Adjustment of the endoscopic third ventriculostomy entry point based on the anatomical relationship between coronal and sagittal sutures

Laboratory investigation

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Object. The coronal suture is often used as an empirical landmark for the entry point for endoscopic third ventriculostomy. The trajectory for the approach is often drawn based on midsagittal MRI findings. However, because the coronal suture is not perpendicular to the midline, this method may be inaccurate.

Methods. The junction of the coronal and sagittal sutures was exposed at the outer table of the cranium of 15 cadavers. An ideal coronal line was established perpendicular to the sagittal suture at the junction of the sagittal and coronal sutures. The distance from this ideal coronal line at the level of the coronal-sagittal junction to the actual coronal suture was measured at 1-cm intervals. The measured distance between the 2 planes was termed the distance to the coronal suture.

Results. The coronal suture bows forward as it moves from medial to lateral. From 1–6 cm lateral to the sagittal suture, the distance to the coronal suture was 0.1, 0.3, 0.5, 0.8, 1.0, and 1.4 cm, respectively. There was no significant difference between the right and left sides.

Conclusions. The position of a bur hole for endoscopic third ventriculostomy should be moved posteriorly with respect to the coronal suture the more laterally it is placed. Although the adjustment is small, it may be crucial. Failure to make this adjustment may result in suboptimal bur hole placement and increase the risk of morbidity.

(key Words • endoscopic third ventriculostomy • coronal suture • trajectory • endoscopy • diagnostic and operative techniques • hydrocephalus

Abbreviation used in this paper: ETV = endoscopic third ventriculostomy.
Coronal suture as landmark for ETV

thalamus at risk for injury. While image guidance and multiplanar reformatting are sometimes available for this procedure, in most of the world, including some first-world environments, empirical landmarks are used. Pre-operatively, this trajectory is most often estimated on MR images in relation to the coronal suture. Typically, on a midsagittal MRI, a line is drawn to extend from the floor of the third ventricle in front of the mammillary bodies on the tuber cinereum through the center of the foramen of Monro to the skull (Fig. 1). Our previous work has shown that this trajectory and consequently the ideal entry point are quite variable. Traditionally, the coronal suture is used as an empirical landmark for this trajectory, with the bur hole placed in relation to it. The coronal suture, however, does not course perpendicular to the midline. Instead, it projects anteriorly as it proceeds laterally from the sagittal suture. Therefore, the traditional method can lead to an inaccurate estimate of the entry point. When image guidance is used, adjustments may be made on preoperative image planning by using a trajectory view to compensate for this difference. However, when such technology is unavailable, this seemingly slight inaccuracy could become substantially magnified further along the trajectory, thereby risking injury to critical structures adjacent to the projected path. In such cases, a calculated degree of offset between the coronal suture and a perpendicular line to the sagittal suture would be both necessary and useful in making the appropriate adjustments to the entry point. We sought to calculate these offsets by utilizing cadaver heads to measure the difference between the coronal suture and a projected line perpendicular to the sagittal suture as both extend laterally from the midline.

Methods

Fifteen cadaver heads were stripped of the scalp to expose the skull. The sagittal and coronal sutures were completely exposed, and the midline as defined by the sagittal suture was identified. When the course of the sagittal suture began to undulate, its center was marked by multiple points to create a straight line. Flexible templates were made with a right angle to the left or right. The template was placed along the sagittal suture, and the perpendicular line from this line at the junction of the sagittal and coronal sutures was mapped (Fig. 2). This line perpendicular to the sagittal suture was termed the ideal coronal line. The distance from this perpendicular line to the actual coronal suture was measured at intervals lateral to the sagittal suture. Because the course of the coronal suture also undulates, the midpoint of the suture was also used to define a straight line against which to measure. The interval distance lateral to the sagittal suture was termed the distance to the sagittal suture. The distance measured between the ideal coronal plane and the actual coronal plane was termed the distance to the coronal suture. Distances from the coronal suture were measured at 1, 2, 3, 4, 5, and 6 cm on both the right and left sides lateral to the sagittal suture. The mean distances at each interval were calculated on both sides.

Results

The mean values for both sides were calculated to 2 significant digits (Table 1). Moving laterally from the midline, the coronal suture projects anteriorly (Fig. 3). Therefore, as one moves laterally, the distance between the coronal suture and the ideal coronal plane increases. Once the ETV trajectory has been determined from a midsagittal MRI, the position of the bur hole should be moved posteriorly with respect to the coronal suture, the more anterolaterally the suture is positioned.

Discussion

This study may seem to define a technical nuance,
but the entry point for ETV can profoundly affect patient outcomes. In most patients with a small foramen of Monro, the straight-line route to the third ventricular floor is tightly constrained, with little room for variability or margin of error. Thus, determining the most accurate entry point possible is crucial to reach the desired target safely and effectively.

Too medial an entry point may place venous tributaries of the superior sagittal sinus, the body or column of the fornix, or the deep cerebral veins such as the septal vein at risk. Entering too laterally can endanger the column of the fornix or make entry through the third ventricular floor anatomically impossible. Too anterior an entry point places the column of the fornix at risk for injury, while too posterior an entry point places structures such as the thalamostriate vein, venous angle, anterior caudate vein, superior choroidal vein, or anterior thalamus at risk.1–5,6,11–13,22,23,25 Our measurements allow the placement of the bur hole to be adjusted in relation to the coronal suture.

Once the ideal trajectory has been planned from a midsagittal image, the bur hole entry point for the ETV should be corrected posteriorly with respect to the coronal suture. When this entry point is placed more laterally, it may need to be moved posteriorly in relation to the coronal suture to achieve the planned trajectory. Suboptimal placement of the bur hole may result from failure to make this correction, increasing the risk of iatrogenic injury to the key structures described above. Because of the large variation in the optimal entry point and trajectory across patients,1–3 whenever available, image guidance using the trajectory planning views available on many commercial systems should be considered. For the average patient whose bur hole is placed 3 cm from midline, the entry point should be moved back 5 mm from the line drawn on the midline image.

Our measurements have limitations. They were all made on adult skulls and cannot account for potential age-related variations. Furthermore, the foramen of Monro may be larger in hydrocephalic patients and therefore allow a wider range of possible entry points, making the small adjustment this correction accounts for of less importance. However, our own work suggests that the most accurate measurements possible are essential to attain an ideal trajectory.4

**Conclusions**

Traditionally, the coronal suture has been used as a landmark to estimate the entry point for ETV. If the coronal suture runs more anteriorly when moving laterally, the estimated site for the bur hole may be inaccurate, risking injury to structures adjacent to the trajectory. Correcting this discrepancy by calculating the distance between the coronal suture and a line perpendicular to the midline will decrease this potential inaccuracy and should thereby help decrease rates of procedural morbidity and mortality.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. Dr. Nakaji is a consultant for Medtronic.

Author contributions to the study and manuscript preparation include the following: Conception and design: Nakaji, F Chen. Acquisition of data: F Chen. Analysis and interpretation of data: all authors. Drafting the article: F Chen, T Chen. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Nakaji. Statistical analysis: F Chen. Administrative/technical/material support: Nakaji, F Chen. Study supervision: Nakaji.

| TABLE 1: Mean distances anterior to the ideal coronal line* |
|----------------|----------------------|---------------|
| DTSS (cm)      | Mean DTCS ± SD (cm)  |              |
|                | Rt                   | Lt            |
| 1              | 0.1 ± 0.1            | 0.1 ± 0.1     |
| 2              | 0.3 ± 0.2            | 0.3 ± 0.2     |
| 3              | 0.5 ± 0.3            | 0.5 ± 0.3     |
| 4              | 0.8 ± 0.3            | 0.8 ± 0.3     |
| 5              | 1 ± 0.4              | 1 ± 0.3       |
| 6              | 1.4 ± 0.5            | 1.4 ± 0.6     |

* DTCS = distance to the coronal suture; DTSS = distance to the sagittal suture.

Fig. 3. Three-dimensional CT reconstruction demonstrating the relationship of the coronal suture to the sagittal suture.
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References


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