De e c o m p r e s s i v e craniectomy is performed in patients suffering from intractable elevation of ICP following TBI or bleeding (for example, SAH) and is known to improve outcome after cerebral infarction of the MCA. Despite the increasing evidence for the benefit of the procedure, there are no standard guidelines for how to perform DC. Many options exist, even descriptions of in situ hinge craniectomies in which the bone flap is not removed but hinged to the cranium. There is evidence that the size of the bone removal may be crucial. The area of greatest controversy, however, is in the handling of the opened dura mater. A wide opening of the dura is crucial to lowering the ICP. Some authors prefer to perform a duralast with insertion of some form of dural graft and watertight suturing of the graft. It is argued that watertight suturing is necessary to prevent rapid closure technique in decompressive craniectomy

Clinical article

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Object. The object of this study was to describe the rapid closure technique in decompressive craniectomy without duraplasty and its use in a large cohort of consecutive patients.

Methods. Between 1999 and 2008, supratentorial rapid closure decompressive craniectomy (RCDC) was performed 341 times in 318 patients at the authors’ institution. Cases were stratified as 1) traumatic brain injury, 2) subarachnoid hemorrhage, 3) intracerebral hemorrhage, 4) cerebral infarction, and 5) other. A large bone flap was removed and the dura mater was opened in a stellate fashion. Duraplasty was not performed—that is, the dura was not sutured, and a dural substitute was neither sutured nor layed on. The dura and exposed brain tissue were covered with hemostyptic material (Surgicel). Surgical time and complications of this procedure including follow-up (> 6 months) were recorded. After 3–6 months cranioplasty was performed, and, again, surgical time and any complications were recorded.

Results. Rapid closure decompressive craniectomy was feasible in all cases. Complications included superficial wound healing disturbance (3.5% of procedures), abscess (2.6%) and CSF fistula (0.6%); the mean surgical time (± SD) was 69 ± 20 minutes. Cranioplasty was performed in 196 cases; the mean interval (± SD) from craniectomy to cranioplasty was 118 ± 40 days. Complications of cranioplasty included epidural hematoma (4.1%), abscess (2.6%), wound healing disturbance (6.1%), and CSF fistula (1%).

Compared with the results reported in the literature for decompressive craniectomy with duraplasty followed by cranioplasty, there were no significant differences in the frequency of complications. However, surgical time for RCDC was significantly shorter (69 ± 20 vs 129 ± 43 minutes, p < 0.0001).

Conclusions. The present analysis of the largest series reported to date reveals that the rapid closure technique is feasible and safe in decompressive craniectomy. The surgical time is significantly shorter without increased complication rates or additional complications. Cranioplasty after a RCDC procedure was also feasible, fast, safe and not impaired by the RCDC technique. (DOI: 10.3171/2009.12.JNS091065)

**Key Words** • decompressive craniectomy • duraplasty • subarachnoid hemorrhage • intracerebral hemorrhage • cerebral infarction • brain swelling

**Abbreviations used in this paper:** DC = decompressive craniectomy; EDH = epidural hematoma; ICH = intracerebral hemorrhage; ICP = intracranial pressure; MCA = middle cerebral artery; OR = odds ratio; RCDC = rapid closure decompressive craniectomy; SAH = subarachnoid hemorrhage; SDH = subdural hematoma; TBI = traumatic brain injury; VP = ventriculoperitoneal.

This article contains some figures that are displayed in color online but in black and white in the print edition.
Rapid closure in decompressive craniectomy

Postoperative complications, such as hygroma, infections, or CSF fistula. Many types of dural grafts have been suggested, including periosteum, fascia lata, and miscellaneous artificial grafts. Other authors prefer to cover the exposed brain tissue with the loosely replaced remaining dura and diverse materials and have reported using this technique without detecting any increase in the rate of postoperative complications.9 This idea is supported by emerging evidence that in supratentorial craniotomies watertight duraplasty may not be necessary.3 The aim of the present study was to report data pertaining to RCDC, with a particular focus on surgical time and incidence of complications. We also analyzed all subsequent cranioplasties to be sure that RCDC did not render cranioplasty more difficult and to ensure that we did not miss any late complications possibly induced by RCDC.

Methods

Patient Population

Between October 1999 and October 2008, RCDC was performed 341 times in 318 patients. Information, including patient demographic characteristics, clinical characteristic of the case on admission and during the course of treatment, radiological features, presence of infarction, bleeding (ICH, SDH, EDH, or SAH), complications of RCDC and cranioplasty, and the specific indication for DC, was entered in a prospective SPSS database (SPSS Version 15 Institute, Inc.).

Primary RCDC was performed in cases of acute intractable brain swelling after ictus or due to mass effect in patients with a large intracranial hematoma. Secondary RCDC was performed for intractable elevated ICP (> 20 mm Hg, despite medical therapy) during the course of intensive care treatment.4,6

Patient Stratification

Patients were stratified according to initial diagnosis into the following groups: 1) TBI, 2) SAH, 3) ICH, 4) cerebral infarction, and 5) other (tumor, abscess).

Surgical Technique of RCDC

The site was determined according to the site of the main pathology and/or mydriasis (hemicraniectomy was performed in 299 cases, bifrontal craniectomy in 42).

All procedures were done in a strictly standardized step-by-step fashion.

In cases of emergency surgery (most TBI cases), the hemicranium was shaved or both sides of the head were shaved from the tragus along a line shortly behind the coronal suture in cases of bifrontal craniectomy. In other cases only a 3-cm-wide strip along the incision line was shaved with an electric razor. To protect the skin, no razor blades were used.

A trauma flap was created—in the shape of a reverse question mark—starting at the tragus and continuing to slightly across the midline. The skin flap was larger than the bone flap, which facilitates wound opening for subsequent cranioplasty (it being easier to open the wound over intact skull).

The skin, galea, fascia, and temporal muscle were elevated as a single flap. We used at least 3 bur holes in hemicraniectomies, placed as follows: 1) at the base of the temporal bone, just in front of and above the root of the zygoma; 2) behind the lambdoid suture; and 3) 1.0–1.5 cm lateral to the bregma (Fig. 1A).

Thus a large frontotemporoparietal bone flap, extending from the supraorbital rim to shortly behind the lambdoid suture and from the temporal base to close to the midline (1.0–1.5 cm away), was removed. The temporal bone was removed down to the base of the middle cerebral fossa. The size of the craniectomy was at least 11 × 16 cm.

In patients undergoing bifrontal craniectomy, a large bone flap extending from the roots of the zygoma bilaterally and from about 1 cm parallel and superior to the orbital rim to about the coronal suture was removed in a single piece, or in a 2-piece fashion, leaving a small rim of bone (~ 2.5 cm wide) over the midline. The dura mater was opened widely and the opening was extended to the sinus and bone margins in a stellate fashion (Fig. 1B). External ventricular drains or ICP probes (Spiegelberg) or brain tissue partial O2 pressure probes (Raumedic) were inserted in selected patients. The exposed brain tissue was covered by the loosely replaced remaining dura (Fig. 1C) and Surgicel (Fig. 1D). No watertight duraplasty was applied. The dura was not sutured. This RCDC technique was used in all cases.

Surgical Technique of Cranioplasty

During cranioplasty, the layer for the replacement of the bone fragment was dissected between the myocutaneous flap and the dura-like layer (neo-dura) covering the brain (Fig. 2A). The bone margins encasing the cranietomy defect were exposed (Fig. 2B), which was facilitated by the cross-midline skin incision. The temporalis muscle was

![Fig. 1. Intraoperative images of a left-sided RCDC. A: Preparation of the myocutaneous flap and shape of craniectomy. B: The dura is opened in a stellate fashion and folded back. C: Exposed brain is covered by the loosely replaced remaining dura. D: No watertight duraplasty is applied. The dura is not sutured. Exposed brain tissue and replaced dura are covered by Surgicel.](image-url)
dissected as a separate layer (Fig. 2C) and subsequently fixed at the bone flap after the bone flap was fixed with titanium plates and screws. Subpial injury due to the attachment of the brain to the scalp was not noted, and exposure of the brain surface (below the neo-dura) was not necessary. The surgical procedures were performed by residents in training, supervised by a consultant neurosurgeon.

All patients received a single intravenous dose of an antibiotic agent and a wound drain for craniectomy and cranioplasty. In selected patients a lumbar drain was inserted before cranioplasty.

### Statistical Analysis

Statistical analysis was performed using an unpaired t-test for parametric variables. Categorical variables were analyzed in contingency tables using the Fisher exact test. Results with p < 0.05 were considered significant. In a second step, a multivariate analysis was performed to find independent predictors for complications after craniectomy and cranioplasty (using a binary logistic regression analysis) and to find confounding effects between potentially independent predictors. Variables with significant p values in univariate analyses were considered as potentially independent variables in the multivariate analysis. A backward stepwise method was used to construct multivariate logistic regression models with the inclusion criterion of p < 0.05. All calculations were made with standard commercial software (SPSS Institute, Inc).

### Results

#### Patient Characteristics and RCDC Groups

Patient characteristics, including age, sex, and presence of tentorial herniation according to the primary admission diagnosis are shown in Table 1.

Craniectomy was performed 341 times in 318 patients. Stratified by underlying pathological condition, 137 (40.2%) procedures were performed due to TBI, 79 (23.2%) due to SAH, 23 (6.7%) due to ICH, 78 (22.9%) due to infarction, and 24 (7%) due to other primary diagnoses. Other diagnoses included swelling after intra- and extraaxial tumor extirpation (19 RCDC procedures) and space-occupying abscess (5 RCDC procedures). Depending on the site of the brain swelling or space-occupying lesion, hemicraniectomy was performed 299 times and bifrontal craniectomy 42 times.

Age differed between the RCDC groups, with age being highest in the Infarction Group and lowest in the TBI Group (mean ± SD, 51 ± 12 vs 41 ± 23 years, p < 0.0001). Overall clinical signs of tentorial herniation (mydriasis) were present in 158 patients (162 procedures). The mean time from the ictus to RCDC was 56 ± 26 hours. The mean surgical time for RCDC was 69 ± 20 minutes overall.

#### Cranioplasty

Cranioplasty was performed 196 times. The mean time to cranioplasty (measured from last RCDC procedure) was 97 ± 6 days. The mean surgical time for craniop-
Rapid closure in decompressive craniectomy

TABLE 2: Patient characteristics at the time of cranioplasty*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>RCDC Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TBI (74 pts)</td>
</tr>
<tr>
<td>mean time to CP in days</td>
<td>95 ± 14</td>
</tr>
<tr>
<td>VP shunt</td>
<td>15</td>
</tr>
<tr>
<td>lumbar drainage</td>
<td>1</td>
</tr>
</tbody>
</table>

* Values represent numbers of patients (%) unless otherwise indicated. Abbreviations: CP = cranioplasty; pts = patients.

plasty was 118 ± 40 minutes. At the time of cranioplasty, 52 patients (26.5%) had a VP shunt in place and 16 (8.2%) had lumbar drainage (Table 2).

Complications of RCDC

Complications after RCDC are shown in Table 3, stratified by group. Postcraniectomy complications requiring surgical intervention included superficial wound healing disturbance (12 cases [3.5%]), abscess (9 cases [2.6%]), CSF fistula (2 cases [0.6%]), EDH or SDH (7 cases [2.1%]), and hygroma (1 case [0.3%]). Impaired wound healing was defined as dehiscent wound margins. Abscess was diagnosed radiologically and verified microbiologically after surgical revision.

In patients who underwent RCDC due to cerebral infarction, the rates of wound healing disturbance and cerebral abscess were significantly higher compared with patients who underwent RCDC due to any other reason (wound healing: 7.7 vs 2.3%, p = 0.03, OR 3.6, 95% CI 1.1–11.4; cerebral abscess: 7.7 vs 1.1%, p = 0.005, OR 7.2, 95% CI 1.7–29.6).

Complication rates stratified by type of craniectomy (bifrontal craniectomy vs hemicraniectomy) are shown in Table 4. Comparing the complication rates according to the craniectomy modality, the only significant difference found was a higher rate of EDH or SDH in patients who underwent bifrontal craniectomy (7.1 vs 1.4%, p < 0.0001, OR 62, 95% CI 20.9–185.7).

Complications of Cranioplasty

Complications after cranioplasty included wound healing disturbance (12 [6.1%] of 196 cranioplasties), abscess (5 [2.6%]), CSF fistula (2 [1.0%]), EDH or SDH (8 [4.1%]), hygroma (3 [1.5%]) and other (bone flap dislocation after 1 cranioplasty [0.5%]) (Table 5). Hygroma developed after cranioplasty in 3 (5.8%) of 52 patients with VP shunts and 0 of 144 in patients without VP shunts (p = 0.01, OR 20.4, 95% CI 1–403).

In patients who underwent RCDC due to TBI, the rate of wound healing disturbance after cranioplasty was significantly higher than in patients undergoing RCDC because of any other primary diagnosis (10.8 vs 3.3%, p = 0.03, OR 3.5, 95% CI 1.7–7.2).

When the data were stratified according to RCDC modality, no significant differences in cranioplasty complication rates were found.

Multivariate Analyses

Using a backward stepwise method in a binary logistic regression model, the multivariate relationships were analyzed in patients with RCDC for the variables “complication after craniectomy” and “complication after cranioplasty.” Of the variables that influenced the complication rates after craniectomy and cranioplasty in the univariate analyses only the variable “VP shunt” for the cranioplasty group (p = 0.003, OR 3.3, 95% CI 1.5–7.2) remained significant in the multivariate regression model (Nagelkerke $R^2 = 0.30$). The complication associated with the presence of a VP shunt was EDH or SDH.

Discussion

Decompressive craniectomy is known to be effective in reducing refractory elevated ICP after TBI, cerebral infarction, and intracranial bleeding as well as after SAH. There is controversy concerning the necessity of a duraplasty after craniectomy. Neurosurgeons performing watertight duraplasty argue that without duraplasty the rates of CSF fistula and infections might be higher and bone flap reinsertion could be difficult. On the other hand, performing a watertight duraplasty significantly increases the time required for surgery.

TABLE 3: Complications after RCDC*

<table>
<thead>
<tr>
<th>Complication</th>
<th>RCDC Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TBI (137 ops)</td>
</tr>
<tr>
<td>wound healing disturbance</td>
<td>1</td>
</tr>
<tr>
<td>abscess</td>
<td>1</td>
</tr>
<tr>
<td>CSF fistula</td>
<td>1</td>
</tr>
<tr>
<td>EDH or SDH</td>
<td>2</td>
</tr>
<tr>
<td>hygroma</td>
<td>1</td>
</tr>
</tbody>
</table>

* Values represent numbers of procedures (%).
We performed the current analysis to evaluate feasibility and to provide data for complication rates after craniectomy without watertight duraplasty in the largest surgical series of decompressive craniectomies reported to date. To improve decision-making, special emphasis was placed on the clinical settings that led to the indication for DC. We stratified our patients according to the underlying pathological condition—that is, into the following 5 groups: TBI, SAH, ICH, Infarction, and Other.

An argument against duraplasty might be that the “enlargement” effect would be compromised by small dural grafts. Too small dural grafts might actually represent a clinical problem due to costs or surgical time. In RCDC these arguments are irrelevant and the enlargement effect is still not compromised.

Decompressive Craniectomy and RCDC

According to the prospective data from the DECI-MAL trial analyzing malignant MCA infarction, 1 (7%) of 15 patients in the hemicraniectomy group developed a cerebral abscess. The group of patients with large MCA infarcts seems to be at higher risk for infectious complications. The current abscess rates of 7.6% in patients undergoing RCDC due to infarction are comparable to the rate in the DECIMAL trial.

In a retrospective study by Malliti et al., deep wound infection rates using a synthetic dural substitute (61 patients) or pericranium (63 patients) were 15 versus 5% and CSF fistula rates were 13 versus 1.6%, favoring pericranium for duraplasty. Our overall abscess rate of 2.6% is significantly lower than that reported for the dural substitute group (p < 0.0004, OR 6.5, 95% CI 2.4–17) and lower than, although not significantly lower than, that reported for the pericranium group. Rapid closure decompressive craniectomy leads to lower rates of CSF fistula formation (0.6 vs 1.6% for pericranium and 13% for dural substitute, p < 0.0001, OR 22, 95% CI 4.6–107).

Aarabi et al. analyzed outcome of DC after TBI, reporting a deep wound infection rate of 6%. Expansive duraplasty was used in every case; the rate of wound healing disturbance was 2% and hygroma developed in 50% of the patients. Different definitions of the complications might at least partly explain their much higher incidence. Yang et al. analyzed 108 cases involving patients undergoing DC for TBI and found an overall complication rate of 50%, with half of the patients exhibiting more than 1 complication. The postcraniectomy complications included hygroma (21.3%), infection (3.7%), and CSF fistula (3.7%). Herniation through the craniectomy defect was described in 27.8% of the cases, in 6.5% probably caused by a small craniectomy, as stated by the authors. Instead of performing a watertight dura expansion after a small craniectomy, we prefer to perform a large decompressive craniectomy and wide opening of the dura in a stellate fashion. On the basis of our experience, shearing injury at the bone margins might be best preventable when the craniectomy size is large.

A series of patients undergoing large craniectomy without watertight duraplasty and without the replacement of the bone flap that might work as support against CSF leakage and its consequences is still missing. Data from the current study show that omitting a watertight dura expansion after DC for TBI and found an overall complication rate of 50%, with half of the patients exhibiting more than 1 complication. The postcraniectomy complications included hygroma (21.3%), infection (3.7%), and CSF fistula (3.7%). Herniation through the craniectomy defect was described in 27.8% of the cases, in 6.5% probably caused by a small craniectomy, as stated by the authors. Instead of performing a watertight dura expansion after a small craniectomy, we prefer to perform a large decompressive craniectomy and wide opening of the dura in a stellate fashion. On the basis of our experience, shearing injury at the bone margins might be best preventable when the craniectomy size is large.

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TABLE 4: Complications according to DC modality

<table>
<thead>
<tr>
<th>Complication</th>
<th>Hemicraniectomy</th>
<th>Bifrontal Craniectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean op time for DC in min</td>
<td>66 ± 20</td>
<td>73 ± 21</td>
</tr>
<tr>
<td>mean op time for CP in min</td>
<td>107 ± 33</td>
<td>170 ± 49</td>
</tr>
<tr>
<td>complications after craniectomy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wound healing disturbance</td>
<td>11/299 (3.7)</td>
<td>1/42 (2.4)</td>
</tr>
<tr>
<td>abscess</td>
<td>9/299 (3.0)</td>
<td>0/42</td>
</tr>
<tr>
<td>CSF fistula</td>
<td>2/299 (0.7)</td>
<td>0/42</td>
</tr>
<tr>
<td>EDH or SDH</td>
<td>4/299 (1.4)†</td>
<td>3/42 (7.1)†</td>
</tr>
<tr>
<td>hygroma</td>
<td>0/299</td>
<td>1/42 (2.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complication</th>
<th>Hemicraniectomy</th>
<th>Bifrontal Craniectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>complications after cranioplasty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wound healing disturbance</td>
<td>10/171 (5.8)</td>
<td>2/25 (8)</td>
</tr>
<tr>
<td>abscess</td>
<td>4/171 (2.3)</td>
<td>1/25 (4)</td>
</tr>
<tr>
<td>CSF fistula</td>
<td>2/171 (1.2)</td>
<td>0/25</td>
</tr>
<tr>
<td>EDH or SDH</td>
<td>7/171 (4.1)</td>
<td>1/25 (4)</td>
</tr>
<tr>
<td>hygroma</td>
<td>3/171 (1.8)</td>
<td>0/25</td>
</tr>
</tbody>
</table>

* Values represent numbers of procedures (%) unless otherwise indicated.
† p < 0.0001, OR 62, 95% CI 20.9–185.7.

We performed the current analysis to evaluate feasibility and to provide data for complication rates after craniectomy without watertight duraplasty in the largest surgical series of decompressive craniectomies reported to date. To improve decision-making, special emphasis was placed on the clinical settings that led to the indication for DC. We stratified our patients according to the underlying pathological condition—that is, into the following 5 groups: TBI, SAH, ICH, Infarction, and Other.

An argument against duraplasty might be that the “enlargement” effect would be compromised by small dural grafts. Too small dural grafts might actually represent a clinical problem due to costs or surgical time. In RCDC these arguments are irrelevant and the enlargement effect is still not compromised.

TABLE 5: Complications of cranioplasty according to DC groups

<table>
<thead>
<tr>
<th>Complication</th>
<th>TBI (74 pts)</th>
<th>SAH (42 pts)</th>
<th>ICH (13 pts)</th>
<th>Infarction (55 pts)</th>
<th>Other (12 pts)</th>
<th>All (196 pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>wound healing disturbance</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>12 (6.1)</td>
</tr>
<tr>
<td>abscess</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>5 (2.6)</td>
</tr>
<tr>
<td>CSF fistula</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>EDH or SDH</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>8 (4.1)</td>
</tr>
<tr>
<td>hygroma</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>other (bone flap dislocation)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (0.5)</td>
</tr>
</tbody>
</table>

* Values represent number of complications (%).
Rapid closure in decompressive craniectomy

can accumulate bleeding, but also by the severity of the injuries that led to bifrontal craniectomy instead of unilateral hemicraniectomy in these patients.

Duration of Surgery

Horaczek et al.9 analyzed the use of a dural substitute in decompressive hemicraniectomy. Surgery time was 96.2 ± 32.1 minutes using the dural substitute in an onlay technique compared with 122.8 ± 43.4 minutes when dural expansion and closure was applied. Surgery time for cranioplasty was 112 ± 49.1 versus 139.3 ± 56.8 minutes.

The mean duration of surgery in the 299 decompressive hemicraniectomy procedures in the current study was 66 ± 20 minutes, which was significantly shorter (p < 0.0001) than surgery time using an onlay substitute or using dural expansion with watertight dural closure. The mean duration of cranioplasty in patients who underwent hemicraniectomy in our study was 107 ± 33 minutes, which was slightly shorter than the time needed for an onlay substitute but markedly shorter (p = 0.003) than performing dural expansion with watertight closure.

In general, shortening the duration of surgical procedures enhances their safety,14 especially when treating critically ill patients, and might reduce blood loss and rates of infection. It saves resources—in addition to the artificial implant—which is under the current health care policy of economic interest, as pointed out by Horaczek et al.9

Cranioplasty

In a prospective multicenter study, Korinek et al.14 analyzed surgical site infections after craniotomies; deep wound infection (abscess and meningitis) developed in 2.5% of cases, wound healing was impaired in 1.5% (bone flap osteitis and wound infection), and a CSF fistula was present in 3.4%. Taking into account that decompressive craniectomies are performed as an emergency procedure in severely ill patients, the skin incision and the bone flap are larger than in regular craniotomies, the current abscess rate of 2.6% is comparable with the rate described by Korinek et al.;14 the impaired wound healing rate is higher but explainable with the craniectomy-specific characteristics.

The rate of wound healing disturbance after cranioplasty was significantly higher in patients undergoing RCDC due to TBI than in the group of all patients undergoing RCDC due to any other primary diagnosis (10.8 vs. 3.3%). This might be due to the fact that patients after TBI are commonly admitted with injuries of the skin or of pneumatised cavities leading to secondary infections or contamination of the bone flap.

The RCDC modality (bifrontal craniectomy vs hemicraniectomy) was not associated with any further difference in the frequency of complications following cranioplasty.

We found it helpful to extend the skin incision to slightly beyond the midline (cross-midline skin incision). This enabled us to cut with the scalpel from the skin directly to the bone for easy, safe, and fast incision and opening of the skin flap at the time of cranioplasty. If there is no bone below the scar, sometimes it may be more bothersome and time consuming to dissect the scar directly above brain tissue. This would be the case if the skin incision is smaller and the skin is retracted by hooks as advocated by some. The cross-midline skin incision technique without the need for skin retraction may also be one reason for our rather low rate of infection. In turn, the short operation time may also be a factor in the low rate of infection.

Limitations

In this study of consecutive patients the data accumulation was prospective, but the analysis was retrospective. Accordingly, the study suffers from deficiencies of a retrospective analysis. There was no control group, and the results were compared with historic controls from the literature. Despite being the largest consecutive series the results represent only a single-center experience.

Conclusions

We provide detailed data on surgical time and complications for decompressive craniectomies and subsequent cranioplasty in a large series. A particular description of the surgical steps of RCDC is given. The present data suggest that RCDC is feasible, safe, time and cost sparing, and is associated with a complication rate that is comparable to or even lower than when watertight duroplasty is performed. Rapid closure DC does not seem to complicate follow-up surgery and cranioplasty is also feasible, fast, and safe.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the manuscript preparation include the following. Conception and design: E Güresir. Acquisition of data: P Schuss, Á Oszvald. Critically revising the article: H Vatter, A Raabe, V Seifert. Reviewed final version of the manuscript and approved it for submission: V Seifert, J Beck. Statistical analysis: E Güresir, J Beck. Administrative/technical/material support: H Vatter.

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