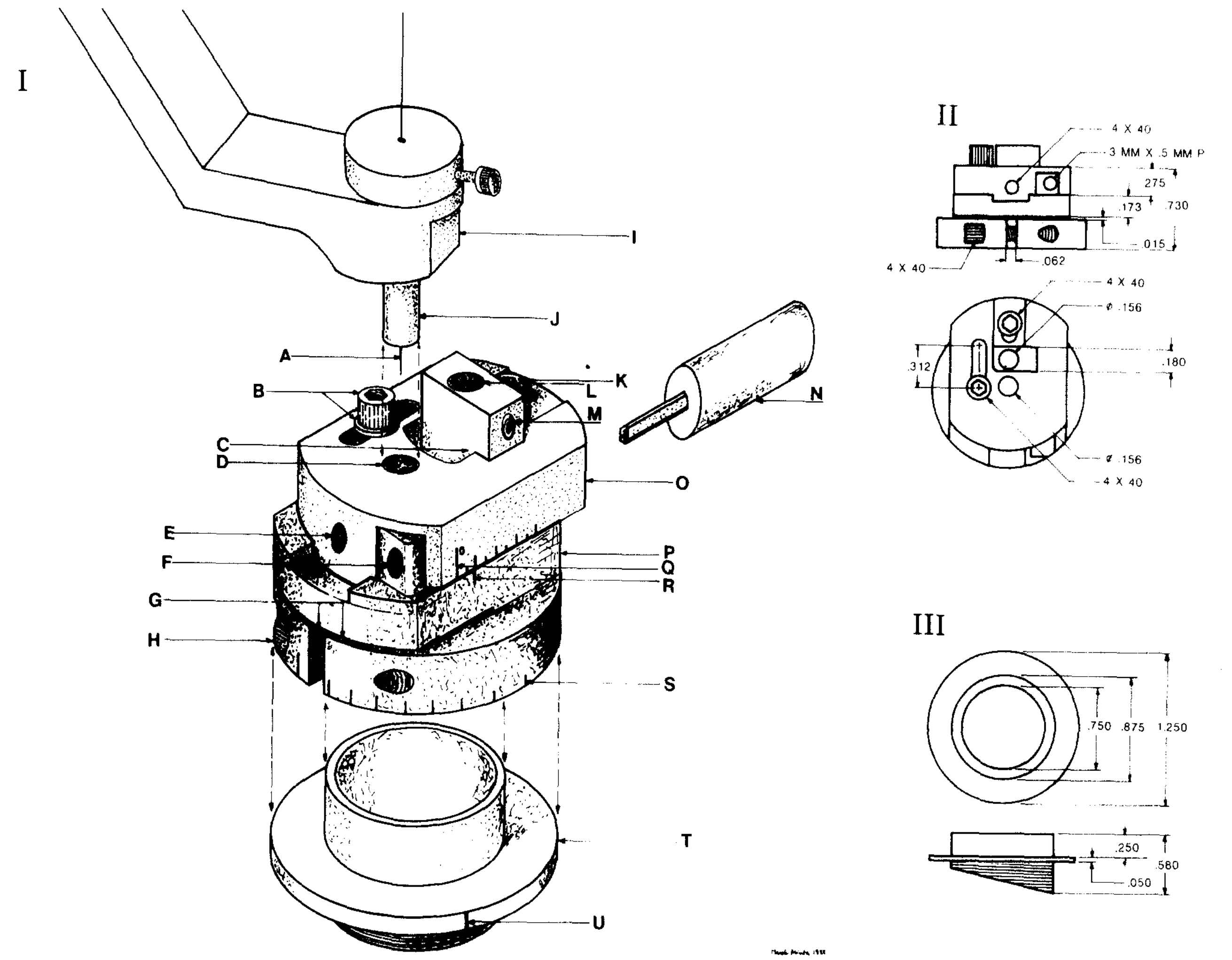

FIG. 1. Part I shows an exploded view of the micropositioner, recording chamber and microdrive. The two main parts of the micropositioner are the base, (P), and sliding element, (O). The Kopf hydraulic microdrive, (I), is attached to the micropositioner and the micropositioner is attached to the recording chamber (T). The parts of the device are as follows: A) Electrode. B) Belleville washer and clamping machine screw. C) Movable block for second microdrive. D) Electrode guide shaft [to fit part (J)]. E) Set screw to fix electrode guide. F) Worm screw guide. G) Saw cuts which permit lower half of base to clamp recording chamber using H), clamping screw. I) Hydraulic microdrive. J) Electrode guide fits shaft, (D). K) Screw to fix the position of the movable block, (C), which holds second microdrive. L) Second microdrive guide shaft. M) Set screw to fix electrode guide in the movable block. N) Hex wrench tool used to turn worm screw in (F) for positioning the sliding element (O). P) Base of micropositioner. Q) Scale to indicate radius distance of electrode guide shaft, (D), from the center of recording chamber. R) Index mark or home position for scale, (Q), S) Scale in 10 degree increments used for angular position. T) Recording chamber implanted on skull. U) Index mark used with scale, (S), for setting angular position. Part II: A top and side view of the micropositioner. Dimensions given in inches. Set screws and clamping screws had standard 4×40 threads. The worm screw should be implemented with a metric thread (3×0.5 mm) to provide an even number of turns per mm of slide movement. Part III: Top and side view of the matching recording chamber. Dimensions in inches. The outside surface of the bottom half of the chamber has grooves for embedding in dental acrylic.

mounting the microdrive by ensuring a straight penetration of the electrode through the dura with no possibility of off-axis wobble. The danger of brain damage by angular penetration or wobble is avoided. It was the shorter guide shaft that deteriorated in the previously used X-Y micropositioner.

The angular position of the electrode in the chamber is set by rotating the adapter base on the recording chamber. The adapter can be clamped to any radial position, and this feature, along with the radius control, allows the electrode to be set to any X-Y position within the chamber. A scale with marks at every 10 degrees and an index mark (Fig. 1) on the chamber is used to set the angular position. In our studies, the recording chamber is fixed to the skull during surgical implantation with the index mark set to the front of the chamber on the same medial-lateral stereotaxic line as the center of the chamber. The desired position of the electrode track in the anterior-posterior (AP) and lateral (L) plane is specified by the displacement from the center of the chamber, i.e., ΔAP and ΔL, and the quadrant. From these values the angular rotation, (Θ), from the index mark is computed by:

$$\phi = \tan^{-1} (\Delta L/\Delta AP).$$

$\Theta = \phi$ except for the quadrant in which $\Delta AP < 0$ and $\Delta L > 0$, where

$$\Theta = \phi + 180,$$

and the quadrant in which $\Delta AP < 0$ and $\Delta L < 0$, where

$$\Theta = \phi - 180.$$

The direction of the angular rotation is indicated by the sign of Θ. The radial distance from the center of the chamber (r) is calculated by:

$$r = | \Delta L/\sin \phi |.$$

Potential errors due to angular positioning will be the greatest at the extreme reaches of radial settings. With a radial setting of 7 mm and a maximum expected error of 2 degrees in angular position, the actual X-Y location could be shifted up to 0.25 mm from the intended location. At smaller radial settings, deviations due to angular positioning quickly become insignificant. Placement errors of this magnitude are within the range of deviations expected from even slight bending of the electrode shaft, thus, a scale with 10 degree markings was found adequate for our purposes. A finer angular scale could be implemented if greater positioning accuracy is required.

An optional movable block with a second microdrive guide shaft (Fig. 1) can be added to micropositioner, allowing two microdrives to be mounted at the same time. Two electrodes could be separated by 5 to 7 mm, but only the distance between electrodes can be changed. Both guide shafts lie on the same radial line.

The recording chamber is a smoothly-finished cylinder with an inside diameter of 18 mm and has a machined platform to mate with the bottom of the micropositioner (Fig. 1, III). On the outside surface of the cylinder, under the platform, grooves are machined for embedding the chamber in dental acrylic. The chamber is machined from surgical grade stainless steel or titanium. The micropositioner is made of aluminum and after machining is anodized, producing a hardened oxide layer that inhibits corrosion and facilitates cleaning. A plastic protective cap was machined to cover the chamber when the animal is in its home cage. The mass of this micropositioner is 27 grams, 6 grams heavier than the previous X-Y slide positioner. The accessible surface area is much larger with this micropositioner. Unlike the X-Y slide positioner, which limited access to a 10 mm square (100 mm^2) inside its circular chamber, the radial micropositioner permits access to the entire chamber, 154 mm^2 in this version of the micropositioner, which has a maximum radial setting of 7 mm. Compared to the X-Y slide positioner we had been using, this is an increase of 54% (154 vs. 100 mm^2).

DISCUSSION

The radial micropositioner has proved to be reliable and easy to use. The X-Y positions of the electrode must be converted to radial and angular coordinates, but the calculation is straightforward and easily incorporated into recording programs. The micropositioner has been used successfully for over a year on both monkeys and cats. In comparison with the manipulator it replaces, the micropositioner accesses a larger surface area, permitting exploration of a much larger volume of brain with a single chamber implantation. The more robust design is less prone to damage, it is easier to attach and clamp and it is more easily maintained.

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