

ROMANIAN
NEUROSURGERY

Vol. XXXIV | No. 3 September 2020

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Ventriculoperitoneal shunt occlusion and cranioplasty. A case report

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ABSTRACT

Decompressive craniectomy (DC) is an urgent neurosurgical procedure, effective in the reduction of intracranial pressure (ICP) in patients with elevated ICP and in complications of brain infarction that do not respond to clinical treatment; traumatic brain injury (TBI); intracerebral haemorrhage (ICH) and aneurysmal intracerebral haemorrhage. Symptomatic hydrocephalus is present in 2 to 29% of patients who undergo craniectomy. They may require a ventriculoperitoneal shunt (VPS). The literature does not yet show standard management of cranioplasty in patients who have previously undergone a shunt, showing evidence of sinking skin flap syndrome. This case shows parenchymal expansion after VPS occlusion and cranioplasty in the patient's profile. The 23-year-old male patient, right-handed, went to the hospital in January 2017 due to severe traumatic brain injury following multiple traumas. The patient underwent urgent DC surgery for the management of elevated ICP. The patient developed hydrocephalus. It was decided to perform the VPS implant. After 2 years, and with quite a sunken flap, the patient was submitted to cranioplasty procedure after shunt occlusion was performed. The patient left the hospital receiving outpatient care with no more complaints. In spite of the favourable outcome, new studies are fundamental to decide upon the best approach.

INTRODUCTION

Decompressive craniectomy (DC) is efficient in reducing intracranial pressure (ICP) in patients with intracranial hypertension in complications of brain infarction that do not respond to clinical treatment, traumatic brain injury (TBI), intracerebral hemorrhage and aneurysmal intracerebral hemorrhage.^{1,4}

Hydrocephalus is present in 2 to 29% of those who undergo craniectomy, possibly requiring ventriculoperitoneal shunt (VPS) after the subacute stage. Most of the patients needing craniectomy accompanied by VPS develop sinking skin flap syndrome. This particular factor may be challenging during cranioplasty due to the difficulty in parenchymal expansion because of the *shunt* and the increased

Keywords
cranioplasty,
VPS,
VPS Occlusion



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ISSN online 2344-4959
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Neurosurgery



First published
September 2020 by
London Academic Publishing
www.lapub.co.uk

chances of material gathering in the vacant space created between the implant and brain parenchyma.¹²

The literature does not yet show a standard management of cranioplasty in patients who have previously undergone a shunt, showing evidence of sinking flap syndrome.

The reported case demonstrates parenchymal expansion after VPS occlusion and the cranioplasty that ensued for this patient. In spite of this favorable outcome, new studies are necessary for the best approaches to benefit these types of patients.

CASE STUDY

A right-handed, 23-year-old male patient entered hospital in January 2017 due to a diagnosis of TBI accompanied by multiple traumas, which required decompressive craniectomy on the right side to control raised ICP. Hydrocephalus evolved in the patient and a ventriculoperitoneal shunt was performed. After a positive medical evaluation, he was able to leave the hospital for the cranioplasty to occur at a later stage. Due to demanding workloads and loss of *follow up* procedures during 2018, the cranioplasty procedure was left until January, 2020.

Upon his second admission to hospital, the patient presented a quite sunken flap with a concave aspect (Figure 1). In order to plan the surgery, a pre-operative tomographic exam took place. The exam showed up parenchyma from the right side sheering off towards the side that had not been fractured, with structural deviances in the midline greater than 1 cm. The catheter of the VPS was normally placed in the frontal position of the right lateral ventricle (Figure 2).

In the wake of parenchymal expansion after cranioplasty, caused by the existing VPS, plans were made (after consulting the neurosurgery and plastic surgery departments) for shunt occlusion before performing cranioplasty during the same surgical period.

Electively, the patient was then submitted to occlusion of the distal end of the ventriculoperitoneal shunt catheter through clavicular incision. Within the same surgical period, the cranioplasty proceeded with the customization of the polymethylmethacrylate (PMMA) prosthesis created from a sterile mold based on the reconstruction of bones in the gaps with the help of

a 3D printer (Figures 3 and 4). No complications arose during the time of the procedure.

Immediately after the operation, the tomography of the cranium showed cerebral parenchyma that had not expanded and the presence of its gathering in the subdural area (Figure 5).

The patient was directed to the neurological intensive care unit (ICU), with rigorous observations on level of consciousness and serial neurological exams. Through the evolution of the patient's recovery, the exams showed no alteration in level of consciousness, nor any physical changes. On the fourth and ninth days of the post-operative period, controlled observation by tomography showed gradual expansion of cerebral parenchyma until the point of total expansion in nine days (Figure 5). The patient, in spite of ventricular ectasia, recovered with no additional complaints. After one-week of observation, he was released from hospital (Figure 6). An outpatient *follow-up* was performed 3 times a week for 4 weeks. Clinically, the patient remained stable.

Outpatient care has continued without any additional complaints.



Figure 1.



Figure 2.

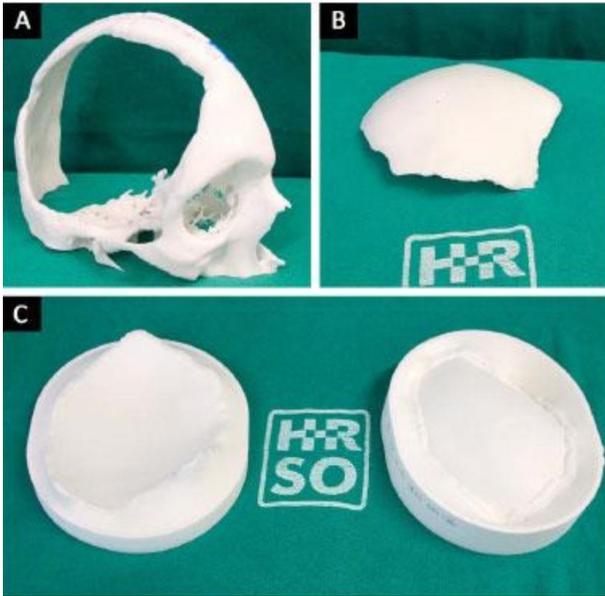


Figure 3.

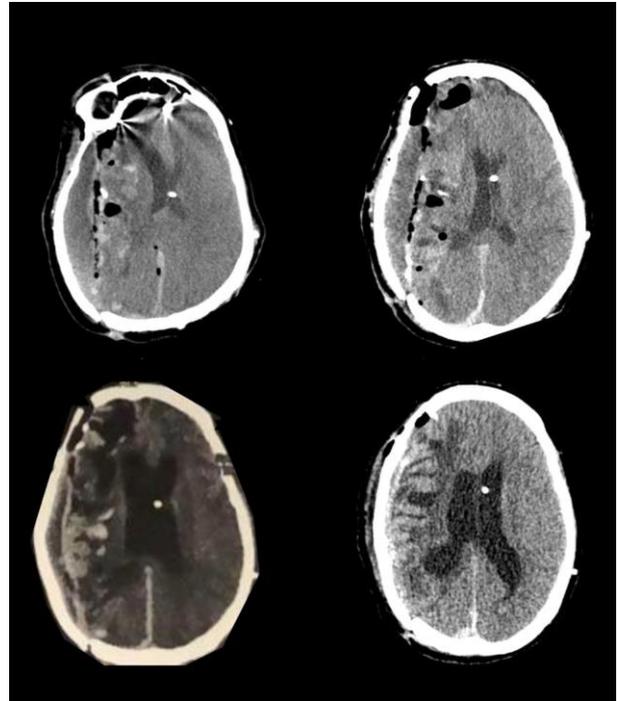


Figure 5.

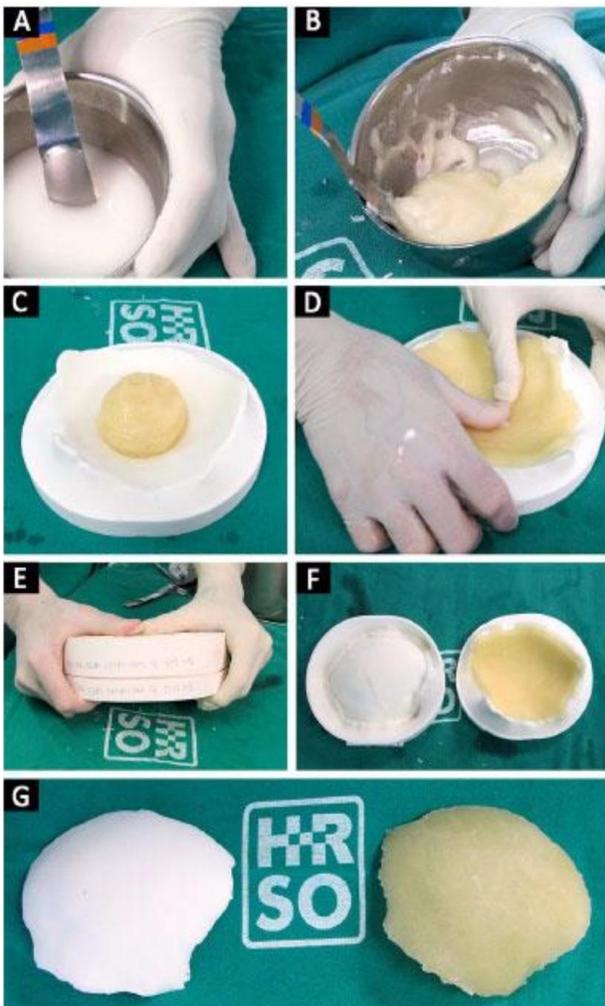


Figure 4.



Figure 6.

DISCUSSION

DC is indicated for the treatment of elevated intracranial pressure in grave situations of traumatic injury to the brain. This procedure consists of the removal of a significant part of the skullcap. The removal entails parts of the frontal, temporal, parietal, and part of the sphenoid from the affected side, permitting the free expansion of cerebral edema without exceeding limits inside the cranial vault. Even though this procedure saves lives, in many cases it leaves behind grave aesthetic and functional disadvantages for the patient. Even after the decrease in cerebral edema and when the

patient has achieved a favorable clinical profile, cranial reconstruction is recommended. The surgery seeks to recover cerebral protection against traumas, recover the cranial contour and improve neurological symptoms by re-establishing physiological intracranial pressure. The restoration of the anatomic barrier between intracranial structures and the environment normalize the dynamics of CSF and the blood flow inside the brain.^{1,4,5}

Even though the ideal moment for performing cranioplasty remains uncertain, recent studies show that it should be done between 3 to 6 months later, in order to allow for significant motor skill and cognitive recovery.^{4,12}

Cranioplasty after DC for management of elevated intracranial pressure is a neurosurgical procedure that seeks to restore stasis, improve the dynamic of CSF and establish the conditions for protecting the brain. Under these circumstances, the procedure can facilitate neurological rehabilitation and potentially improve neurological recovery.^{11,15} Otherwise, cranioplasty can be associated with complications and even morbidity.^{2,13}

A significant cranial defect after DC can alter the dynamics of the circulation of CSF and turn itself into a risk factor in terms of hydrocephalus. In relation to complications after DC in patients suffering TBI, hydrocephalus is present in between 2 to 29% of patients. In this context, patients submitted to DC may need cranioplasty and VPS after the subacute stage.^{1,8,12}

Diagnostic of hydrocephalus in people who have had hemicraniectomy surgical procedures done is necessarily subjective, since criteria based on measuring intracranial pressure or details on ventricular structure are generally not reliable in the scenario of an open cranial vault. However, the almost universal disposition towards the progressive accumulation of CSF in these individuals, frequently manifested as an increase in extra-axial gatherings over the hemispheric convexity, indicates an incapacity for adequately balancing the production of CSF by draining the venous sinuses.^{3,14}

The physiopathology of patients operated by craniectomy has still not been well established. However, it is believed that the absence of skull bone coverage near the arachnoid granulations modifies the hydrodynamics of fluid absorption. Besides this, it is possible for other factors to contribute, besides

alteration in the dynamics of intracranial pressure – for example, mechanical blockage or inflammation of arachnoid granulations because of post-surgical remains. Furthermore, these patients could present other isolated risk factors for hydrocephalus – for example, subarachnoid hemorrhage.^{3,10}

The management of the dynamic of fluids after hemicraniectomy can be quite a challenge as a result of problems in hemispheric change or compartmentalization, emphasizing that the definitive resolution for the accumulation of CSF is a great priority. In patients with a bulging scalp flap and ventriculomegaly (VM), some authors indicate temporary management until cranioplasty by way of frequent lumbar puncture or the placement of a ventricular or external spinal tap. Some studies demonstrate that cranioplasty, performed as early as possible, can promote an immediate solution for the problem of hydrocephalus. In spite of this, many patients possess a persistent hydrocephalus, especially when cranioplasty occurs at a late stage. This can make them predisposed for the necessity of a previous shunt, as described in this case study.^{8,10,12,14}

In the patients who have gone through craniectomy and whose hydrocephalus is persistent, the literature's point of view is still controversial as to the management of and the adequate time for applying shunt and cranioplasty. Recent data suggest that patients submitted for cranioplasty procedures and VPS by stages can benefit from less complicated results when compared to patients who go through the two procedures at the same time. Some authors will defend the shunt for managing hydrocephalus and cranioplasty at a later stage.^{3,6,8,9}

Cranioplasty in patients with VPS may be challenging, mainly in those patients presenting a sunken flap due to the shunt. In patients with the sunken flap, there is a technical difficulty at the time of operating during the separation of the cutaneous layer, dura mater and encephalic tissue. Besides this, in these patients, due to the presence of the VPS, a major difficulty can occur in the expansion of cerebral tissue, facilitating the gathering of material in the vacant space between prosthesis and encephalic tissue that has not expanded. Until now, there are no randomized studies that can guide one through the knowledge in handling these situations. In the case described, what was chosen was the

closing of the VPS in order to permit parenchymal expansion after the cranioplasty procedure.^{3,8,10,12,14}

As in the majority of hydrocephalus cases, after decompressive craniectomy there is a spontaneous resolution with cranioplasty. VPS occlusion was maintained after cranioplasty, and a rigorous post-operative observation was conducted with regard to expansion inside the brain and the necessity for a shunt. After one week of observation, involving more than one hospital, with good clinical improvement, a follow up was done on an outpatient basis, three times per week for 4 weeks. No worsening in the patient's condition was observed.^{3,8,9}

The literature is yet to offer a standard for managing cranioplasty in patients with previous shunt and sunken skin flap. In spite of the success in the case related, there is no relevant sample or previous works available to compare such a case. New studies are fundamental to pave the way for a better approach to these patients.

CONCLUSION

Therefore, the path chosen for cranioplasty procedure, associated with occlusion of the VPS, is quite rare. We still do not know much about the best approach for cranioplasty in patients who have a previous shunt and sunken skin flap. In spite of the case's favorable outcome, new studies are fundamental in order to discover the best way to approach the problem

DISCLOSURE

The authors report no conflicts of interest

ABBREVIATIONS AND ACRONYMS

CSF = cerebrospinal fluid; DC = Decompressive craniectomy; ICH = intracerebral hemorrhage; ICP = intracranial pressure; PMMA = polymethylmethacrylate; TBI = traumatic brain injury; ICU = intensive care unit; VM = ventriculomegaly; VPS = ventriculoperitoneal shunt.

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