Accurate ventricular catheter placement is an important variable influencing shunt surgery outcome. Correct catheter placement rates of approximately 90% are reported in cases in which a posterior catheter guide (PCG) is used. This represents a significant improvement compared with free-hand methods; however, selection of a proper catheter trajectory is critical to successful placement.

The technique of manually measuring and calculating a burr-hole site relative to the external occipital protuberance is prone to error. In the current report a new device is described that is designed to improve this burr-hole selection process.

Design Concept

Our design objectives were to develop a mechanical posterior burr-hole localizing system that would: 1) be simple to use; 2) not require hand measurements from anatomical landmarks; and 3) not rely on the external occipital protuberance. The concept that evolved is based on the hypothesis that a consistent anatomical relationship exists between the anterior horn of the lateral ventricle and the nearby orbital roof and superior attachment point of the external ear.

Neuronavigational software was used to create a three-dimensional computerized tomography (CT) scanning-based image of a normal adult male human head and to study the geometric relationships between the superior attachment point of the external ear, the superior orbital roofs, and the cerebral ventricles. Using this technique, an axial trajectory plane was defined that traversed the body and anterior horn of the lateral ventricles, as depicted in Fig. 1.

The “anchor” point is a single midline frontal target site positioned on the forehead 2 cm above the line connecting the palpable superior edges of the two orbits (that is, supraorbital rims [Fig. 2]). The axial trajectory plane projects posteriorly from the frontal target site toward the occiput. Bilateral ear spacers extend perpendicularly down from the axial trajectory plane and set the plane a fixed 4 cm above the superior attachment point of each ear. Once the axial trajectory plane is defined, the burr-hole location is selected as the scalp point within the plane that is 3 cm anterior to the ear spacers.
from the posterior midline. The actual catheter trajectory becomes the line connecting the burr-hole site and the frontal target point.

The validity of this geometric relationship between the lateral ventricles, supraorbital rims, and the superior attachment point of the ear was confirmed by means of a retrospective review of CT scans obtained in 50 adult patients with hydrocephalus.

**Description of Device**

A burr-hole localizer device (Localizer) was constructed at the University of Iowa Medical Device Machine Shop according to the geometric principles described earlier. A triangular frontal target-localizing device with bilateral supraorbital rim tabs is used to assist the surgeon in placing a midline scalp mark 2 cm above the supraorbital rims (Fig. 2).

The head band–based Localizer is placed on the patient’s head and secured by tightening a posterior knob. An anterior eyelet is oriented over the frontal target scalp mark, and bilateral ear spacers abut the superior attachment points of each ear. A flexible posterior trajectory-aligning piece projects backward around the occiput and a trajectory sighting slot is aligned along the optimum trajectory plane (Fig. 3). A sagittal sighting bar is positioned 3 cm to the right of the posterior midline (Fig. 4). The point on the scalp under which a burr hole should be made is defined by the intersection of the sagittal plane– and trajectory plane–sighting slots.

**Clinical Trial**

After completion of the anatomical validation study and testing of the Localizer on cranial phantoms with different head sizes, a clinical trial was initiated following approval by the University of Iowa Human Subjects Review Board. The trial was open to all adult patients who were scheduled to undergo ventriculoperitoneal shunt placement performed using the PCG. In all cases preoperative CT or magnetic resonance (MR) images were analyzed to ensure that the patient’s ventricles were sufficiently enlarged so that a line drawn from a posterior scalp point located 3 cm from the midline to an anterior midline scalp point traversed the body of the lateral ventricle. A trajectory based on the ear and supraorbital rims is not specifically measured during routine use. The end points studied included: 1) number of catheter passes per operation; 2) postoperative imaging data; and 3) catheter-related complications.

**Results**

The Localizer was used to select the ventricular catheter trajectory in 28 adult patients with hydrocephalus who were treated by five staff and six resident neurosurgeons. Posterior catheter placements were performed intraoperatively by using the PCG. The Localizer was easy to use.
and the mechanism of cranial placement was similar to placing a sun visor on a patient’s head. Less than 5 minutes was typically required to perform the trajectory selection process.

In all cases ventricular catheters were successfully placed on the first pass. Postoperative plain x-ray films (26 patients) and CT scans (22 patients) demonstrated that the catheter entered the anterior horn of the ipsilateral ventricle in all cases. In 10 patients, the ventricular catheter was too long and the catheter tip penetrated through the wall of the ipsilateral frontal horn a distance ranging from 1 to 3 mm. The distance separating the center of the burr hole from the posterior midline was measured in the 22 cases in which postoperative CT scans were available. Distances ranged from 1.7 to 4 cm (mean 2.3 cm). There were no catheter-related surgical complications.

**Discussion**

A wide variety of strategies based on hand measurements and visual aiming techniques have been described to assist the surgeon during posterior ventricular catheter insertions.1,3,6,7 Prior to the development of the PCG, the efficacy of these methods could not be critically analyzed in isolation because of the confounding effect of the free-hand pass. With the free-hand technique, an optimum trajectory selection method might be associated with poor catheter placement because of the inability of the surgeon to pass the catheter along the intended path by using mental imagery and hand–eye coordination alone.

Because the PCG mechanically guides a catheter along the path that has been selected, in theory any poor placements that occur should be attributable to improper trajectory selection.4 In practice, a group of neurosurgeons who
use the PCG have noted that when errors occur, the mis-
cue usually relates to a poorly positioned posterior burr
hole.

The Localizer device described in the current report
was designed to eliminate the need for hand measure-
ments and subjective estimates of anatomical landmarks.
Instead of using the external occipital protuberance as a
point of reference, the device is positioned relative to
clearly defined cranial landmarks in greater proximity to
the anterior horn of the lateral ventricle: the supraorbital
rims and the superior attachment points of the external
ears. The device functions by defining two planes; these
are an axial trajectory plane and a sagittal plane 3 cm to
the right of the posterior midline. The point on the poste-
rior scalp where these two planes intersect is visually
delineated by the intersection of two sighting slots.

The Localizer device is rugged, lightweight, and easy to
use. It is secured to the patient’s head by means of an
adjustable head band and the process of marking the burr-
hole site typically requires less than 5 minutes. To date,
28 patients have undergone shunt placement in which
the Localizer and PCG have been used. In all cases the
catheter was placed with a single pass and analysis of
postoperative radiographic studies indicated that the
catheter traversed the body and anterior horn of the ipsi-
lateral lateral ventricle. There were no catheter-related
complications. The mean distance separating the posterior
midline from the center of the burr hole was 2.3 cm (range
1.7–4 cm). This variability in burr-hole placement may be
caused by factors such as inaccuracies in Localizer place-
ment on the patient’s head, displacement of scalp tissue
during patient positioning, or inaccurate intraoperative
assessment of which point on the skull directly underlies
the scalp mark.

Although these early results suggest that the Localizer
may be safe and effective when used in combination with
the PCG, several caveats must be considered. The device
is only suitable for use in adult patients with enlarged ven-
tricles and normal scalp and external ear anatomy. Al-
though the system has been tested by using a wide variety
of head sizes, it is likely that situations will occasionally
be encountered in which a patient’s head is too small or
too large for the device. The system serves the discrete
function of assisting in the trajectory selection process and
does not assist the surgeon with other important aspects of
the procedure such as selecting the proper catheter length.
As with any device, optimum performance will depend on
how carefully the surgeon attends to the details of its use.

Disclosure

The University of Iowa has filed a United States patent applica-
tion for the Localizer and has listed Dr. Howard as the inventor.
Both the University of Iowa and Dr. Howard have a financial inter-
est in the device.

Acknowledgments

The authors thank Dr. John VanGilder for his support of the de-
vice development project and Angela McGlothlen for her help with
manuscript preparation. We also thank the skilled craftsmen of the
University of Iowa Medical Device Machine Shop for their out-
standing work.

References

1. Ames RH: Ventriculo-peritoneal shunts in the management of
2. Becker DP, Nulsen FE: Control of hydrocephalus by valve-reg-
ulated venous shunt: avoidance of complications in prolonged
3. Hammon WM: Evaluation and use of the ventriculoperitoneal
placement of parietooccipital ventricular catheters. J Neuro-
surg 82:300–304, 1995
shunt in the treatment of adult hydrocephalus. Results and com-
7. Pudenz R: The surgical treatment of hydrocephalus. A histori-
8. Sekhar LN, Moossy J, Guthkelch AN: Malfunctioning ven-
triculoperitoneal shunts. Clinical and pathological features. J
Neurosurg 56:411–416, 1982

Manuscript received November 12, 1997.
Accepted in final form March 3, 1998.
Address reprint requests to: Matthew A. Howard III, M.D., Di-
vision of Neurosurgery, University of Iowa Hospitals and Clinics,
Iowa City, Iowa 52242. email: mhoward@surgery.uiowa.edu.