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Soft tissue expansion and cranioplasty: For which indications?

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ABSTRACT

Purpose: The aim of this study was to better define indications for scalp tissue expansion before cranioplasty, and to describe our methodology for calculate the surface of tissue needed, by combining a preoperative analysis of both the size of the defect and the quality of skin above.
Material and methods: A retrospective analysis of patients who underwent expansion before cranioplasty between 2009 and 2015 was conducted. Information was collected on the etiology, size and location of the defect, and reasons of skin contracture. Data concerning expansion and cranioplasty were reviewed.
Results: Among 47 patients who underwent operation for cranioplasty, five (10.6%) required previous scalp tissue expansion. The etiology of the bone defect was tumoral in three cases, posttraumatic in one case, and a decompressive craniectomy in one case. The mean surface of the bone defect was 69.6 ± 18.7 cm^2. The locations of the defects were fronto-temporo-parietal, frontal, temporo-frontal, on the vertex, and occipital. The cause associated with the skin contracture was an infection in four cases and a delayed cranioplasty in one case. A round-profile expander and a custom-made porous hydroxyapatite implant were used for all patients.
Conclusions: The accurate assessment of tissue needed before cranioplasty is as essential as the choice of the material used for bone reconstruction. After previous infected cranioplasty or delayed reconstruction of large defects, scalp tissue expansion should be proposed.

1. Introduction

Cranioplasty has become a common surgical procedure performed by craniofacial and neurosurgeons when reconstructing bone defects caused by multiple events including traumas, resections of malignant tumors extending to the cranial vault, bone flap infections after neurosurgical craniectomy, and congenital malformations of the skull.

Bone reconstruction techniques use either autologous bone (Agrawal et al., 2010) or alloplastic materials (Cabraja et al., 2009; Greene et al., 2008; Staffa et al., 2012). Beyond this choice, a successful cranioplasty requires soft tissue coverage with a tension-free suture in order to minimize the risk of both implant and bone flap exposure. In most cases, the conservation of native scalp tissue overcomes this issue. However, a simple stretch of the remaining tissue might not be a safe option when the scalp soft tissue has previously been damaged or avulsed. Skin closure is actually more difficult when performed further to a previous infection, radiotherapy, or a scalp burn. This is due either to a lack of tissue or to a loss of its quality. Thus, recruiting tissue becomes necessary. In scalp reconstruction, conventional procedures include the following approaches: local flaps such as rotational or advancement flaps; free vascularized flaps such as the latissimus dorsi flap or the anterolateral thigh flap (Reddy et al., 2014); and tissue expansion (Leedy et al., 2005).

Regarding cranioplasty, tissue expansion seems to be the least risky procedure, since it results in fewer scars, and flaps failures are avoided. This technique, described in the 1950s (Neumann, 1957) and developed in the 1980s (Manders et al., 1984; Radovan, 1984; Van Rappard et al., 1988), is based on the progressive stretch of soft tissues by means of an expander placed in a subgaleal plane. Some authors have also performed tissue expansions using an external approach that relied on a "silicone suture" technique (Fan and Wang, 2004).

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The clinical application of tissue expansion in cranioplasty has already been demonstrated, but very few patients were included in the studies (Ferrand et al., 1993; Kasper et al., 2012; Miyazawa et al., 2007), and little information was given about its indications. Actually, well-codified indications for scalp tissue expansion are limited to cases of congenital giant naevi (LoGiudice and Gosain, 2003) and postburn alopecia (Bilkay et al., 2004), in which iterative excisions can be completed. Cranioplasty requires a more reasoned approach, since surgeons not only have to decide whether to use an expander or not, but also have to calculate the exact gain that they will obtain for a tension-free scalp suture. To date, no clear rules have been available to solve these issues.

The aims of this article are as follows: (1) to share our experience with tissue expansion for cranioplasty; (2) to better define the associated indications; and (3) to describe our methodology to calculate the surface of tissue needed, by combining a preoperative analysis of both the size of the defect and the quality of the skin above it.

2. Material and methods

This is a retrospective clinical study in patients who underwent soft tissue expansion before a cranioplasty procedure in a hospital between January 2009 and February 2015.

A minimum of 6 months' follow-up was required.

Collected patients features were as follow: age; gender; medical history; smoking; etiology of the bone defect; size and location of the defect; and reason of skin contracture.

Data concerning tissue expansion included the following: volume, radius on the base and profile of the expanders; number of expanders used for each patient and their location; maximal inflation for each expander; time between expander placement and cranioplasty; and complications that occurred during expansion.

Reviewed data after cranioplasty were as follows: complications of the reconstructed area; development of the empty space between the brain and cranial implant on postoperative computed tomography; residual alopecia; and hair graft procedures.

2.1. Tissue expansion procedure

In our department, soft tissue expansion was usually performed using smooth and round expanders that were inserted in the subgaleal plane and next to the cranial defect to be covered. The expander had to be placed under native tissue, preferably without any damage, in order to improve the results of the expansion.

A local infiltration with dilute epinephrine was made before scalp incision. A hydro-dissection between the galea and the pericranium was made to facilitate the expander placement and to decrease perioperative bleeding. The skin incision was performed in an oblique way, parallel to the direction of hair follicles, to prevent alopecia. It was also preferably made radially to the location of the expander to minimize both the skin tension during the expander filling and the risk of expander exposure. Through the same incision, the expander and the filling reservoir had to be placed in two separate compartments. Separating them avoided spreading any infection or hematoma from one compartment to another. Mastoid and temporal bones were our preferred locations because the risk of reservoir switching during inflation was minimal. After creating a subgaleal pocket reaching the bone defect margin, hemostasis was checked and the expander was inserted. One or two suction drains were inserted before skin suturing and were kept in place until the drainage was down to 30 cc per day. Antibiotic coverage was prescribed perioperatively and maintained for 10 days. The suture of the galea, which supports the hemostasis of the scalp and the solidity of the scar, was performed with 2/0 Vicryl suture. A tricophytic suture was made for skin closure. This technique involved a tangential excision of about 1 mm of the upper wound margin.

At the end of the surgery, the reservoir was systematically tested and filled with normal saline. The inflation was stopped when a low tension was created on the suture, usually when reaching between 10% and 20% of the expander volume. A gauze wrap was applied on the patient's head for the first 24 h.

After the surgery, our protocol of expansion consisted of filling up the reservoir once or twice a week. The first expansion began 1–2 weeks after the operation, depending on the healing of the incision. Each inflation was stopped when the patient started to feel discomfort and before the appearance of any sign of ischemia on the skin such as skin blanching. The expanders were inflated up to 150% of their capacity.

2.2. Cranioplasty procedure

When achieving a satisfactory expansion, the expander was removed and the cranioplasty could be performed. All patients underwent a personal project to produce a custom-made, porous hydroxyapatite implant (Custom-Bone Service Fin-Ceramica, Faenza) based on a 3-dimensional (3D) computed tomography (CT) scan. CT scan acquisitions followed this protocol: slide definition of 512×512 pixels, gantry tilt 0°, and length of acquisition maximum 2 mm. A temporary acrylic resin prototype model at a 1:1 ratio was made by 3D stereolithography before creating the definitive implant.

The incision was made by following the same procedure as described for expansion, while taking into consideration the location of the defect. We preferred to place it away from the defect so the wound would not directly be in contact with the cranial implant. The first step consisted of removing the expander. A subgleal dissection was then carried out to expose the entire bone defect and the periosteum above. A rectangular periosteum flap was dissected over the bone defect, allowing exposure of the dura. We took care not to make any dural tear during the dissection. To stimulate a better osteo-integration of the implant, bony edges were sharpened to expose healthy cancellous bone before placing the implant. Suspension of the dura was performed to avoid postoperative epidural hematoma. The cranial implant was then correctly placed on the defect, and the holes were drilled on native bone, protecting the dura with a rugine. Silk threads were placed through the drilled holes and tightened once the implant was properly positioned. The periosteum flap could then be repositioned over the implant to protect it from exposure. Following this step, an advancement flap of the expanded scalp flap was performed, and the extra fibrotic tissue was excised. No other types of local flaps have been used to mobilize expanded tissue in our patients. We made a capsulectomy at the base of the expander pocket to achieve further advancement of the galeal flap. However, we never scored the galea, so no vascular risk would be taken. The scalp closure was performed with a tricophytic suture in two layers, and had to be tension-free to prevent alopecia. A drain was always used in a subgaleal layer for about 48 h to prevent hematoma. A postoperative CT scan was performed in all patients to check the correct fit of the implant. Additional CT scans were performed during the follow-up period if the patient presented with clinical complications or as systematic examinations to follow the evolution of a vascular or tumoral disease.

2.3. Statistical analysis

Categorical variables are presented as counts and percentages. Results are reported as mean ± standard error of the mean for the detailed analysis.