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ORIGINAL ARTICLE

Is preoperative brain midline shift a determinant factor for neurological improvement after cranioplasty?

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Background/Purpose: In patients with traumatic brain injury, the degree of brain midline shift is related to prognosis. In this study, we evaluated the impact of the presence of a preoperative brain midline shift on the Glasgow Coma Scale (GCS) scores and muscle power (MP) improvement after cranioplasty.
Methods: In this 6-year retrospective cohort study, we compared cranioplasty patients from Taiwan with and without a preoperative brain midline shift. We assigned the patients to the following two groups: the midline shift group and the nonmidline shift group. The GCS score and MP contralateral to the lesion site were recorded and analyzed both prior to and 1 year after the operation.
Results: We enrolled 56 cranioplasty patients (35 patients with a midline shift and 21 without a midline shift) and analyzed their complete clinical characteristics. There were significant improvements in the GCS ($p = 0.0078$), arm MP ($p = 0.0056$), and leg MP ($p = 0.0006$) scores after cranioplasty. There was also a significant improvement in the GCS score in the brain midline shift group (0.4 ± 0.149 in the brain midline shift group vs. 0.05 ± 0.48 in the nonmidline shift group, $p = 0.03$).
Conclusion: For patients who underwent craniectomy, an improvement in neurological function 1 year after cranioplasty was observed. The patients with brain midline shift showed more

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improvement in consciousness after cranioplasty than those without a brain midline shift. The presence of a preoperative brain midline shift may be an isolated determinant for the prediction of the outcome after cranioplasty.

Introduction

Cranioplasty is performed mainly to protect the brain and to restore preinjury appearance.[1] It has been reported that some patients with large skull defects showed improvements in neurological status after cranioplasty.[2,3] The reversal in neurological deterioration is generally thought to be related to a reduction in the effects of local cerebral compression by atmospheric pressure. Over time, many craniectomy patients present with a persistent contralateral brain midline shift.[4] In this study, we aimed to determine whether such a brain midline shift is a significant factor in functional improvement after cranioplasty.

Methods

Between May 2003 and November 2009, we conducted a retrospective cohort study and included 82 cranioplasty patients undergoing regular follow-up for 1 year at Chang Gung Memorial Hospital, a tertiary care center in Chia-Yi (Taiwan). The indications of decompressive craniectomy were cerebral edema due to post-traumatic or post-ischemic brain swelling, or epidural abscess. During the study period, the Glasgow Coma Scale (GCS) score and muscle power (MP) in the upper and lower limbs contralateral to the cranioplasty site were recorded in the rehabilitation ward or in the neurosurgery clinic. Inclusion criteria were (1) unilateral craniectomy, (2) diameter of craniectomy defect >10 cm, (3) the duration between craniectomy and cranioplasty was ≥2 months, (4) brain computed tomography (CT) scan images or magnetic resonance images were obtained ≤1 week prior to cranioplasty, (5) regular follow-up in the rehabilitation ward or in the neurosurgery clinic of our hospital for >1 year. Exclusion criteria were (1) accept further brain surgery after cranioplasty during our follow-up and (2) lost to follow-up. Sixteen patients were excluded from the study because they required further brain surgery after cranioplasty [a ventriculoperitoneal (VP) shunt or a craniectomy because of an epidural abscess]. Ten patients were excluded because they were admitted for other severe medical diseases. Finally, 56 patients were enrolled in the study.

The patients in this trial had undergone a CT scan more than 2 months after a craniectomy and had a stationary neurological condition prior to cranioplasty. Craniectomy was performed to treat severe head injury, intracerebral hemorrhage, malignant large infarction, and intracranial infection. In the subgroup of patients with traumatic brain injury, their precraniectomy CT scans were categorized according to the Marshall CT classification[5] and are presented in Table 2. The Marshall CT classification was a CT classification for grouping patients with traumatic brain injury according to multiple CT characteristics.[5]

We assigned the patients based on the preoperative brain CT findings into the following groups: the midline shift group (midline shift: 1–12 mm; 35 patients) and the nonmidline shift group (midline shift: 0 mm; 21 patients). The GCS scores and MP of the upper and lower limbs contralateral to the lesion site were recorded prior to and 1 year after cranioplasty.[2] The midline shift distances were calculated using brain CT prior to cranioplasty by the same neurosurgeon. The GCS scores and MP of patients with sunken brain were also recorded and defined as nonpulsatile concave and unpinchable scalp.[6] A plain CT image of the brain is shown in Fig. 1.

Statistical analyses

The GCS scores and MP of the upper and lower limbs contralateral to the lesion site prior to and after cranioplasty were compared between the midline shift and the nonmidline shift groups. Categorical data were compared using the Chi-square test, and continuous data were compared using an unpaired t test. Pearson correlation coefficient was used to evaluate associations between variables. For all relevant results, 95% confidence interval (CI) was used. In the midline shift group, the midline shift distance was analyzed using linear regression analysis to evaluate whether neurological improvement was related to the midline shift grading. A result was considered statistically significant if two-tailed $p < 0.05$.

Results

Table 1 shows the characteristics of the 56 patients. The mean age in the midline shift group and the nonmidline shift group was 41.5 ± 17.4 years and 37.4 ± 17.7 years, respectively ($p = 0.40$). There were 21 men (out of 35 patients) in the midline shift group and 16 men (out of 21 patients) in the nonmidline shift group ($p = 0.21$). The number of patients with previous VP shunt was five (14%) in the midline shift group and two (10%) in the nonmidline shift group. The number of patients with sunken brain prior to cranioplasty was eight (23%) in the midline shift group and two (10%) in the nonmidline shift group. The GCS score ± standard deviation (SD) prior to cranioplasty was 13.6 ± 2.1 in the midline shift group and 14.2 ± 1.4 in the nonmidline shift group ($p = 0.23$). The GCS score ± SD after cranioplasty was 14.2 ± 0.3 in the midline shift group and 14.0 ± 0.3 in the non-midline shift group ($p = 0.63$). The worst GCS score in our patients was 8. The arm MP ± SD value before cranioplasty was 3.74 ± 0.26 in the midline shift group and 3.52 ± 0.46 in the non-midline shift group ($p = 0.81$). The leg MP ± SD value before cranioplasty was 3.74 ± 0.26 in the midline shift group and 3.52 ± 0.46 in the non-midline shift group, ($p = 0.66$). The arm MP ± SD value