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PERICRANIAL-ONLAY CRANIOPLASTY TECHNIQUE – A CASE REPORT

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Abstract

Cranioplasty is a neuroplastic surgical technique used to repair cranial defects in order to restore functional anatomy, preventing any neurological drawbacks and taking into account the cosmetic issues.

This procedure is required for patients undergoing decompressive hemicraniectomy for life-threatening conditions such as diffuse traumatic brain injury, acute subdural hematoma, intracerebral hemorrhage, and severe ischemic stroke. It involves utilizing autologous or non-autologous bone flaps, with various preservation methods such as subcutaneous abdominal tissue or cryopreservation.

Decompressive craniectomy, a procedure used to alleviate intracranial pressure, involves the excision of skull segments to accommodate cerebral edema. Cranioplasty is associated with high complication rates. The timing of the cranioplasty procedure, its potential benefits and risks, should be calculated in each individual case.

A 59-year-old patient who underwent a decompressive hemicraniectomy because of diffuse traumatic brain injury and acute subdural hematoma, presents with mild right sided hemiparesis, speech disorder, episodes of neck dystonia, psycho-organic syndrome and sinking skin flap syndrome. Pericranial-onlay cranioplasty was preformed using autologous bone flap previously implanted in his abdominal pouch. The surgical procedure was uneventful with satisfactory cosmetic results and improved neurological function.

Cranioplasty after decompressive hemicraniectomy is necessary for improving neurological function of the brain and improving the aesthetic appearance of the patient. Personalized approach is used for the skull reconstruction depending on the resources of the institution and the surgical technique used by the staff.

Keywords: cranioplasty, decompressive hemicraniectomy, autologous bone graft, abdominal pouch.

Introduction

Cranioplasty, as a neuroplastic surgical procedure, is pivotal for restoring structural integrity, promoting neurological recovery and improving the aesthetic appearance of the patient. Previous decompressive hemicraniectomy, a procedure involving the removal of a portion of the skull to alleviate intracranial pressure, is the main clinical indication to perform a cranioplasty [5].

Through cranioplasty, the skull is able to regain its preoperative shape and normalization of cerebrospinal fluid and cerebral blood flow can be expected. Bone flap replacement by using an autologous graft is the most commonly used option because of its good tolerability and favorable biological properties [13,14].

This case report delves into the clinical course of a 59-year-old patient who underwent decompressive craniectomy following a traumatic incident, and a subsequent cranioplasty 6 months later.

Case report

A 59-year-old male was brought into the hospital in an unconscious state. The family reported that the patient fell from a ladder, resulting in a head injury. Upon initial examination, the patient was unconscious with right-sided limb immobility and left-sided weakness. The Glasgow Coma Scale (GCS) on admission was 6 (V2, M3, E1). The CT scan of the brain revealed traumatic subarachnoid hemorrhage, intraventricular hemorrhage, and a subdural acute hematoma on the left hemisphere. Signs of brain herniation were present, necessitating urgent surgical intervention.

Surgical Procedure:

After preoperative checkups and preparations including head shave, the surgical treatment of the patient was performed at our hospital, during which the following steps were taken: a wide arciform skin incision was made in the shape of an inverted questionnaire. A wide osteoplastic craniotomy the size of a man's palm was performed to evacuate the acute subdural hematoma and address brain edema. The boarders of the craniotomy were low frontobasal and low temporobasal, superior parasagittal, posterior to the occipital region. Duraplasty using temporal fascia and periosteum was executed. Epicranial flap closure was performed and passive drainage was placed. The extracted bone flap was implanted above the fascia of the external oblique abdominal muscle on the left side in a subcutaneous pocket.

Figure 1 Decompressive craniectomy procedure steps **(A)** Intraoperative showing of the isolated wide osteoplastic craniotomy surgical field **(B)** Evacuation of the acute subdural haemathoma **(C)** Intraoperative showing of the performed duraplasty **(D)** Implantation of the extracted bone flap in the subcutaneous abdominal pocket

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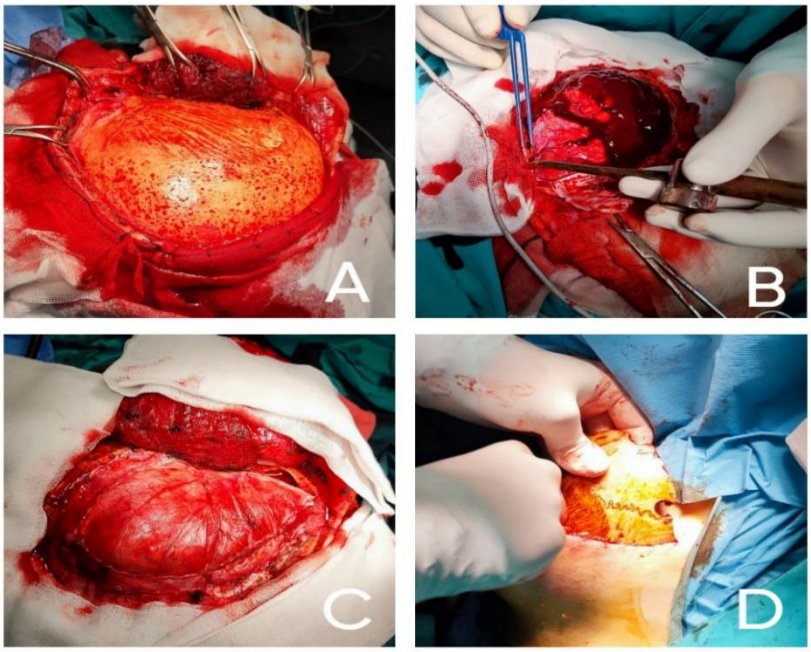

Six months later, the patient presented with a collapsed left frontotemporoparietal flap (sinking skin flap syndrome), psycho-organic syndrome, mild right sided hemiparesis, episodes of neck dystonia and a speech disorder.

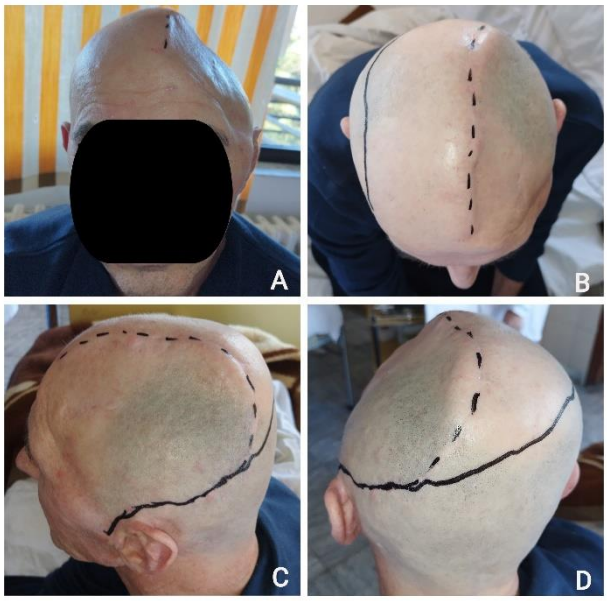

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Figure 2 Cosmetic appearance of the head **(A)** Cosmetic appearance of the head in the anterior view **(B)** Preoperative markings of the planned incision from a superior view **(C)** Cosmetic appearance of the head in a lateral view **(D)** Cosmetic appearance of the head in a posterior view

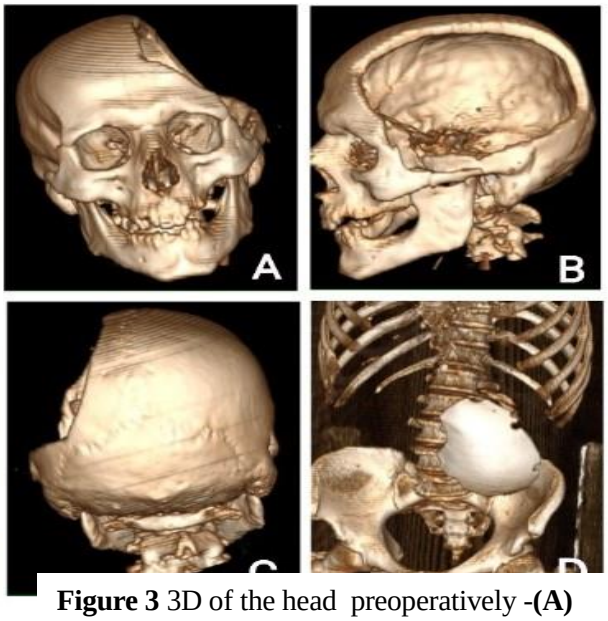
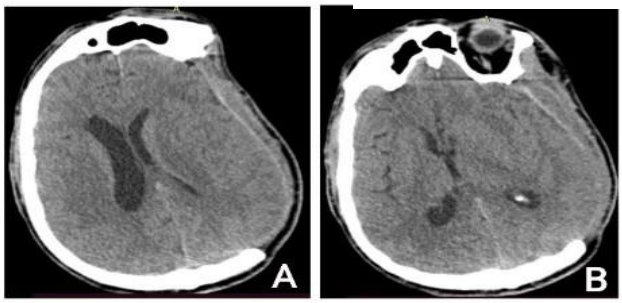


Figure 3 3D of the head preoperatively **-(A)** preoperative showing of the structural bone defect in an anterior view **(B)** preoperative showing of the structural bone defect in a lateral view **(C)** preoperative showing of the structural bone defect in a posterior view **(D)** preoperative showing of the bone graft implanted in the left abdominal flank.

Figure 4. CT scan of the head preoperatively -brain preoperatively **(A)**



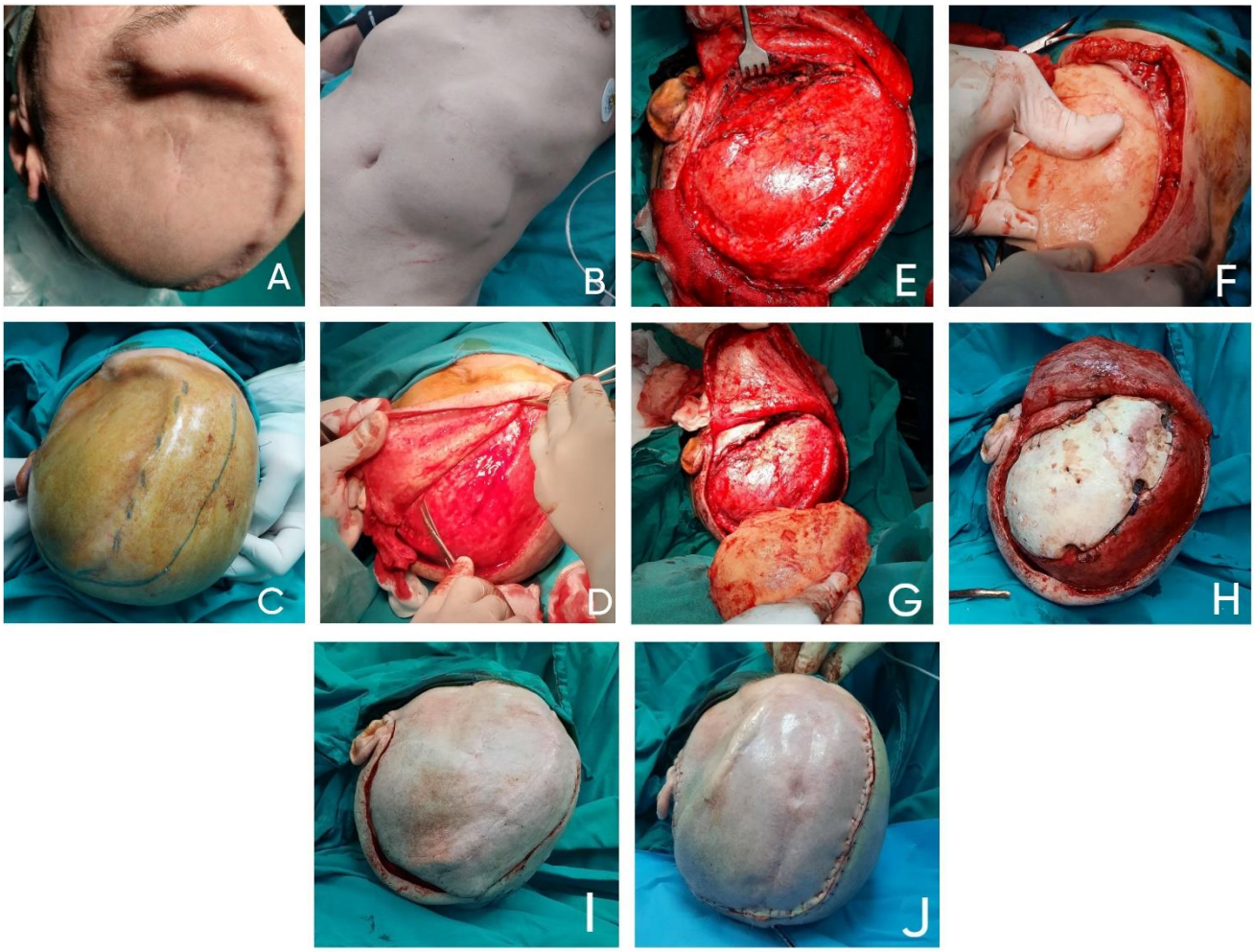
Preoperative finding of a collapsed left frontoparietotemporal flap after craniectomy **(B)** Preoperative finding of a collapse of the left cerebral hemisphere, pseudo compression of the left lateral ventricle and shift of the central structures to the right.

Surgical Procedure:

The subsequent surgical treatment of the patient was performed at our hospital, during which the following steps were taken: in the first act of the procedure the patient was approached with an arched skin incision on the left frontotemporoparietal region, starting with the sagittal skin incision on the right frontoparietal region at the height of the right pupillary line and continued in the posterior-lower part along the scar from the previous incision on the left temporal and preauricular region without a lesion of the left superficial temporal artery.

Careful preparation of the scalp along the alveolar tissue just below the galea was the guide for further preparation of the soft tissue flap over the craniectomy opening with complete preservation of the underlying periosteum and no lesion of the dura, without oozing. The edges of the bone defect were completely prepared and the temporal muscle was raised over the dura for the inferior part of the bone defect. In the second act of the intervention, a longitudinal skin incision was made on the previously implanted bone operculum in the region of the left flank of the abdomen and it was removed entirely with preserved vitality. The bone flap was inserted under the temporal muscle and it was secured with 3 sutures to the bone, while the complete length of the temporalis muscle was not provided due to its atrophy. The soft-tissue flap was returned without accompanying tension and with preserved vascularization at the flap edges. The procedure concluded with proper wound closure and drainage placement.

Figure 5 Cranioplasty procedure steps **(A)** Preoperative cosmetic appearance of the skull **(B)** Preoperative appearance of the left abdominal flank **(C)** Intraoperative sterile markings with methylene blue of the planned excision **(D)** Careful preparation of the scalp along the alveolar tissue just below the galea with complete preservation of the underlying periosteum **(E)** Preparation of the edges of the bone defect and raising the temporal muscle **(F)** Extraction of the previously implanted bone operculum in the left flank of the abdomen **(G)** Insertion of the bone flap in previously created skull defect **(H)** Securing the bone flap

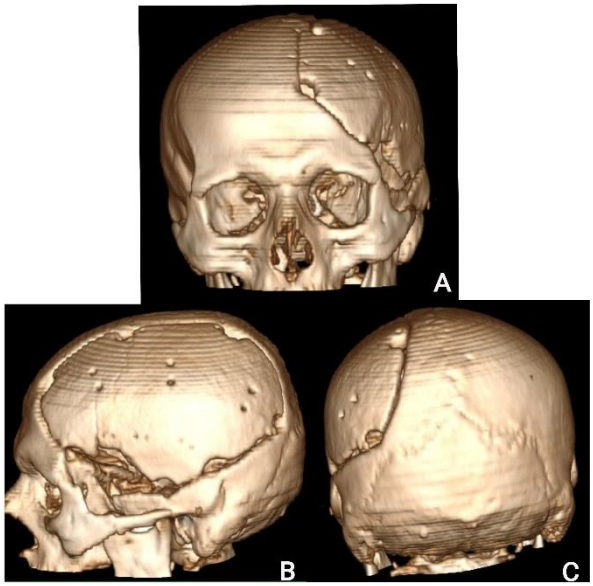


under the temporal muscle and suturing it to the surrounding bone **(I)** Soft-tissue skull flap without accompanying tension and with preserved vascularization at the flap edges **(J)** Proper suture of the flap with no wound tension.

Postoperative Course:

Subsequent CT and 3D CT scans revealed successful cranioplasty, with the bone flap in proper position. There was a slight shift in brain structures, hypodense post contusive changes, and compression of the left lateral ventricle. Meropenem was administered intravenously pre and postoperatively as a prophylaxis in correlation with the high incidence of postoperative infection. The patient recovered without complications during the hospitalization period, and drains were removed on the second postoperative day. The Glasgow Outcome Scale (GOS) after the first surgery was 4, compared to the GOS after the second surgery which was improved with a score of 5.

Figure 6 Postoperative 3D CT scan of the head **(A)** Postoperative finding of the proper position of the bone flap in the anterior view **(B)** Postoperative finding of the proper position of the bone flap in the lateral view **(C)** Postoperative finding of the proper position of the bone flap in the posterior view



Follow-up:

The patient continued to improve, as evidenced by subsequent neurosurgical examinations. Sutures were removed, and the patient was discharged in good general condition. Ongoing neurological assessments and biochemical reviews were conducted, showing progressive improvement.

Figure 7: 2 months postoperative follow-up **(A)** Aesthetic appearance of the head in the anterior view **(B)** Aesthetic appearance of the head in the antero-lateral view **(C)** Aesthetic appearance of the head in the lateral view **(D)** Aesthetic appearance of the head in the posterior view

Discussion

This case report contributes to the evolving understanding of cranioplasty and decompressive hemicraniectomy as integral components in the continuum of care for severe traumatic brain injuries. Cranioplasty is an operative technique aimed at restoring skull integrity and addressing complications like sinking skin flap syndrome and psycho-organic syndrome, as previously mentioned in our case presentation. Literature highlights the importance of cranioplasty in improving neurological outcomes, decreasing postoperative complication rates, and facilitating quicker rehabilitation in patients with large skull defects [1, 2].

The proper timing of cranioplasty after decompressive hemicraniectomy is still a matter of debate. The findings of Malcolm et al. (2018), Qasmi et al. (2015) and Zheng et al. (2018) support the notion that early autologous cranioplasty after decompressive craniectomy for severe traumatic brain injury is associated with greater neurological improvement in patients [3,4,5]. Abouhashem et al. (2022) did a clinical study with patients who underwent cranioplasty after decompressive hemicraniectomy for severe traumatic brain injury and they were categorized into two groups based on the timing of cranioplasty: within 2 months (early group) or after 2 months (late group). They found that, although not statistically significant, early cranioplasty may lead to better neurological and functional outcomes compared to late cranioplasty [6].

While they all share the same hypothesis, Schuss and co-workers (2012) suggest that patients who undergo late cranioplasty might benefit from a lower complication rate which correlates with the clinical course of our patient [7].

In Goedemans et al. (2020) case study on the complications in cranioplasty after decompressive craniectomy, with special emphasis on the timing of the intervention, they concluded that early cranioplasty was associated with more complications, explained by the higher incidence of pre-cranioplasty cerebral spinal fluid flow disturbance and acute subdural hematoma as etiology [8]. Therefore, the timing of the cranioplasty procedure, its potential benefits and the risks for the patient, should be calculated in each individual case. Regarding our patient, we opted for a delayed cranioplasty because of the etiology of the injury, the superficial wound on the flap and the lower postoperative complication rate of a delayed cranioplasty.

Songara et al.(2016) concluded that there was improvement in CT perfusion parameters after either early or late cranioplasty on both operated and contralateral sides, and this was correlated favorably with the improvement in neuro-cognitive outcome [9].

Alkhaibary et al. (2020) and Wolff et al (2018), provided a comprehensive review covering the history, materials, surgical aspects, and complications of adult cranioplasty [10,11]. Their insights contribute to a more thorough discussion and understanding on the diverse facets of cranioplasty.

Several studies [12, 13, 14] have explored different techniques for preserving bone flaps after decompressive craniectomy. Ishikawa et al. (2022) discussed bone flap preservation in a subcutaneous abdominal pocket, while Mirabet et al. (2021) and Morina et al. (2011) investigated storage methods and abdominal wall preservation, respectively. These studies provide valuable insights into numerous approaches for bone flap preservation and allow us to make informative choices for the most appropriate patient treatment. In our case presentation, we used an autologous bone graft, and as a preservation technique we used implementation of the graft in the subcutaneous abdominal tissue.

Iaccarino and co-workers (2020), described the most common complications after a cranioplasty, such as: wound dehiscence, infection, ulcers, necrosis, and hydrocephalus. Infection being the most common complication, was noted in 36.5% of the reported cases[21]. They presented the most commonly used material types for bone implants which include: autologous bone, poly-methyl-methacrylate, titanium, porous hydroxyapatite, and 3-D prosthesis. Their study concludes that autologous bone is the most commonly used material for cranioplasty [15].

When discussing non-autologous bone grafts, Wolff et al (2018) used clear customized implants, made of poly-methyl-methacrylate (PMMA). This implant material showed the lowest complication profile in comparison to the other customized implants available [11].

On the basis of Beauchamp et al. (2010)′s 5-year query (2003–2007) of the level I neurotrauma database, they believe that the preferred material for cranioplasty should be autologous bone, because higher infection rates were associated with cranioplasties performed with synthetic materials[16]. In our case, we successfully used an autologous bone and had no sign of postoperative comlications.

Gordon et al. (2014) present the pericranial on-lay technique that was used on 50 patients in their case study. The novelty with this technique is that it preserves the vascularized pericranium as a protective layer against infection. It divides the full-thickness scalp flap into 2 segments: a lower segment containing a vascularized “pericranial on-lay” and an upper segment consisting of a new galeal fasciocutaneous (partial-thickness) scalp flap based on the superficial temporal vessels which is why it is essential to preserve those vessels during the procedure. This in turn provides a “vascularized sandwich” encasing and protecting the replaced bone flap or implant. This approach can be used for all types of secondary cranial reconstruction regardless of the choice of autologous or alloplastic material [17]. This technique served a successful purpose in the treatment of our patient and there were no signs of postoperative infection.

Decompressive hemicraniectomy emerged as a pivotal intervention in alleviating intracranial hypertension and preventing secondary brain injury. The procedure's effectiveness in reducing mortality and improving outcomes in severe traumatic brain injury cases has been substantiated by various clinical trials and systematic reviews [18, 19]. In our case report, we used this technique for the management of increased intracranial pressure.

Ongoing rehabilitation and long-term follow-up are imperative components of traumatic brain injury management. The patient's progress, psychomotor agitation, and eventual stabilization underscore the importance of continued care and support in optimizing functional outcomes [19, 20].

Conclusion

In conclusion, this case report underscores the critical role of cranioplasty following decompressive hemicraniectomy in restoring neurological function and aesthetic appearance in patients with severe traumatic brain injury. The abdominal pouch can be used to store the bone flap. Reimplantation of the bone graft as soon as possible is the preferable course of action to prevent its atrophy and/or resorption.

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