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Cryopreservation versus subcutaneous preservation of autologous bone flaps for Cranioplasty: Comparison of the surgical site infection and bone resorption rates

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ABSTRACT

Objective: Decompressive craniectomy is performed to treat malignant brain hypertension. Surgical site infection (SSI) and bone resorption are common complications following cranioplasty, and the storage method that minimizes such complication has yet to be identified.
Methods: Over a 10-year period, the details of 290 decompressive craniectomy procedures performed at our trauma and stroke center were recorded. Bone flaps from 110 patients were preserved in subcutaneous pockets (SPs), and 180 were preserved via cryopreservation (CP).
Results: SSIs occurred in 20 cases (18.2%) in the SP group and 20 cases (11.1%) in the CP group ($P = 0.129$). After dividing each group according to the traumatic brain injury (TBI) etiologies, we found that in the SP group, the SSI rates in the TBI and non-TBI patients were 17.3% and. 20.7% ($P = 0.899$), respectively, and in the TBI- and non-TBI CP-group patients, the SSI rates were 11.9% and. 9.7% ($P = 0.864$), respectively. The average decrease in bone flap thicknesses were 1.14 mm in the SP group ($n = 34$) and 1.89 mm in the CP group ($n = 57$), and this difference was significant ($P = 0.039$).
Conclusions: In this series, the SSI rates were similar in the SP and CP groups. There was no significant difference when the patients were grouped by TBI etiology. The incidence of bone flap resorption in the CP group was higher than that in the SP group. However, identifying of the method that yields superior results might depend on the individual surgeon's preference and the available equipment.

1. Introduction

The use of decompressive craniectomy (DC) for the treatment of severe intracranial hypertension following trauma, tumor surgery, or cerebrovascular accident reemerged in the mid-1990s [1–3]. When the patient survives the illness, cranioplasty with an autologous bone graft or another reconstructive material is often performed to repair the skull defect. Autologous bone flaps remain the among the of the most commonly used materials for delayed cranioplasty, and their use was first reported in the 1950s [4].

Autologous bone flaps need to be sterilely preserved for several weeks or months until the cranioplasty can be performed. Several storage methods are available for this purpose, and two popular methods are currently in use. The first method is preservation in a subcutaneous pocket (SP). Nakajima et al. reported the method of the subcutaneous preservation of bone flaps in the thigh [5], and Acikgoz et al. preserved bone flaps between the abdominal fat and the muscle layers [6]. This method requires additional surgical procedures. The second favored method is cryopreservation (CP) of the bone flap, typically in a deep freezer. The choice of method is usually based on the surgeon's preference, and only a few previously published papers have discussed whether one method is superior to the other.

To clarify whether differences in the methods used to store bone flaps influence the incidences of surgical site infection (SSI) and bone flap resorption following cranioplasty, we retrospectively reviewed the clinical results obtained from our patients who underwent DC and delayed cranioplasty within a 10-year period.

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2. Materials and methods

Between May 2001 and May 2010, 430 patients underwent cranioplasty in our trauma and stroke center. Patients with cranioplasties that utilized bone cement, primary cranioplasties due to traumatic skull fractures or skull bone tumors, and craniectomies performed in other hospitals were excluded. Consequently, 290 patients who underwent DC for malignant brain hypertension and subsequent cranioplasty with autologous bone flaps were enrolled in this study. The standard procedure for DC is to create a large frontotemporoparietal hemicraniectomy (>8 × 8 cm) and dural opening. This technique was performed for TBI, malignant infarction and hypoxic encephalopathy. DCs for aneurysmal subarachnoid hemorrhage were performed with pterional bone flaps that were typically removed for intraoperative brain swelling. The DCs for intracerebral hemorrhages (ICHs) and tumors depended on the surgical procedures. Some basic patient information is presented in Table 1.

For the majority of the study period, the bone flaps were routinely stored in our bone bank at a temperature of −70 °C. Of the study participants, 180 patients were included in this CP group. In our standard CP procedure, the soft tissue attached to the bone flap is removed completely, bacterial cultures are performed, the bone flaps are then are immersed in a Betadine solution for at least 30 min and a vancomycin solution (500 mg in 500 ml normal saline) for another 30 min, wrapped in one layer of sterile glove and one layer of a sterile plastic bag, and finally covered with two more layers of sterile cloth. This package is placed into a deep freezer within 30 min. On the day of the cranioplasty, the bone flap is removed from the bone bank at the beginning of the operation. The flap is again soaked in a Betadine solution for 30 min and a vancomycin solution for 30 min prior to implantation.

From August 2003 to October 2006, our freezer in the bone bank was not functioning. Therefore, we had to use the SP method to preserve the bone flaps. During this period, 110 bone flaps were stored in SPs. The standard procedure in our institution is to create an SP in the anterolateral thigh. Soft tissue attached to the bone flap is removed completely, and a bacterial culture is performed then. The SP is created in the subcutaneous layer above the muscular fascia. After carefully ensuring hemostasis, the bone flap is inserted, and one 10 mm drainage tube is left in place. The thigh wound was reopened, and the bone flaps were retrieved at the time of the cranioplasty.

SSI was defined as a surgical wound site that exhibited focal erythema, pus-like discharge or wound rupture. Cases of infection required an additional surgery for bone graft removal.

The microbiologic results are reported in Tables 4 and 5.

We were also interested in the incidence of bone flap resorption. After cranioplasty, we compared the thicknesses of the frontal bones and the bone flaps via brain CT. We defined the standard section of the brain CT using the bilateral frontal horns and the foramen of Monro. The data were recorded by two neurosurgeons who were blinded to the storage method. The difference in the thickness of the bone flap edge compared to that of the contralateral side (non-operative side) was defined as the "decreased thickness" (Fig. 1). The interval for follow-up brain CT was limited to within 6–12 months after cranioplasty.

Because most of the patients in our series had experienced traumatic brain injury (TBI), we also divided each method group into two subgroups based on etiology (i.e., TBI or non-TBI); the SSI incidences in each subgroup were determined and are presented in Table 2. The clinical characteristics of the patients who experienced SSIs are also summarized in Table 2.

Moreover, Inamasu et al. [7] has reviewed the literature related to the incidence of SSI following cranioplasty. We have included data from recently published reports in Tables 6 and 7.

Continuous variables are expressed as the mean ± the standard deviation and were compared using Student's t test, and categorical variables were compared using the Fisher's exact test. Differences that produced P values <0.05 were considered statistically significant.

3. Results

Basic data

There were fewer patients in the SP group than in the CP group (110 vs. 180) because our freezer was broken for only 3 years. During this period, we had to use the SP method to store the skull flaps. After the freezer was fixed, the CP method employed.

For the SP group, the interval between DC and cranioplasty ranged from 11 to 288 days (mean 61.24 ± 60.95 days), and for the CP group, this interval ranged from 9 to 358 days (mean 59.82 ± 47.71 days). The timing of the cranioplasty was determined by each neurosurgeon. The difference in this interval between the groups was not statistically significant ($p = 0.829$). These basic data are summarized in Table 1.

Table 1
Basic patient data and infection rates.

	SP group ($n = 110$)	CP group ($n = 180$)	P value
Sex (M:F)	79:31	118:62	0.328
Age (yr)	48.97 ± 17.87	50.45 ± 18.80	0.509
Initial diagnosis			0.112
TBI	81 (73.6%)	118 (65.6%)	
Malignant infarction	18 (16.4%)	33 (18.3%)	
Spontaneous ICH	5 (4.5%)	11 (6.1%)	
Subarachnoid hemorrhage	4 (3.6%)	13 (7.2%)	
Tumor edema	0 (0.0%)	5 (2.8%)	
Hypoxic encephalopathy	2 (1.8%)	0 (0.0%)	
Surgical site infection	20 (18.2%)	20 (11.1%)	0.129
Duration of bony preservation (days)	61.24 ± 60.95	59.82 ± 47.71	0.829

χ^2 test, Yates' correction χ^2 test, student's t-test.
CP, cryopreservation; ICH, intracerebral hemorrhage; SP, subcutaneous pocket; TBI, traumatic brain injury.

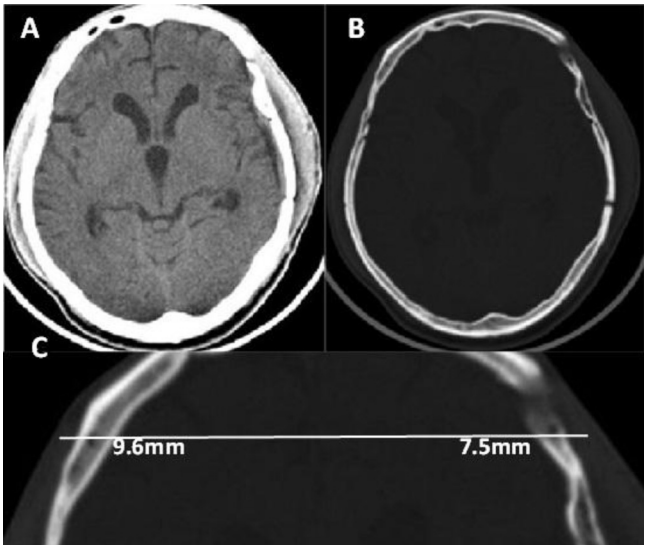

Fig. 1. Measurement of bony resorption. (A) Obtain standard postoperative brain CT cut using foramen of Monroe and bilateral anterior horns. (B) Switch to bone window. (C) Divide the image with a line drawing and determine the difference in thickness between the cranioplasty edge and the contralateral bone.