

Cranioplasty with cryopreserved autologous bone in craniectomized patients due to brain trauma, a current and safe option: experience of 97 cases

Craneoplastia con hueso autólogo criopreservado en pacientes craniectomizados por trauma craneal, una opción vigente y segura: experiencia de 97 casos

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Abstract

Background: Cranioplasty is the used method in neurosurgery for repairing cranial bone defects. In our environment, the most widely used material is cryopreserved autologous bone (ABCp). **Objective:** A retrospective observational study was proposed in order to analyze complications in patients who underwent decompressive craniectomy for brain trauma, with subsequent cranioplasty with ABCp. **Method:** Patients who underwent cranioplasties with consecutive ABCp performed at our institution over a four-year period (2016-2019) with subsequent follow-up were included, collecting multiple variables in relation to the appearance of complications. **Results:** 113 cranioplasties were performed, of which 85.8% ($n = 97$) were performed with ABCp. Mainly with frontotemporoparietal bone defect (94.84%) performed late (> 3 months) in 91.76%. The complication rate was 16.49%, the most significant being the infection of the surgical site ($n = 8$, 8.24%), the presence of intracranial hematoma ($n = 3$, 3.09%) and the reabsorption of the autologous bone ($n = 2$, 2.06%), meriting surgical management in nine of them (9.27%). **Conclusions:** ABCp is a valid and safe option, which meets the basic characteristics to consider it the ideal material, with an acceptable rate of complications, biocompatible, with osteogenic potential, adequate protection of the brain and decrease in surgery costs.

Keywords: Cranioplasty. Autologous bone. Decompressive craniectomy. Complications.

Resumen

Antecedentes: La craneoplastia es el método utilizado en neurocirugía para reparar los defectos óseos craneanos. En nuestro medio, el material utilizado mayormente es el hueso autólogo criopreservado (HACp). **Objetivo:** Realizamos un estudio retrospectivo observacional para analizar las complicaciones en pacientes sometidos a craniectomía descompresiva por trauma craneoencefálico y realización de craneoplastia con HACp. **Método:** Se incluyeron pacientes que fueron sometidos a craneoplastias con HACp consecutivas realizadas en un periodo de 4 años (2016-2019) con seguimiento posterior, recabando múltiples variables en relación con la aparición de complicaciones. **Resultados:** Se realizaron 113 craneoplastias, de las cuales el 85.8% ($n = 97$) fueron realizadas con HACp, principalmente con defecto óseo frontotemporoparietal (94.84%), realizadas de forma tardía (> 3 meses) en el 91.76%. El índice de complicaciones fue del 16.49%, siendo las más significativas la infección del sitio quirúrgico ($n = 8$, 8.24%), la presencia de hematoma endocraneano ($n = 3$, 3.09%) y la reabsorción del hueso autólogo

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($n = 2$, 2.06%), ameritando manejo quirúrgico en nueve ocasiones (9.27%). **Conclusiones:** El HACp es una opción válida y segura, la cual cumple con las características para considerarlo el material ideal, con un aceptable índice de complicaciones, biocompatible, con potencial osteogénico, adecuada protección encefálica y disminución de los costos de la cirugía.

Palabras clave: Craneoplastia. Hueso autólogo. Craniectomía descompresiva. Complicaciones.

Introduction

Head trauma, brain tumors, hemorrhagic and ischemic vascular processes, as well as infections, are frequent causes of intracranial disorders that can increase intracranial pressure and in some cases require a decompressive craniectomy¹. However, this leaves the brain tissue unprotected, and also entails a significant aesthetic defect, with multiple psychological repercussions for the patient².

Cranioplasty is the method used in neurosurgery to repair bone defects³, being cryopreserved autologous bone (HACp) the most widely used material in our environment, since it better meets the basic characteristics to be considered the ideal material (Table 1)⁴. On occasions, autologous bone may not be available due to fracture, contamination, and even due to lack of availability of a tissue bank; for this reason, different materials have emerged, such as polymethylmethacrylate plate, titanium mesh, and hydroxyapatite, among others⁵.

We carried out an observational and retrospective study in order to analyze the complications that arose in patients who underwent decompressive craniectomy for cranial trauma and subsequent performance of cranioplasty with HACp.

Method

In this study, we retrospectively examined all CAH cranioplasties performed at our institution consecutively over a 4-year period (2016-2019), in which decompressive craniectomy was performed due to trauma. All information was collected from the hospital's electronic system and completely anonymized prior to statistical analysis. We include those cases with a complete file, with a total of 97 procedures.

At our institution, the HACp is obtained at the time of craniectomy, stripped of all adhering tissue and placed in sterile bags. A culture is taken, and if it is reported with bacterial presence it is discarded; if there is no growth in the culture, radiation sterilization is performed. It is kept at a temperature of -76°C and is thawed at room temperature the night before it is replaced.

The standard surgical procedure performed at our institution consists in the reopening of the previous incision by decompressive craniectomy with separation of the epicranial tissues of the dura mater and the bone contour, and the subsequent repositioning of the HACp fixed by means of miniplates.

The data of the variables analyzed were obtained retrospectively from the electronic records: age, sex, location of the bone defect, time between craniectomy and cranioplasty, complications, time between cranioplasty and complication, surgery required, and culture results in case of infectious complication. The time at which the intervention was performed was classified as early (between 1 and 3 months) or late (more than 3 months) cranioplasty, as has been done in previous publications⁴.

Descriptive statistics were performed using IBM SPSS version 26. The variables were collected in a Microsoft Excel spreadsheet (Office 2016, Microsoft), expressing quantitative variables through measures of central tendency and dispersion, and qualitative variables through frequencies and proportions.

Results

Characteristics of the included patients

97 patients were included (Table 2), of which 73.19% ($n = 71$) were men and 26.81% ($n = 26$) were women, with a mean age of 34.33 ± 14.03 years and 39 ± 14.59 years, respectively, corresponding to a global average of 35.54 ± 14.15 years.

The vast majority of procedures were unilateral frontotemporoparietal, in 94 cases (94.84%), followed by bilateral in 3 cases (3.09%) and bifrontal only in 2 (2.06%). Between 1 and 3 months (early cranioplasty) 8 skulls (8.24%) were reconstructed and more than 3 months later (late cranioplasty) 89 cases (91.76%) were operated.

Complication rate

There was a complication rate of 16.49%. As seen in table 3 and figure 1, of all the complications, infection of

Table 1. Characteristics of an ideal material for cranioplasty

Characteristic	Advantages
Availability	– Widely available and inexpensive
Biocompatibility	– Absence of inflammatory response – Absence of systemic toxicity – Minimum infectious potential
Reproduction of bone contours	– Moldable – Easy to contour – No reabsorption – Available in the necessary sizes
Brain protection	– Resistant to fractures and deformations – Rigid fixing to the shell – No thermal conduction
Osteogenic potential	– Able to stimulate osteogenesis – Ability to vascularize
Compatible with imaging studies	– Radiolucent

Table 2. Characteristics of the patients included in the study (n = 97)

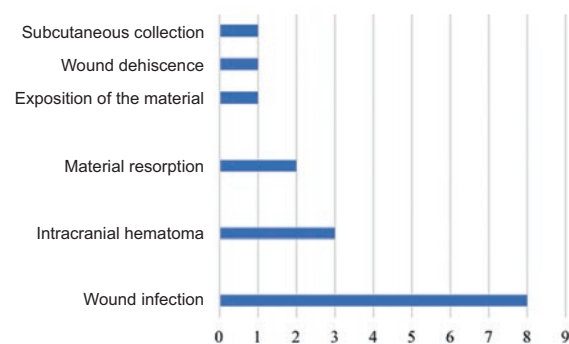
Sex	n (%)
Female	26 (26.8)
Male	71 (73.19)
Age (years)	Mean ± SD
Female	39 ± 14.59
Male	34.33 ± 14.03
Total	35.54 ± 14.15
Bone defect location	n (%)
Frontotemporoparietal (unilateral)	92 (94.84)
Bilateral	3 (3.09)
Bifrontal	2 (2.06)
Timing of cranioplasty	n (%)
Early (1-3 months)	8 (8.24)
Late (> 3 months)	89 (91.76)

SD: standard deviation.

the wound or surgical site was the most predominant (n = 8, 8.24%), for which 62.5% of the cases presented a positive culture, Gram-positive cocci being more prevalent (n = 4) and one case with gram-negative bacilli. After infection, in order of frequency, intracranial hematoma occurred in 3 cases (3.09%) and HACp reabsorption in 2 cases (2.06%) (Fig. 2); finally, with only 1

Table 3. Complications reported in the study, with their management granted

Complication	Total n (%)	Management granted	Total n (%)
Wound infection	8 (8.24)	Surgical cleaning	5 (5.15)
		Antibiotic	3 (3.09)
Intracranial hematoma	3 (3.09)	Hematoma evacuation	2 (2.06)
		Conservative	1 (1.03)
Material resorption	2 (2.06)	Material removal	1 (1.03)
		Conservative	1 (1.03)
Exposure of the material	1 (1.03)	Surgical management (removal)	
Wound dehiscence	1 (1.03)	Medical management and suturing of the wound	
Subcutaneous collection	1 (1.03)	Medical management (expectant)	

**Figure 1. Complications reported in the study.**

case (1.03%), material exposure occurred (Fig. 3), wound dehiscence and uninfected subcutaneous collection. Regarding the requirement of surgery as management of complications (Table 3), there were 9 (9.27%) in total, 5 (5.15%) required surgical cleaning, 2 (2.06%) required surgical evacuation of the hematoma and another 2 (2.06%) required removal of the HACp. The average time interval between surgery and the appearance of the complication was 142.69 ± 117 days.

Discussion

Numerous neurosurgical pathologies entail the need to perform a decompressive craniectomy, which results in neurological, psychological, mechanical and aesthetic alterations. Cranioplasty is the ideal method to date to repair bone tissue loss with various materials, such

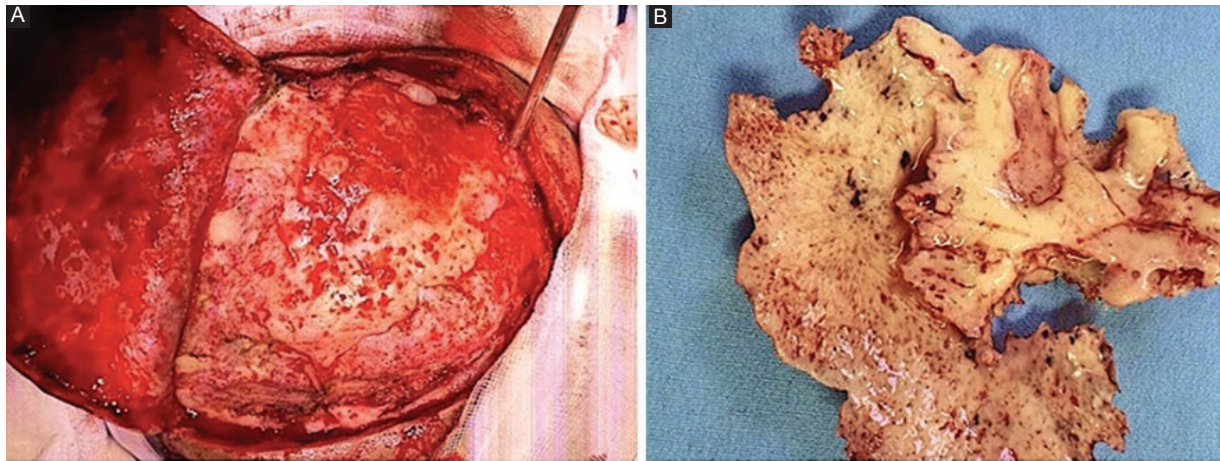


Figure 2. **A:** trans-surgical image of a 32-year-old patient with cryopreserved autologous bone resorption, showing the areas of exposed dura mater around the bone graft. **B:** autologous bone is removed, observing areas of bone erosion compatible with resorption on the inner table irregularly. There are no data on the infectious process, with a histopathological report of chronic granulomatosis without bacterial growth in cultures.



Figure 3. A 29-year-old male who presented autologous bone exposure, for which the material was removed, with placement weeks later of a polymethylmethacrylate plate.

as autologous and heterologous bone graft, polymethylmethacrylate plate or titanium mesh, among others¹.

Although cranioplasty is a technically simple procedure, short- and long-term complications can occur. The rate of complications reported in general in the literature is highly variable, being 5% in some series

and up to as high as 60% in others^{6,7}. There are characteristic complications depending on the material used: bone resorption for autologous and heterologous bone, erosion and exposure for titanium mesh, infection for all materials, etc. Our complication rate for HACp (16.49%, n = 16) contrasts with what has been reported in other studies; in a series of 286 patients⁷ complications were reported in 33.3%, and also in about a third of 136 patients treated with autologous bone flaps⁸.

Bone resorption is a well-known complication for autologous bone grafting, which has been frequently reported in some series. For example, Martin et al.⁹ found a resorption rate of 81.8% in a series of 27 young children and 54.4% of patients required surgical revision, and Vince et al.⁷, in a series of 286 adult patients, had only 8 patients (3.6%) who required surgical intervention.

Several studies have reported correlations between patient age, multiple fractures, bone flap location, ventriculoperitoneal shunt, and skull defect size with the development of bone flap resorption¹⁰. Having multiple fractures has previously been considered to be at high risk for resorption. Bone flaps with multiple fragments are thought to be the underlying pathologic mechanism¹¹. The application of synthetic skull implants is a valid method to avoid the risk of resorption; however, the increased risk of infection⁷ and rejection, higher costs and implant imperfection do not justify the use of alloplastic materials¹².

There is evidence that HACp can be maintained for up to 19 months at temperatures below -20 °C and still retain its revascularization capacity¹³, since the osteoblasts remain viable in the cryopreserved bone

tissues allowing an adequate integration of the HACp to the bone border.

The time elapsed between performing decompressive surgery and cranioplasty with respect to the appearance of complications is a controversial issue. There are studies that do not demonstrate a significant difference between performing an early or late craniectomy¹⁴, while in others a lower incidence of complications was found with delayed cranioplasty¹⁵.

Cosmetic results after cranioplasty have been reported less frequently. A study carried out to identify factors associated with the degree of aesthetic satisfaction after cranioplasty with autologous bone in patients who presented head trauma reported that 86.2% were satisfied with the procedure; the rest were not convinced of the results, mainly in relation to the presence of subsidence in the surgical site, also finding a negative correlation between satisfaction and the presence of postoperative infection¹⁶.

Conclusions

Even though there are multiple materials to reconstruct cranial defects on the market, they still represent an aesthetic and functional challenge. HACp is a valid and safe option, which meets the basic characteristics to be considered the ideal material, with an acceptable rate of complications, biocompatible, with osteogenic potential and adequate protection for the brain. In addition, with it it is possible to reduce the costs of surgery, an important issue if we are in a hospital with limited resources.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of people and animals. The authors declare that no experiments were carried out on humans or animals for this research.

Data confidentiality. The authors declare that they have followed the protocols of their work center regarding the publication of patient data.

Right to privacy and informed consent. The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

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