Use of hinge craniotomy for cerebral decompression

Technical note

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Decompressive craniectomy to relieve cerebral edema and intracranial hypertension due to traumatic brain injury is a generally accepted practice; however, the procedure remains controversial because of its uncertain effects on outcome, specific complications such as the syndrome of the sinking skin flap, and the need for subsequent cranioplasty. The authors developed a novel craniotomy technique using titanium bone plates in a hinged fashion, which maintains cerebral protection while reducing postoperative complications and eliminating subsequent cranioplasty procedures.

The authors conducted a retrospective review of data obtained in all consecutive patients who had undergone posttraumatic cerebral decompression craniotomy using the hinge technique at a Level I trauma facility between 1990 and 2004.

Twenty-five patients, most of whom were male (88%) and Caucasian (88%) with a mean age of 38.2 ± 16.1 years, underwent the hinge craniotomy. The in-hospital mortality rate was 48%, and good cerebral decompression was achieved. None of the patients required surgery for flap replacement. Long-term follow-up data showed that one patient required subsequent cranioplasty due to infection and one patient presented with cranial deformities. None of the patients presented with bone resorption or sinking flap syndrome.

The hinge technique effectively prevents procedure-related morbidity and the need for subsequent surgical bone replacement otherwise introduced by traditional decompressive craniectomy. A randomized controlled trial is required to substantiate these findings. (DOI: 10.3171/JNS-07/09/0678)

KEY WORDS • craniotomy • head trauma • hinge • intracranial pressure

Decompressive craniectomy is performed in the treatment of uncontrollable cerebral edema from trauma and other conditions.4,9,21–23,29 This procedure and its indications remain controversial,3,5,14,18,31,32 yet much study data suggest the procedure is beneficial for some conditions, particularly head trauma.2,16,25,27,28,32 Typically, the procedure involves the removal of a large bone flap from either one or both sides of the skull, followed by a large opening of the dura mater to relieve ICP. If there is a favorable outcome, the bone flap is replaced or a substitute cranioplasty is performed from 6 weeks to several months later.13,28

The condition resulting from the absence of the bone flap and the need for additional bone flap replacement surgery are problematic. Authors of several reports have described adverse outcomes related to the condition created by the absence of the bone flap;12,28,33 however, symptoms improved following replacement of the bone flap or cranioplasty.12,30

We know of no reports on a surgical technique for bone flap replacement using titanium bone plates in a hinged fashion such as the one we describe. The aim of this report was to describe our experience in patients who have undergone a posttraumatic cerebral decompression craniotomy utilizing a hinge to create a mobile bone flap secured to the skull. We used titanium bone plates in a hinged manner to allow decompression while maintaining cerebral protection and reducing postoperative complications. This technique also eliminates the need for subsequent surgery for cranioplasty or bone flap replacement.

Materials and Methods

Twenty-five patients underwent hinge craniotomy after presenting with clinical signs of elevated ICP that was not treatable with medical management. Demographics and baseline characteristics are shown in Table 1.10,25 Hinge craniotomy operative procedure times lasted between 1 hour and 39 minutes, and 3 hours. All patients were treated according to the Advanced Trauma Life Support Guidelines and the Association of Neurological Surgeons Guidelines for the Management of Severe Head Injury.4

Operative Technique

With the patient in a state of general anesthesia, a large
unilateral scalp incision is made. A large (> 12 cm) bone flap is removed and prepared for replacement in a typical fashion, with three titanium bone plates and screws placed around its periphery. A large dural opening is then created and the hematoma is evacuated. In cases of obvious cerebral edema the dura is left open but laid back over the brain, and the exposed brain is covered with a sheet of compressed Gelfoam or Duragen. The bone flap is then returned to the operative field. An anterior superior titanium Y-shaped plate is secured to the surrounding skull in a manner that allows the bone flap to rise as cerebral edema occurs (Fig. 1). Proper orientation of the hinged bone flap in the wound can be maintained by placement of a Y- or T-shaped titanium plate secured to the surrounding bone at the site of the hinge (Fig. 2). The galea is closed with sutures, the skin with staples, and the head is gently wrapped with gauze. After a few weeks, with relaxation of brain swelling because of the mobility of the flap (Fig. 3), the bone flap returns to a more normal anatomical position (Fig. 4). Good cosmesis and cerebral protection result from this procedure. No helmet is needed in the postoperative period. Subsidence of the bone flap and the syndrome of the sinking skin flap are not seen because of the resistance provided by the other titanium plates on the periphery of the settling bone flap.

Results

Overall survival was 52% (13 patients). Only one of the survivors required subsequent cranioplasty because of complications related to infection of the surgical wound (Table 2).\textsuperscript{7,8,11} Regarding flap mobility, postsurgical CT scans revealed that acceptable mobility was attained with regression of midline shifting postprocedure (Table 3). Long-term follow-up data showed that none of the patients reported symptoms compatible with the syndrome of the sinking skin flap, and no occurrences of bone resorption were observed. Only one patient presented cosmetic problems due to the persistent elevation of the hinged bone flap from severe and extended edema.

Discussion

The overall survival in the present cohort was 52%. Results from a late 1970s report showed that survival rates in patients suffering from head injury who underwent craniotomy were as high as 70% whenever the surgical procedure was accompanied by vigorous medical management.\textsuperscript{2} More recent data have revealed survival rates from 60 to 95%, with two thirds of those survivors having favorable outcomes.\textsuperscript{13,16,24} Thus, on first impression it appears that our technique does not represent the best surgical option for relieving elevated ICP and evacuating a hematoma. However, craniectomy outcomes are difficult to compare and summarize among techniques. Moreover, with our small sample size, it would not be possible to compare the mortality rates associated with our technique and those linked to other types of surgical decompression.
One of the greatest limitations of our analysis is that ICP data were not available in all the patients; Nonetheless, postprocedure CT scans demonstrated that the technique might allow acceptable release of ICP by providing sufficient movement of the bone flap.

The most significant finding of our study is that only one of the survivors required subsequent cranioplasty, because of a surgical wound infection. With a traditional craniectomy, during which bone is removed without immediate replacement, surviving patients are then subjected to additional surgical procedures. Some authors have suggested that the removed bone flap can be discarded, frozen, or placed in the abdominal or thigh subcutaneous tissues.

Conditions created by the removal of a large cranial bone flap can be problematic. Several authors have described adverse symptoms related to the absence of the bone flap, for example, the syndrome of the sinking skin flap and the syndrome of the trephined with hemiparesis, headache, vertigo, fatigue, memory disturbance, irritability, and depression. Symptoms often improve following replacement of the bone flap or cranioplasty. Data from one study suggest that patients wear a protective helmet during the months between the decompression and the replacement surgery.

A technique in which a very large “floating” bone flap was left in situ but attached to the dura has been reported—performed in two patients. However, both patients undergoing this procedure died and thus the technique was discounted. Leaving an unsecured bone flap has been criticized because it compromises the extent of cerebral decompression.

In another attempt to improve the safety profile of craniotomy, Jiang et al. tested a limited-size craniotomy tech-

\[\text{TABLE 2}
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Outcomes in 25 patients who underwent hinged craniotomy

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. (%)</th>
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<tr>
<td>mean length of stay</td>
<td>17 ± 12.9</td>
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<tr>
<td>survival</td>
<td>13 (52.0)</td>
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<tr>
<td>anisocoria regression*</td>
<td>4 (16.0)</td>
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<tr>
<td>seizures</td>
<td>1 (4.0)</td>
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<tr>
<td>wound infection</td>
<td>1 (4.0)</td>
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<tr>
<td>other infection</td>
<td>6 (24.0)</td>
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<tr>
<td>cranioplasty†</td>
<td>1 (4.0)</td>
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<tr>
<td>long-term outcomes</td>
<td></td>
</tr>
<tr>
<td>long-term care facility</td>
<td>16 (64.0)</td>
</tr>
<tr>
<td>discharged home</td>
<td>11 (44.0)</td>
</tr>
<tr>
<td>returned to work</td>
<td>7 (28.0)</td>
</tr>
</tbody>
</table>

* From five patients.  
† Due to wound infection.

Fig. 3. Bone window scan demonstrating bone flap mobility.

Fig. 4. Computed tomography scans obtained in two patients, showing the progression of an acute subdural hematoma. A: Representative preoperative images. B: Seventy-two hours postoperative images. C: Three weeks postoperative images revealing extracranial cerebral decompression. D: Six weeks postoperative images demonstrating restoration of skull contour following edema resolution.
Hinge craniotomy for cerebral decompression

**TABLE 3**

<table>
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<th>Case No.</th>
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<tr>
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<td>2</td>
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* Values represent millimeters.

23. Munch E, Horn P, Schurer L, Piepras A, Paul T, Schmiedek P:...


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