Low Incidence of Bone Flap Resorption After Native Bone Cranioplasty in Adults

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■ OBJECTIVE: **Cranioplasty via use of the patient's autologous bone is performed often after craniectomy procedures. Bone resorption remains a matter of concern in patients with native bone cranioplasty. The objective of this study was to evaluate the rate of native bone resorption in adults and review associated factors that may increase the risk of resorption.**

■ METHODS: **This is a single-center retrospective cohort study that assessed consecutive patients who had cranioplasty via use of the patient's native bone flap. A total of 114 patients were identified. Electronic medical records were reviewed for demographic and operative data.**

■ RESULTS: **The mean age was 51.2 years. The main indications for initial craniectomy included subarachnoid hemorrhage (SAH) in 50.9%, intracerebral hemorrhage in 17.5%, ischemic stroke in 14.9%, and trauma in 13.2% of patients. Mean interval between craniectomy and cranioplasty was 6 months. Mean follow-up after cranioplasty was 25 months. Bone resorption occurred in 3 patients (2.7%): at 6 months in a 30-year-old woman who presented with SAH followed by decompressive craniectomy and cranioplasty 3.5 months later; at 19 months in a 67-year-old female patient who presented with intracerebral hemorrhage followed by decompressive craniectomy and cranioplasty 6 months later; and at 9 months in a 50-year-old man who presented with SAH followed by craniectomy for clip ligation and cranioplasty 3 months later. Two of these patients underwent replacement of the native flap with synthetic material.**

■ CONCLUSIONS: **The rate of autologous bone flap resorption in adult patients undergoing cranioplasty is low even after a mean interval for cranioplasty of 6 months.**

INTRODUCTION

Cranioplasty is performed for protective, cosmetic, and therapeutic reasons in surviving patients who have undergone craniectomy previously for the management of space-occupying intracranial pathologies, including intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), traumatic brain injury, malignant cerebral edema after acute ischemic stroke, or various brain tumors and intracranial infections.[1-3] Several materials can be used to repair the cranial defect. The traditional and most commonly used method is autologous bone graft with reinsertion of the native bone flap. This method is especially preferred in pediatric patients because of the potential reintegration of the flap as the patient grows up without introducing other foreign materials. Other materials that can be used to repair the defect include polymethyl methacrylate, hydroxyapatite cement, titanium mesh, or metal plates.[4]

Cranioplasty is associated with an important rate of complications, up to 34%.[5] The main complications include infection, postoperative hematoma formation, hydrocephalus, seizures, and bone resorption.[6,7] Bone resorption remains a matter of concern in patients with native bone cranioplasty because it may result in cosmetic flaws and increased risk of brain injury and may require reoperation and replacement of the flap with other materials. The rate of bone resorption after native cranioplasty has been reported to be as low as 2% and as high as 32% in adult patients[8,9] and even greater in pediatric patients after autologous

Key words
- Autologous bone
- Cranioplasty
- Resorption

Abbreviations and Acronyms
CI: Confidence interval
CT: Computed tomography
ICH: Intracerebral hemorrhage
OR: Odds ratio
SAH: Subarachnoid hemorrhage
VP: Ventriculoperitoneal shunt

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cranioplasty.[10-12] Several factors pertaining to the cranioplasty procedure, such as the condition of the native bone flap, storage techniques, time to reinsertion of the bone flap, and patient characteristics, have been reported to influence the rate of bone resorption. The aim of this study is to evaluate the rate of bone flap resorption in an adult population and review associated factors that may increase the risk of this event in patients with native bone cranioplasty.

MATERIAL AND METHODS

Patient Selection

The study protocol was approved by the University Institutional Review Board. This is a single-center retrospective cohort study that assessed consecutive patients who had a cranioplasty procedure in which their native bone flap was used, performed by the neurovascular department during a 10-year period. Adult patients (>18 years of age) who underwent cranioplasty after craniectomy for increased intracranial pressure as the result of SAH, ischemic stroke, intraparenchymal hemorrhage, arteriovenous malformation rupture, subdural hematoma, or trauma were included in the study. Patients undergoing cranioplasty by a different neurosurgical service were not included in the study, including cranioplasty attributable to craniectomy for tumor resection and skull bone tumors. Patients were excluded if they were younger than 18 years of age, if an alternative method of cranial defect repair initially was used instead of the patient's autologous bone flap, and if patients were lost to follow-up after cranioplasty or if they did not survive to discharge. A total of 114 patients meeting the study criteria were identified.

Variables and Outcomes

Electronic medical records were reviewed to identify demographic and operative data, including patient age, sex, smoking status, diabetes, hypertension, the initial surgery performed before cranioplasty, reason for cranioplasty, time interval between the initial procedure and cranioplasty, location of bone flap storage, size of the defect, and follow-up time after cranioplasty. The main outcome of this study was to evaluate the rate of bone flap resorption in adult patients who underwent native bone cranioplasty and review factors associated with the occurrence of resorption. Patients were considered to have bone resorption when there was clinical or radiographic evidence of an enlarging cranial defect or bone flap erosion. Computed tomography (CT) scans were obtained routinely for follow-up after cranioplasty. Further imaging was obtained when clinically indicated. Follow-up CT scans were evaluated by a neuroradiologist and the treating neurosurgeon.

Other outcomes of interest included evaluation of other complications related to cranioplasty, including infection documented by positive cultures, hematoma formation that required surgical evacuation, new-onset seizures, and hydrocephalus documented on CT scan that required the placement of a ventriculoperitoneal (VP) shunt.

Storage

Immediately after the bone flap has been removed from the patient, the flap is placed in a container with a lid holding 1000 mL of normal saline mixed with 50,000 units of bacitracin. The attending surgeon determines whether to store the patient's skull flap to be used at a later time for autotransplantation and verbally communicates to the operating room staff as soon as he/she determines the need to retain the skull flap.

Once it has been determined that the skull flap will not be reimplanted, the same day, after the craniotomy, the circulating nurse opens the contents of the skull flap kit that contain all the sterile ingredients to wrap the skull flap for placement into the freezer and hands the items to the scrub nurse. The scrub person dries the flap with a towel and removes any gross blood, double gloves and places the skull flap into a zippered storage bag and seals it, places the bag on a 2-ply wrapper and wraps it securely, and hands the wrapped skull flap to the circulating nurse for labeling. The wrapped skull flap is then placed into a larger zippered plastic bag and closed. The skull flap will remain in the freezer until it is reimplanted or for a period of 2 years, whichever comes first. The freezer is used for skull flaps only. No other products are accepted into the freezer. The skull flap freezer temperature is set at −40°C to −80°C.

On the day of reimplantation, before the procedure, the skull flap is removed from the outside the zippered plastic bag. With a sterile technique, the contents of the wrapper are opened and placed on the sterile field. The scrub nurse removes the skull flap from the bag and places it into a sterile container with a secure lid containing 1 liter of normal saline and 50,000 units of bacitracin, taking care to cover the entire skull flap. The skull flap should remain in the solution until thawed. Once the skull flap has thawed, it is completely immersed in Betadine solution (Purdue Products, LP, Stamford, Connecticut, USA) for 3 minutes, then rinsed in 1 liter of normal saline. The skull flap is then placed on a dry towel. The skull flap should is used as soon as possible after it is thawed, and it should never be refrozen once it has been thawed. The bone flap is never autoclaved or flashed.

Cranioplasty

The timing of cranioplasty after the initial surgery was left at the discretion of the treating neurosurgeon. Patients were placed under general endotracheal anesthesia. Antibiotic prophylaxis was administered before the incision was made, in addition to seizure prophylaxis and deep-vein thrombosis prophylaxis with pneumatic compression devices. The previous incision was reopened with a #10 blade. With Metzenbaum scissors and bipolar cautery, the plane was identified very carefully between the galea and the duraplasty. The plane was dissected carefully, and meticulous hemostasis and copious irrigation were achieved. Then, the native bone flap was replaced with titanium plates and screws. A Jackson-Pratt drain was placed in the subgaleal space in some patients. Closure of the temporalis muscles, subcutaneous tissues, and skin was then performed.

RESULTS

In the 114 patients identified, the mean age at the time of cranioplasty was 51.2 years (Table 1); 53% of patients were women and 47% were men. A total of 41.2% of patients were smokers, 16.7% had a history of diabetes mellitus, and 60.5% of patients had a history of hypertension. The indications for the initial