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THE BONE FINDER: A SIMPLE DEVICE FOR IMPROVING THE ACCURACY OF DEEP STEREOTAXIC PLACEMENTS

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PURPOSE AND BRIEF DESCRIPTION

Despite tremendous improvements in the precision and accuracy of stereotaxic instruments and maps, there is still considerable uncertainty attending efforts to place an electrode tip precisely into any deep cerebral structure. The idea for the Bone Finder was motivated by a desire to reduce this uncertainty for targets lying close to cranial bone.

Briefly, the Bone Finder is a probe carried on the shaft of an electrode or other intracranial device. The probe travels parallel to, and in front of, the actual electrode and serves to indicate the precise depth of the bone along its path. This information may then be used to make a refined estimate of the depth of the target structure, and thus improve the accuracy of the stereotaxic placement.

Because the Bone Finder is a simple, inexpensive and easily fabricated device that has significantly increased the effective yield of our stereotaxic experiments, we thought our fellow Kopf-users might be interested in learning about it.

DETAILED DESCRIPTION AND USE

As illustrated in Figure 1, the Bone Finder consists merely of a slender pin held in a sleeve of syringe tubing. The sleeve, in turn, is cemented to the shaft of the electrode or other carrier-born device. The sleeve is located on the electrode such that when the pin is fully inserted, its tip protrudes a certain known distance beyond that of the electrode.

When this assembly is advanced toward the target, the pin passes through the brain and past the target until it encounters bone. The pin, because it is held only by friction, then stops. This event is recognized by observing movement of the pin head relative to the sleeve during electrode advancement. At the moment one first notices this movement, the distance between the electrode tip and the bone is immediately known because that distance is preset at ihe time the Bone Finder and electrode are assembled.

In our studies of the connections of the auditory system, we target various small nuclei of the superior olivary complex in adult male Sprague-Dawley rats. We begin in the conventional way by estimating the coordinates of a target structure, referring to the atlas of Paxinos and Watson (1986). Next we determine the carrier settings necessary for the tip of the electrode or injection pipet (with its attached Bone Finder pin temporarily withdrawn) to pass through the center of the target. However, before making the actual injection or lesion, information obtained from

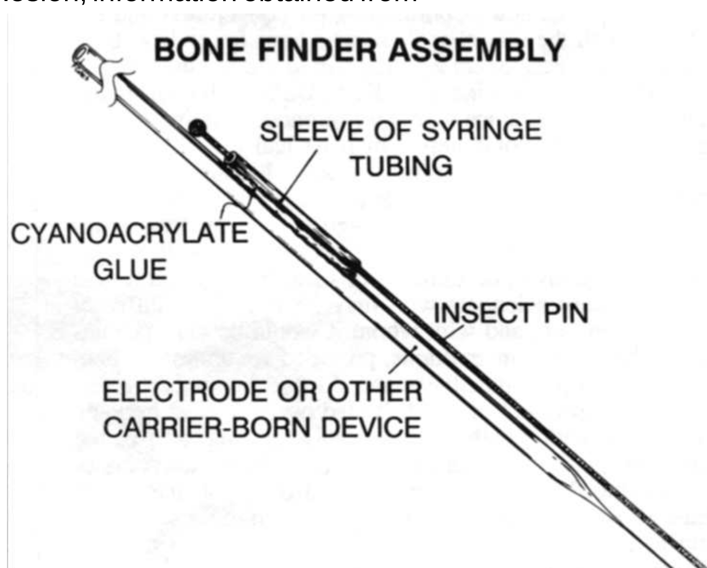

Figure 1. Drawing of the Bone Finder Assembly. Before being advanced towards the target structure, the insect pin is moved all the way forward in the sleeve until the pin head is seated, thus setting the distance by which the pin leads the electrode tip. When the pin contacts bone, the distance of the electrode tip above the cranial floor is known, as indicated by movement of the pin head relative to the sleeve.

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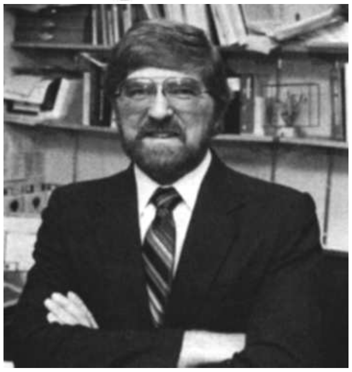

Editor's Column

It is a beautiful day here in Athens, Ohio. We have hadthefirstwhite Christmas here in about 10 years! In fact, it even snowed about 3 inches on Christmas day. That certainly added to the holiday spirit for those of us who grew up in places where having snow in December was the norm rather than the exception. It was also very cold here, breaking records which have stood for almost 100 years, getting down to almost 18°F below zero for several nights. Many water pipes froze and burst. However, in a couple of days, it is to be almost 50°F above zero, so the snow will soon be gone. I certainly hope that all of you had a good holiday and are enjoying the new year.

This new decade certainly will bring many challenges and opportunities for our field. Uncertain funding and animal rights challenges are probably the most critical problems just now. Unequaled scientific progress and opportunities for expanded professional contacts are probably the most exciting prospects for the decade. The advances in electronic data and information exchange have made much of our routine work in the pursuit of our science much less onerous.

The recent changes in the Eastern Bloc nations have opened up vast new opportunities for cooperation and exchange with the scientists there who have for so long been almost inaccessible. On a recent trip to the Soviet Union, I was able to visit a scientist in Kiev, USSR, who was struggling to do his science with very outmoded equipment and a couple micro computers which he had managed to get through Japan, but the going was slow because they were having to translate the manuals from Japanese into Russian (I have enough trouble translating the manuals from com-puterese into English). With the opening of the Iron Curtain come many opportunities for us to have access to and to help many scientists who may have slightly different views from ours and with whom it would be very profitable to have some interactions, provided we approach them with some openmindedness and do not dismiss their science and views out of hand. It also opens a great heritage of science with which we are simply too unaware for the most part, and which can be of great value to all of us as we go into the next ten years. If you have contacts in the Eastern Bloc, it is a great time to reach out to them and begin to build more interactions. That activity will pay big dividends for all of us in the future.

Happy New Year!

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the Bone Finder is used to re-estimate the depth of the target along the path of the electrode. This re-estimation is obtained by simply adding 0.5 mm, an estimate of the sub-dural space underlying the rostral medulla, to actual distance measurements made on 50 micrometer thick frozen sections between a given target structure and the ventral surface of the brain, corrected for the actual angle of electrode approach, if different from the plant of the tissue sections.

The accuracy thus obtained in making small injections in the lateral superior olivary nucleus, a structure measuring about 1 mm in diameter, is approximately 75%, and not surprisingly, our errors of placement in the dorso-ventral direction have virtually disappeared. Overall, we estimate that our present yield of successful placements has nearly doubled since introducing the Bone Finder device. Moreover, most of our misses are at least close to the intended target and are thus useful as controls.

CHOICE OF MATERIALS

There are two basic requirements for constructing a Bone Finder. First, one needs to find a slender, sharp and rigid needle that can pass through the brain without bending or causing intolerable damage. Second, one needs to select a rigid, snugly fitting sleeve to hold it.

At present, we construct our Bone Finders from two readily available stock items: 1) 000 gauge insect pins, with a black rust resistant finish, purchased from Fine Science Tools Inc (800-521-2109) and 2) 26 gauge, 3/8 inch Becton Dickinson disposable syringe needles, generally available from medical supply companies. We find that these two elements slide together with a friction fit that prevents free movement but allows the pin to slide within the tubing when slight force is applied.

We have found the pins described above to be quite satisfactory from the standpoint of length (37 mm), stiffness, sharpness of point, and visibility to the naked eye. In addition, the spherical nylon heads on these pins provide a reliable insertion stop and visible reference for motion detection, which during actual use is the indication that bone has been "found." The nylon heads are also easy to trim, as is sometimes necessary in order to create clearance between the head and the electrode shaft.

However, one drawback of insect pins is that, as shown in Figure 2, they taper very abruptly from their 250 micrometer diameter to the tip and thus create a recognizable track through the brain. As an less invasive alternative to insect pins, we have found that Parylene-C insulated 0.010" tungsten microelectrodes (available from Micro Probe Inc. (301-972-7100) taper very gradually to a sharp tip while maintaining adequate stiffness. In addition, these electrodes are much longer (75 mm vs 37 mm) than insect pins (an important consideration in larger species) and yet form a perfect friction fit with 26 gauge syringe tubing. We have not actually used these electrodes as Bone Finders, but they would appear to be ideal for the purpose.

The 26 gauge syringe tubing can be obtained commercially in lengths as short as 6 inches from Small Parts Inc. (305) 751-0956.

FABRICATION AND ASSEMBLY

Bone Finders can be made in advance and attached to electrodes or other devices when needed. The process is quite simple, and probably "easier done than said," as you may agree after reading the steps described below. Be-

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cause the various materials comprising the Bone Finder are rather small, good lighting and some form of magnification is helpful. Before starting, it would be best to have the following items close at hand:

Head Loupe Magnifier or stereomicroscope	grinding stone
2 plastic millimeter rulers	000 insect pins
26 gauge syringe needle	cyanoacrylateglue
miniature file	tissue paper
small pliers or straight hemostat	fine forceps

STEP 1: Making the sleeve out of syringe tubing. Using the grinding stone, blunt the syringe needle tip to avoid possible injury. To remove syringe needle, insert an insect pin down the shaft and using the file, score the entire circumference of the tubing close to its attachment to the plastic housing.

Using the pliers, grasp the tubing close to the scoring, and gently move the tubing back and forth until it breaks. Too great a movement could result in a kink in the tubing and difficulty in extricating the pin. Slide the insect pin back and forth in the sleeve to ream out any metallic debris. Withdraw the pin and use again, if it is not damaged.

STEP 2: Fitting a probe to the sleeve. Insert a new insect pin into the sleeve. The pin should form a snug friction fit, but should slide easily and without bending when the tip is pressed gently against a solid object.

STEP 3: Aligning the Bone Finder with an electrode. The purpose of this step is to bring the Bone Finder and electrode into parallel alignment and to set the distance between their respective tips.

First, in order to create a calibrated straight edge against which to align the Bone Finder and electrode, tape the millimeter ruler to a flat white surface, as shown in Figure 2B. Place the electrode against the calibrated edge and line up the tip with one of the millimeter marks.

Next, bring the Bone Finder, with the pin fully inserted, into close parallel contact with the electrode. In order to obtain the required clearance between the pin head and the electrode shaft, it may be necessary to trim off one side of the pin head or employ two sleeves cemented together, as shown in Figure 2B.

Now, line up the tip of the insect pin with a millimeter mark some distance in front of the electrode tip. We suggest that the actual distance chosen should be slightly greater than that between the bone and the anticipated target, if such be known. Thus, when the Bone Finder encounters bone, the electrode tip will not have yet reached target and can be advanced to it with due caution. For example, we use a two millimeter separation because our targets in the rat medulla are located approximately 1.5-0.5 mm above the cranial floor.

STEP 4: Stabilizing the alignment. Carefully secure the second plastic ruler against the Bone Finder in order to stabilize the entire assembly during application of the cement (see Figure 2C). It may be necessary to position this ruler just distal to the pin head in order to preserve the parallel alignment of the electrode and Bone Finder.

STEP 5: Cementing the entire assembly. Apply a small amount of cyanoacrylate glue to the zone of contact between the Bone Finder sleeve and the electrode. Apply the glue sparingly and spread it with a slender twist of tissue paper. Allow 15 minutes to set.

DISCUSSION

The Bone Finder is a simple device which can quickly and reliably provide supplementary boney reference points close to deep cerebral targets. Our experience indicates that these reference points, together with distance measurements between targets and the adjacent bone, can improve the accuracy of stereotaxic placements.

The practice of obtaining supplemental reference points from the skull is not new. Indeed, lambda and bregma, the intersection of sutures on the surface of the rat skull (Paxinos and Watson, 1986), are commonly used supplementary bony landmarks, but these are too distant from our ventral

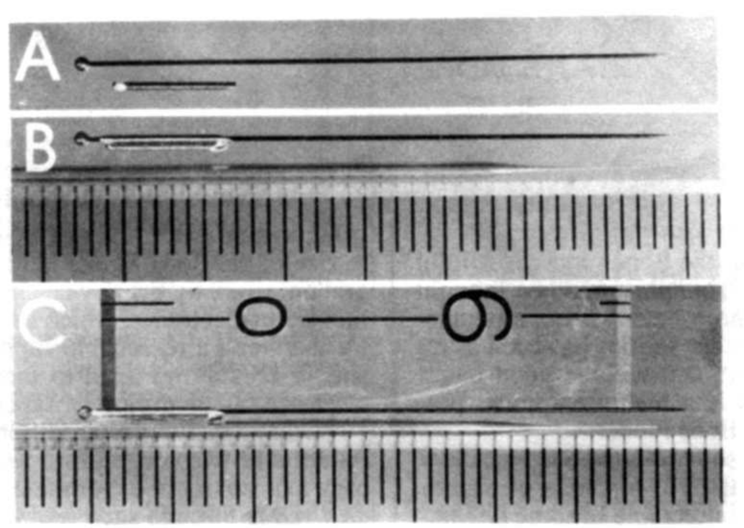

Figure 2. Photographs of Bone Finder parts and method of assembly. A. Insect pin and sleeve of syringe tubing. B. Bone Finder aligned in parallel with an electrode. Note that a double barreled sleeve is being used in this case to increase the separation between the pin and electrode. See text for explanation. C. Photograph showing method of stabilizing Bone Finder and electrode between two plastic rulers at the time of final assembly and glue application. Note that the pin head is seated against the sleeve and the tip of the pin extends beyond that of the electrode by 2mm.

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targets lo be of practical value.

If, as our experience suggests, the Bone Finder is helpful in an animal as uniform as the laboratory rat, then it might be of even greater utility in more heterogeneous populations. Indeed, the brain of no other species has been as reliably mapped as that of the rat, and without good maps, determining target coordinates is a highly empirical process that might be aided by the Bone Finder.

The Bone Finder does have some disadvantages. Chief among these is that the probe itself is a source of experimental artifact which might be intolerable in some circumstances. We minimize damage to experimentally relevant surrounding structures by carefully choosing both the angle of approach, the orientation of the Bone Finder with respect to the electrode, and by adjusting the parallel separation between the Bone Finder and the electrode by making "double barreled" sleeves as shown in Figure 2C. We also suggest that a more tapered probe is both a feasible and less destructive alternative to the insect pins we have been using to date (see Choice of Materials).

Use of the Bone Finder necessitates some advance preparation. Initially the devices have to be fabricated, and cemented to electrodes, which is a somewhat tedious process. Furthermore, a reasonable supply of completed assemblies should be kept on hand to meet emergencies, such as an electrode failure during an experiment.

We hope that this report of our experience with the Bone Finder will encourage other neuroscientists to test its efficacy in a variety of experimental situations and animal species. Only through such use will the Bone Finder continue to undergo technical refinement, and perhaps eventually become, for all those who probe deeply into the brain, a "standard operating procedure."

REFERENCE

Paxinos, G. and **Watson, C.** (1986). T*he Rat Brain in Stereotaxic Coordinates*, 2nd Edition. Academic Press, Sidney.