

Technical Note

In Situ Floating Resin Cranioplasty for Cerebral Decompression

Duck-Hyung Ahn, M.D., Dae-Won Kim, M.D., Sung-Don Kang, M.D.

Department of Neurosurgery, Wonkwang University School of Medicine, Institute of Wonkwang Medical Science, Iksan, Korea

The purpose of this report is to describe our surgical experiences in the treatment of cerebral decompression with in situ floating resin cranioplasty. We included in this retrospective study 7 patients who underwent in situ floating resin cranioplasty for cerebral decompression between December 2006 and March 2008. Of these patients, 3 patients had traumatic brain injury, 3 cerebral infarction, and one subarachnoid hemorrhage due to aneurysmal rupture. In situ floating resin cranioplasty for cerebral decompression can reduce complications related to the absence of a bone flap and allow reconstruction by secondary cranioplasty without difficulty. Furthermore, it provides cerebral protection and selectively eliminates the need for secondary cranioplasty in elderly patients or patients who have experienced unfavorable outcome.

KEY WORDS : Decompressive craniectomy · Floating · Resin cranioplasty.

INTRODUCTION

Decompressive craniectomy has been used to treat intractable intracranial hypertension and cerebral edema and many studies have shown that decompressive craniectomy is effective for reducing intracranial pressure (ICP) in patients with many neurosurgical diseases^{1,4,5,7,9,10,14}. This procedure is intended to increase the volume of space to accommodate brain swelling^{2,16}. Although the outcomes of decompressive craniectomy have been improving, there are several problems associated with decompressive craniectomy, such as the need for secondary cranioplasty, storage of the bone flap, compression due to temporal muscle swelling, and complications related to the absence of a bone flap^{6,11,13}.

For cranioplasty with an autologous bone flap or resin, neurosurgeons must dissect the previous operation field very carefully, which is very troublesome. To avoid this, we have developed a new technique-*in situ* floating resin cranioplasty-for cerebral decompression. This technique

allows the resin flap to float outward for adaptation to brain swelling while maintaining cerebral protection and reducing postoperative complications. In addition, secondary cranioplasty can be performed as a minor procedure because the dissection between the fascia and resin implant is easy.

MATERIALS AND METHODS

We included in our retrospective study 7 patients who underwent in situ floating resin cranioplasty for cerebral decompression between December 2006 and March 2008. Of these patients, 3 patients had traumatic brain injury, 3 patients had cerebral infarction, and 1 patient had subarachnoid hemorrhage due to aneurysmal rupture. The mean age of the patients was 52.7 years, and there were 5 men and 2 women. The patients' scores on the Glasgow Coma Scale ranged from 5 to 12. Demographics and baseline characteristics are shown in Table 1.

Surgical technique

Under general anesthesia, patients underwent a large standard craniotomy approach directed to the presenting pathology. Additional temporal bone was removed from the floor of the middle fossa. A large dural opening was then created and the hematoma was evacuated. A resin implant prosthesis made of Cranioplastic[®] cement (Codman,

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• Address for reprints : Dae-Won Kim, M.D.
Department of Neurosurgery, Wonkwang University School of Medicine,
Institute of Wonkwang Medical Science, 22 Wongwangdaehak-ro,
Iksan 570-749, Korea
Tel : +82-63-859-1466, Fax : +82-63-852-2606
E-mail : kimdw@wku.ac.kr

Table 2. Summary of clinical features in 7 patients who underwent in situ floating resin cranioplasty

Age/ Sex	Mental state on admission	Preoperative GCS	Diagnosis	Preoperative midline shifting	Postoperative midline shifting	Postoperative GCS	GOS
25 / M	stupor	10	EDH	5 mm	3 mm	15	5
63 / M	drowsy	12	MCA infarction	5 mm	4 mm	14	3
55 / F	stupor	9	MCA infarction	6 mm	6 mm	13	4
61 / M	stupor	9	MCA infarction	15 mm	9 mm	13	3
64 / M	semicoma	5	SDH	19 mm	14 mm	6	2
33 / M	semicoma	6	SAH	4 mm	4 mm	12	3
68 / F	semicoma	6	SDH	9 mm	7 mm	3	1

EDH : epidural hematoma, GCS : Glasgow Coma Scale, GOS : Glasgow Outcome Scale, MCA : middle cerebral artery, SAH : subarachnoid hemorrhage, SDH : subdural hematoma



Fig. 1. Intraoperative photographs. A : Photograph showing the resin implant about 1 mm thickness. B and C : The resin implant was designed about 5 mm larger than the outer table of craniotomy bone flap in order to do not sink the implant under craniectomy site. Resin implant was fixed loosely by silk stitches to move freely depend on brain swelling.

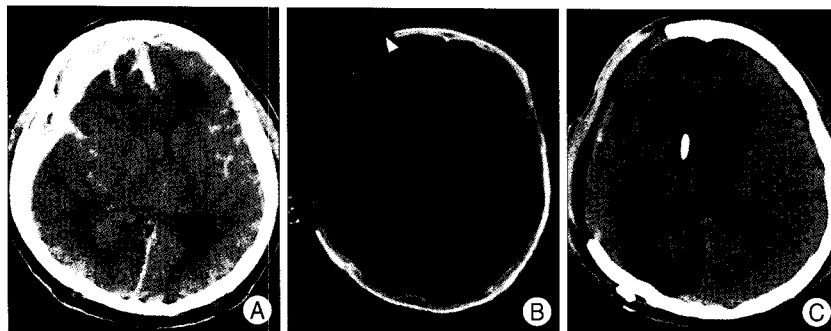


Fig. 2. A 64-year-old male with head trauma. A : Preoperative brain computed tomography (CT) scan shows acute subdural hematoma in the right frontotemporoparietal area with severe mass effect. B : Postoperative CT scan shows floating resin (arrow head) to accommodate brain swelling. C : Follow-up brain CT after 4 months shows ventriculoperitoneal catheter without subsequent cranioplasty.

Raynham, MA, USA) was molded intraoperatively. The mixture was poured over the outer table of the bone flap to achieve a smooth surface that conformed to the normal outer contours of the patient's skull. The resin implant had a thickness of approximately 1 mm (Fig. 1). At this point, the part of the resin implant that covered the temporal area was molded outward to create enough space to prevent temporal lobe herniation. The width of the resin implant was approximately 5 mm larger than the outer table of the bone flap at the margin so as to prevent the sinking of the implant under the craniectomy site. We fixed the resin implant loosely with silk stitches; therefore, the implant could move freely to accommodate brain swelling (Fig. 1).

The galea was closed with sutures and the skin with staples. This technique allowed the resin implant to float outward to accommodate brain swelling and protect the injured brain.

RESULTS

Postoperative results are also shown in Table 1. The overall survival rate was 85.7% (6 patients). Patient outcomes, which were evaluated at discharge, were as follows : good recovery in 1 patients (14.3%), moderate

disability in 1 (14.3%), severe disability in 3 (42.8%), vegetative state in 1 (14.3%), and death in 1 patient (14.3%). Postoperative computed tomography (CT) scans revealed gradual regression of midline shifting and brain swelling (Fig. 2, 3). Brain compression due to temporal muscle swelling and the syndromes arising due to a sinking flap were not seen because of the protection provided by the resin implant. Therefore, favorable cerebral decompression and maintenance of external appearance could be achieved. One of the survivors requested to undergo secondary cranioplasty with autologous bone. Cranioplasty was performed without difficulty because the dissection was very easy.

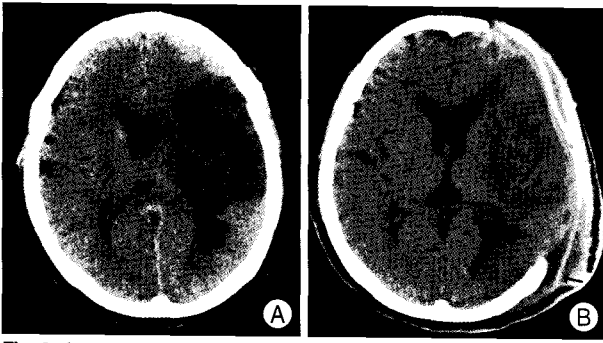


Fig. 3. A 55-year-old female with right hemiparesis. A : Preoperative brain computed tomography (CT) reveals left middle cerebral artery territory infarction with mass effect. B : Postoperative CT scan shows improving of midline shifting and floating resin (arrow).

DISCUSSION

Decompressive craniectomy reduces ICP without biochemical manipulation and may be a valid management option in patients with diffuse brain swelling who do not respond to maximal medical management. Although the outcomes of decompressive craniectomy have been improving, there are several problems associated with decompressive craniectomy. These include the need for additional bone flap replacement surgery and complications related to the absence of a bone flap¹². Several reports have described adverse symptoms related to the absence of a bone flap, including, the syndrome of the trephined with hemiparesis, the syndrome of sinking skin flap, headache, vertigo, fatigue, memory disturbance, and depression^{3,15,17}. Symptoms often improve after replacement of the bone flap or cranioplasty^{3,15}. Therefore, cranioplasty could be considered as the subsequent step of a staged-procedure after decompressive craniectomy.

Many investigators have developed alternative techniques for solving these problems. *In situ* hinge craniotomy for cerebral decompression has been reported^{8,12}. These reports stated that *in situ* hinge craniotomy accommodated brain swelling, eliminated the need for secondary surgery, and reduced the complication caused by the absence of a bone flap. The difference between these techniques and the method presented in our study is the ability to accommodate brain swelling. We think that floating resin cranioplasty is better than *in situ* hinge cranioplasty with regard to the ability of the implant to accommodate brain swelling.

In another attempt to control ICP, Park et al.¹¹ thought that the temporal muscle and fascia were significant limiting factors that contributed to the external herniation of the edematous brain. Therefore, they performed a decompressive craniectomy and expansive duroplasty combined with resection of the temporal muscle and fascia

for patients with a malignant hemispheric infarction. In our procedure, enough space is provided to accommodate swelling of the temporal lobe because the bulky molded resin implant prevented temporal lobe compression by the temporal muscle.

We developed a new technique-*in situ* floating resin cranioplasty-for treatment of cerebral decompression. Our procedure is advantageous for treating cerebral decompression and offers brain protection. It also yields good cosmetic results and reduces the complications related to the absence of a bone flap. Because the resin flap may be adhere to the soft tissue (galea etc.) as time progresses, the patients did not complain of discomfort due to the floating resin. Further, the adherence of the resin flap to the soft tissue was confirming during secondary cranioplasty, and there was no mobility. In addition, secondary cranioplasty can be performed without difficulty because there is no adhesion between galea and dura matter. This procedure would particularly be useful for elderly patients who have decreased activity and those who have experienced unfavorable outcomes as it provides brain protection and there is not need for secondary cranioplasty.

CONCLUSION

As compared to decompressive craniectomy, the outcomes of *in situ* floating resin cranioplasty are not unfavorable. The merits of this technique are that it reduces the complications related to the absence of a bone flap and it easily allows for reconstruction via secondary cranioplasty. Furthermore, it provides cerebral protection and selectively eliminates the need for secondary cranioplasty in elderly patients or those who have experienced unfavorable outcomes. One of the greatest limitations of our study is that ICP data were not available for all patients. In further studies, we will monitor ICP monitoring to judge the efficacy of procedure with regard to that the degree of decompression achieved.

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