Safe entry point for twist-drill craniostomy of a chronic subdural hematoma

Clinical article

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Object. Twist-drill craniostomy (TDC) with closed-system drainage is an effective treatment option for chronic subdural hematoma (CSDH). Because the entry point for TDC has not been described in a definitive area, the aim of this study was to define the optimal twist-drill entry point for CSDH.

Methods. The authors selected 40 random cases involving selective catheter angiography of the external carotid artery, regardless of study purpose, to evaluate the course of the middle meningeal artery. Furthermore, 50 skull radiographs were reviewed to assess the relation of the vascular groove to the coronal suture. On the basis of the radiological anatomical study, the authors propose that the normal TDC entry point should be 1 cm anterior to the coronal suture at the level of the superior temporal line (STL). Thirty patients with symptomatic CSDH were treated using TDC with closed-system drainage at the proposed entry point. The thicknesses of the hematoma and the skull were measured at the proposed entry point. The congruence between the proposed entry point and postoperative craniostomy was estimated and complications were evaluated.

Results. In the radiological study, all the branches of the middle meningeal artery ran posterior to the coronal suture and the vascular grooves were located anterior to the coronal suture at the level of the STL. The average distance of the vascular grooves was 8.0 ± 5.8 mm. Thirty-five procedures were performed. The coronal suture and the STL could be identified clearly on brain CT scans. The mean thickness of the skull and the CSDH at the proposed point was 8 mm (range 5–13 mm) and 20 mm (range 10–28 mm), respectively. All the TDCs except 1 were congruent with the preoperative brain CT scans. One CSDH recurred 1 month after the first operation and was revised using the same procedure. No other complications occurred.

Conclusions. One centimeter anterior to the coronal suture at the level of the STL is suitable as the normal entry point of the TDC for symptomatic CSDH. The thickness of the CSDH can be measured at this point on a preoperative brain CT scan. Furthermore, the entry point on the scalp can be accurately estimated using surface landmarks. (DOI: 10.3171/2008.9.JNS08359)

KEY WORDS • chronic subdural hematoma • coronal suture • superior temporal line • twist-drill craniostomy • vascular groove

The population suffering from CSDHs includes many elderly patients with comorbid medical conditions, and therefore, less invasive surgical techniques have become the initial procedures of choice. As an initial treatment for CSDH, bur-hole craniostomy or TDC with closed-system drainage have been recommended. Twist-drill craniostomy was first reported as a diagnostic procedure in 1966. Since then, many studies have demonstrated that TDC using closed-system drainage is an effective procedure for CSDH as a definitive treatment modality. However, the reports to date make reference to the craniostomy occurring in an indefinite area, such as the rostral or anterior part or the maximal thickness site of the SDH. In these reports, the actual postoperative craniostomy could be in a different location from that of the preoperative design.

The aim of this study was to define the normal safe entry point for performing TDC in CSDH. We hypothesized that this normal safe entry point should have characteristics that include the capability to be readily delineated on brain images and the surface of the scalp, to occur in a frequent location of CSDH, and to avoid areas of vascular structures in the dura.

Abbreviations used in this paper: CSDH = chronic subdural hematoma; ECA = external carotid artery; MMA = middle meningeal artery; SDH = subdural hematoma; STL = superior temporal line; TDC = twist-drill craniostomy.
Methods

To determine an acceptable entry point for TDC of CSDH, we sought to define the craniostomy point through an anatomical study of the dural vasculature and skull landmarks. We then conducted a clinical study for the proposed normal safe entry point for TDC.

Radiological Anatomy

In most cases, CSDH occupies the frontal convexity.\textsuperscript{14} Hemorrhagic complications can potentially occur if vascular structures of the dura mater are injured, and we thus tried to locate the vascular void area around the frontal region where it would be acceptable to introduce a catheter into the subdural cavity. Because the coronal suture and the STL can be measured exactly from the scalp and brain CT scans, we evaluated the vascular void area around the coronal suture and STL.

External Carotid Artery Angiography

Between August 2003 and July 2006, 40 patients who underwent selective catheter angiography of the ECA were randomly selected, regardless of the study purpose. All patients were > 40 years old (mean age $50.1 \pm 10.1$ years), which was not unusual because CSDH typically occurs in elderly people. The course of the MMA was compared with the coronal suture.

Skull Radiographs

Fifty skull radiographs from patients > 40 years old were randomly sampled in our hospital database. The vascular groove, visualized in the lateral view, was assessed for its relation to the coronal suture at the level of the STL. The vascular groove was examined to determine the course of the middle meningeal vein and sphenoparietal sinus.

Patient Population

Thirty-three consecutive patients who presented with symptomatic CSDH underwent surgical drainage using TDC or bur-hole craniostomy between March 2006 and September 2007. The 30 patients who underwent TDC using closed-system drainage at the proposed entry point were included in this study. Informed consent was obtained from all patients. Based on the anatomical study, the normal safe entry point for TDC was defined as 1 cm anterior to the coronal suture at the level of the STL (Fig. 1). We measured the thickness of bone at this point from the preoperative brain CT, as well as the thicknesses of the CSDH at this point and in the largest area of the CSDH. We estimated the congruence between the normal safe point and the postoperative craniostomy site on brain CT scans and reviewed complications related to the surgical procedure.

Surgical Procedures

A Steinman pin (length 4 cm) and twist drill (length 6 cm) were prepared. All the patients were treated in the operating room. The normal safe entry point was measured in the usual manner through the use of external landmarks of the coronal suture and the STL. The area of the scalp to be punctured was then shaved. After scalp preparation with alcohol and a povidone-iodine solution, 2% lidocaine was infiltrated. A stab incision, using a No. 15 scalpel, was made at the drill entry point.

First, a hand drill equipped with a Steinman pin was placed perpendicularly to the surface of the skull and a mark was made on the outer skull to keep the twist drill from slipping down the skull. Then, using the twist drill, the skull and dura were penetrated at a $45^\circ$ angle to the surface of the bone to prevent the catheter from entering the cortex. The typical direction of the drill was postero-inferior toward the auricle. A standard No. 5 ventriculostomy catheter was introduced into the subdural cavity to $\sim 5$ cm. The contents of the catheter flowed freely, according to the up and down movement of the catheter. No aspiration with negative pressure or flushing with normal saline was performed. The drainage system was then closed by attaching the catheter to a ventricular drainage bag. The bag was kept 90 cm below head level so that gravity aided in the drainage from the subdural cavity.

All patients underwent a follow-up brain CT scan 3 hours after surgery to verify the catheter position and to assess the adequacy of drainage. Patients were lying flat the morning after the procedure and were hydrated in the first 24 hours postoperatively using 2000 ml of normal saline to help reexpand the brain. The drainage was stopped based on brain CT scans. The patients were typically discharged the day after the withdrawal of the subdural catheter.

Results

Radiological Anatomy of Dural Vessels

On the ECA angiograms, the MMA and coronal suture were well visualized. The main branches of the MMA were bifurcated around the pterion. The anterior branch of the MMA was located superoposteriorly alongside the
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Coronal suture and the posterior branch followed a course to the occiput. All of the anterior branches of the MMA traveled posteriorly to the coronal suture. Thus, no major arterial branch was found anterior to the coronal suture at the level of the STL.

On the skull lateral radiographs, the vascular groove for the venous sinus was located posteriorly to the coronal suture. The average distance of the vascular groove was 8.0 ± 5.8 mm at the level of the STL. No major arteries and veins were found anterior to the coronal suture around the STL.

**Application of the Normal Safe Entry Point**

We defined the normal safe entry point for TDC of CSDH to be 1 cm anterior to the coronal suture at the level of the STL. Thirty-five procedures were performed in 30 patients with symptomatic CSDH. Eleven CSDHs developed in the right hemisphere, 14 in the left, and 5 in both. The demographic characteristics of the study population are presented in Table 1. The mean patient age was 71 years (range 51–88 years). The 30 patients comprised 22 men and 8 women. Using the clinical grades proposed by Markwalder et al.,16 9 were Grade 1, 17 Grade 2, 3 Grade 3, and 1 was Grade 4.

On brain CT scans, the level of STL was defined as the top of the density of the temporalis muscle around the coronal suture. The coronal suture and the STL could be identified clearly on brain CT scans. The mean thickness of the skull and the CSDH at the safe entry point was 8 mm (range 5–13 mm) and 20 mm (range 10–28 mm), respectively. All the CSDHs were thicker than the skull at the safe point. The ratio of CSDH thickness to skull thickness ranged from 1.3 to 6.2, and the locations of maximal thickness were usually observed in another area. The area of the maximal hematoma thickness was coincident with our safe entry point in only 4 CSDHs.

All postoperative TDCs except 1 had congruent points with the measured area in the preoperative brain CT (Fig. 2). One craniostomy was performed posterior to the coronal suture. No infections or neurological complications related to the procedure were observed, and no symptomatic pneumocephalus occurred. No hemorrhagic complications developed, such as acute epidural hematoma, acute SDH, or brain injury (Table 1). One CSDH recurred 1 month after the first TDC with closed-system drainage. The CSDH that recurred was revised using TDC with closed-system drainage, again in the same manner at the safe entry point (Fig. 3), and resolved after the second operation. The subdural catheters were usually allowed to drain from 1 to 5 days (mean 2.6 days). All patients recovered uneventfully and resumed independent daily life.

**Discussion**

Surgical modalities for CSDH include catheter placement in the hematoma cavity through a bur-hole craniostomy or TDC with closed-system drainage.2,4,6,8,12,15,23,28

**TABLE 1: Summary of patient demographic and clinical data**

<table>
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<th>Parameter</th>
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<tr>
<td>no. of ops (rt/lt/both)</td>
<td>35 (11/14/5)</td>
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<td>clinical grade=a (no. of patients)</td>
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<td>9</td>
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<tr>
<td>2</td>
<td>17</td>
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<td>3</td>
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</tr>
<tr>
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<td>1</td>
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<td>mean thickness of skull on craniostomy (range)</td>
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<tr>
<td>mean thickness of CSDH at craniostomy (range)</td>
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<td>mean maximal thickness of CSDH (range)</td>
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</table>

*a* According to the Markwalder grading system.

† Thickness ratio = thickness of the CSDH / thickness of the skull.

‡ Congruence between the normal safe entry point and the TDC on the postoperative CT scan.

Fig. 2. Skull radiograph (B) and brain CT scans (A, C, and D) obtained in a 75-year-old man who presented with stuporous consciousness and underwent TDC at the normal safe entry point. A: Preoperative axial image showing a hypodense lesion compatible with a CSDH in the right frontal and parietal area. B: Postoperative lateral view showing that the twist-drill hole was made anteriorly to the coronal suture and that the draining subdural catheter was directed posteroinferiorly. C: Axial bone algorithm obtained 3 hours after TDC showing an appropriate craniostomy at the normal safe entry point. D: Axial image obtained 1 month after the operation showing complete resolution of the hematoma. The patient recovered and resumed normal activities.
Because the population suffering from CSDHs includes many elderly patients with comorbid medical conditions, less invasive surgical techniques have become the initial procedures of choice. Thus, TDC with closed-system drainage may be a first choice procedure for CSDH.\(^{21,23}\) The techniques of the twist-drill hole have been well described. Briefly, most are made at a 45° angle to the surface of the bone to prevent inadvertent penetration of the brain.\(^{3,9,25}\) In addition, although perpendicular penetration of the skull and needle insertion to the subdural cavity have been advocated,\(^{18}\) a regular or definite craniostomy site for CSDH had not been described. Typically, reports have described TDC at the point of maximal thickness of the CSDH. The issue of the best normal safe entry point was considered at our institution. The normal twist-drill point should be located where the amount of CSDH is measurable on preoperative brain CT scans. Furthermore, it must be accurately estimated using scalp landmarks. Based on radiographic anatomy and our clinical experience, the normal safe point for TDC is 1 cm anterior to the coronal suture at the level of the STL.

Because medical complications are associated with surgical and anesthesiological invasiveness, the least invasive operative therapy, at least theoretically, offers the best chance to reduce the mortality rate after surgery for CSDH.\(^{20}\) A simple evacuation regimen appears to show better results (fewer complications) than a regimen involving additional rinsing of the hematoma cavity during the surgical procedure.\(^{23,28}\) Slow, continuous catheter drainage following TDC offers substantial advantages in the treatment of CSDHs by allowing the brain to reexpand sufficiently to fill the subdural space.\(^{22}\) The primary mechanism of spontaneous resolution of a remnant hematoma is pathophysiological maturation of the neomembrane.\(^{13}\) As a result of such studies, an evidence-based review recommended that the TDC or bur-hole craniostomy with closed-system drainage can be considered a first-line treatment, whereas craniotomy may be used as a second-line treatment.\(^{29}\) As the result of the studies, simple drainage of the hematoma may be the treatment of choice. If TDC ensures the safety of the procedure, it can be a first-line treatment modality for CSDH.

One ascending frontal branch of the MMA groove follows the parietal bone, 15 mm behind the coronal suture, corresponding approximately to the precentral sulcus.\(^{5}\) No major branch of the MMA passes anteriorly to the coronal suture. Our results from the ECA angiograms were well correlated with this textbook description. In view of the dural veins, the 2 major veins around the coronal suture are the sphenoparietal sinus and the middle meningeal vein. The sphenoparietal sinus begins at the lateral tip of the lesser wing of the sphenoid bone and ends at the cavernous sinus.\(^{26}\) The middle meningeal vein accompanies branches of the MMAs in grooves on the internal parietal surfaces.\(^{5}\) According to anatomical reports and our radiological results, no major vessels occur

**Fig. 3.** Axial CT scans obtained in a 68-year-old man who suffered from left hemiparesis and gait difficulties, and who also suffered a recurrence after TDC using closed-system drainage. Two images (B and E) are bone algorithms. A: Preoperative image shows a large CSDH. B and C: Images demonstrating that the twist-drill hole was anterior to the coronal suture and minimal hematoma remained after the TDC was completed. D: Image demonstrating that the hematoma had regrown with brain compression. After the TDC, the patient had resumed normal activities but returned to our hospital due to gradual weakness 1 month after the operation. E: Image showing that the previous TDC point was tapped again and the subdural catheter was inserted. F: Image demonstrating that the CSDH completely resolved.
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in the frontal bone. The frontal bone could be an acceptable area for a blind craniostomy, an area that has been suggested for a frontal twist-drill ventriculostomy.10

We wanted to define the normal safe entry point for the twist drill, where the exact thickness of the CSDH could be estimated preoperatively. To avoid inadvertent injury, no major dural vessel should lie near the entry point. The coronal suture is a well-known landmark in the neurosurgical field, readily visualized on brain images, and easily located on the scalp.7 The temporal line is palpable as a posteriorly continuing line of the zygomatic process of the frontal bone and is able to be traced at the end of the temporalis muscle.7 The temporalis muscle is palpable if the hand is placed on the temporal fossa and the jaw is clenched and unclenched. Thus, the coronal suture and the STL can be helpful landmarks on brain CT scans and on the scalp surface. In our study, all TDCs except 1 were coincident with the preoperative brain CT scan using the coronal suture and STL as landmarks. The incongruent one may have been tapped inadvertently through twist-drill slippage. Thus, we used a Steinman pin at the initial stage of the craniostomy to avoid slippage on the round skull.

Twist-drill craniostomy carries the risk of hemorrhagic complications because it is a blind technique. Postoperative intracranial hematomas include acute epidural11,22,24,30 subdural,9,18 and intracerebral hematomas due to brain penetration.24 Injury of the MMA during TDC may cause the development of epidural hematomas, and at least theoretically, also of SDHs.30 Acute epidural hematomas may result from detachment of the dura from the inner surface of the skull as a result of a relatively blunt drill, without penetrating into the SDH cavity,24,30 or rapid decompression of CSDH.22 We also experienced a case of an epidural hematoma, which may have been caused by injury of the posterior branch of the MMA before the safe frontal normal point was applied.11 All of these reported cases developed epidural hematomas after the craniostomy was made in the parietal tuber. Unfortunately, a craniostomy in the parietal tuber may not coincide with the preoperatively planned area (based on brain images) because of the lack of anatomical landmarks. Our typical craniostomy was performed in the frontal area and no hemorrhagic complications were experienced.

Inadvertent brain injury can be avoided by drilling through the skull and passing the catheter into the subdural cavity tangentially.2,4,25 Tangential passing, however, may not be enough to avoid brain injuries. An appropriate thickness of the SDH is needed to accommodate the drill tip and the subdural catheter safely into the subdural cavity. When we began using TDC at our institution, the thickness of CSDH had to be twice that of the skull to be candidates for the TDC. As we gained experience, 11 craniostomies were performed unevenly in cases with less than twice the thickness. Of 33 patients treated over 1.5 years, only 3 did not undergo TDC at the normal entry point. These patients had a too-small CSDH in the frontal area, and a bur-hole craniostomy was made on the parietal area. At our institution, we perform a TDC first when the CSDH is of sufficient thickness at the normal entry point. When the hematoma thickness at the normal entry point is insufficient to receive the twist drill and subdural catheter, we perform a bur-hole craniostomy in the parietal area. Other merits of our normal safe craniostomy entry point include that the point is typically located around the hairline; thus, scalp shaving was limited to a small area, postoperative management such as dressings was simple, and the patients were satisfied with the postoperative aesthetic result.

Conclusions

Our proposed safe entry point for TDC in symptomatic CSDH is 1 cm anterior to the coronal suture at the level of the STL. The thickness of the CSDH can be measured at this point on a preoperative brain CT scan, and the entry point on the scalp can be accurately estimated using surface landmarks.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References


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