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Prediction parameters of bone flap resorption following cranioplasty with autologous bone

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ABSTRACT

Objective: The number of patients who need cranioplasty after decompressive craniectomy has increased. In most cases, autologous bone flaps are used for cranioplasty, and there have been reports of the complication of bone flap resorption. Based on these facts, we analysed patients who underwent cranioplasty in our institution to learn about potential risk factors of cranioplasty.
Methods and results: We performed a retrospective study and analysed 58 patients who underwent cranioplasty between 2006 and 2013. We found that patients with a defect size >120 cm^2 whose reimplantation was delayed tended to have a risk of bone flap resorption.
Conclusion: Patients with delayed reimplantation and a defect size >120 cm^2 show a tendency of aseptic bone flap resorption. In these cases, a patient-specific implant (PSI) could be the first choice material for this procedure to reduce the rate of this complication.

1. Introduction

In recent years, the number of decompressive craniectomies has risen considerably. Although it is a radical intervention that often arouses controversial discussions, it is a common surgical procedure, and several recent studies have confirmed its efficacy. Advances in medical therapy in general and, more specifically, in intensive care have resulted in a decline in the mortality rate for these patients; thus, the number of patients who need cranioplasty after craniectomy has risen. While several studies have clearly shown the necessity of cranial repair, the optimal timing and optimal material for reconstruction are still unclear.

In the literature, autologous bone flaps are used in most cases because they are inexpensive and do not induce a tissue reaction; however, there are some reports of risk factors associated with the use of autologous bone flaps, such as infection and, especially, resorption.

In our prospective study we analysed patients who underwent cranioplasty at our institution to learn about possible predictive factors of the abovementioned complications. Based on these facts, we further tried to define a potential high-risk subgroup in which alloplastic bone flaps could be considered as the material of first choice to reduce distress for the patient as well as additional costs due to further hospitalisation.

2. Methods

In this retrospective study, we included patients who underwent unilateral decompressive craniectomy (DC) and subsequent cranial repair between January, 2006 and January, 2013 at the Department of Neurosurgery, Medical University Graz.

DC was performed according to the standardised technique using a frontotemporoparietal craniectomy followed by durotomy.

The removed bone flaps were cleaned with salt solution, wrapped thrice in sterile vinyl plastic bags and stored in a refrigerator at −84 °C in the tissue bank. When brain swelling resolved allowing for cranioplasty (CP), the bone flap was thawed, sterilised and fixed with titanium plates and screws in its original position.

If a patient specific implant (PSI) with polyetheretherketone (PEEK) was used for cranial repair, a thin layer computer tomography (CT) was performed before the cranioplasty. The CT data were then sent to a company to use for the production of the PSI.

In cases of reconstruction with polymethyl-methacrylate (PMMA) we used Palacos ®.

The patient data were analysed for age, interval between DC and CP, infection rate, aseptic bone flap resorption, defect size and overall treatment costs.

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Table 1
Epidemiological data of patients with bone flap resorption.

Patient	Sex	Age	Diagnosis	Size (cm^2)	Interval craniectomy – reimplantation (d)	Interval reimplantation – resorption (d)
Case #1	M	19 a	TBI	92	160	185
Case #2	M	21a	TBI	106	35	109
Case #3	M	59 a	Infarction	111	435	1011
Case #4	F	51 a	Infarction	153	58	1001
Case #5	M	39 a	SAH	85	221	310
Case #6	F	46 a	Infarction	110	55	259
Case #7	M	34 a	Infarction	152	156	360
Case #8	F	14 a	Infarction	156	40	120

The defect size area was calculated from postoperative plain X-ray examination as an ellipse with the longest axis being 2*a* and the 90° short axis being 2*b* with the formula: $\pi \times a \times b$.

Data acquisition was performed with Microsoft Excel Software 2007. For the statistical analysis SPSS for Windows version 21.0 was used (SPSS Inc., Chicago, IL, USA).

3. Results

Our study cohort comprised 58 patients, 33 males and 25 females, with a mean age of 46 years (range: 14–73). The leading cause of DC was malignant brain oedema due to infarction of the middle cerebral artery. This occurred in 24 cases (40%). Eighteen patients (31%) suffered from medically intractable intracranial pressure due to TBI. Ten patients (17%) had severe brain swelling after subarachnoid haemorrhage. In 6 cases (12%), oedema occurred intraoperatively during tumour resection, making osteoplastic craniotomy impossible.

CP was performed as soon as possible, when brain swelling subsided and adequate sinking of the scalp flap was observed. The mean interval between DC and CP was 233 days (range: 1–4206), the mean defect size was 90 cm^2 (range: 17–168). The patients were routinely followed-up six months after reimplantation; radiological examination was only performed in cases with clear bone flap dislocation or sinking.

Due to contamination or interruption of the freezing process, 13 autologous bone flaps were discarded. Thus, 9 patients (15%) received PSI as the material of choice. For CP, PMMA was used in 3 cases (5%), and a titanium plate was used in one case (2%). Of the cases for which autologous bone flaps were not used, 2 patients with a PSI implant (22%) and 2 with a PMMA implant (66.6%) suffered from infection. These patients were excluded from further correlative statistical analysis.

Autologous bone flaps were used in 45 cases (78%). The mean age of those patients was 44 years (range: 14–73). The mean interval between DC and CP was 147 days (range: 6–456), and the mean defect size was 99 cm^2 (range: 27–168).

In 8 patients (18%) with a mean age of 36 years (range: 14–59) resorption of the autologous bone flaps, both tabula interna and externa, was observed (Table 1 and Fig. 1). In these cases, the mean defect size was 121 cm^2 (range: 75–156) compared with 94 cm^2 in the uncomplicated cases. The mean interval between DC and CP for the complicated cases was 194 days (range: 35–454), and a mean of 419 days (range: 109–1011) elapsed between cranioplasty and bone flap resorption. Wound infection in that group occurred in 2 patients (4.5%).

In addition to a descriptive analysis, the "autologous bone flap subgroup" was then analysed for possible predicting factors for bone flap resorption. The parameters of "defect size", "patients' age" and "interval between DC and CP" were tested for correlation to resorption with the Spearman correlation. Then the Kruskal and Wallis test was performed to compare all risk factors combined with resorption (Figs. 2–4).

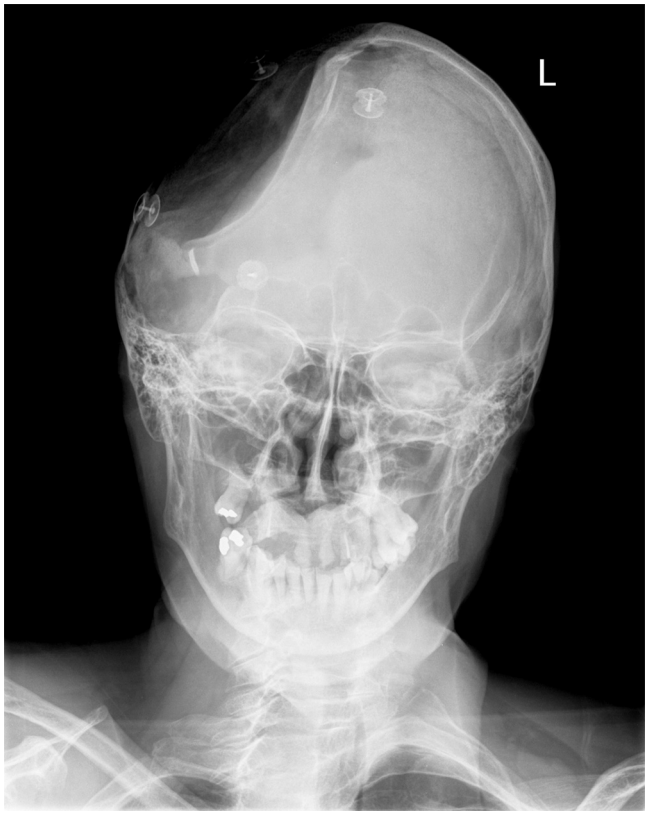

Fig. 1. a.p. X-ray of the skull showing massive aseptic autologous bone flap resorption with persistent metal clamps (Craniofix®).

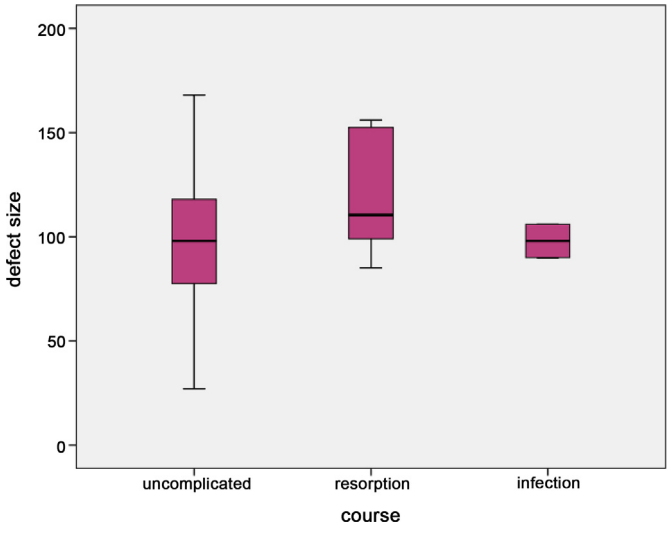

Fig. 2. Clinical course and distribution related to defect size.