The Kempe incision for decompressive craniectomy, craniotomy, and cranioplasty in traumatic brain injury and stroke

Isaac Josh Abecassis, MD,1 Christopher C. Young, MD, PhD,1 David J. Caldwell, PhD,1 Abdullah H. Feroze, MD,1 John R. Williams, MD,1 R. Michael Meyer, MD,1 Ryan T. Kellogg, MD,2 Robert H. Bonow, MD,1,3 and Randall M. Chesnut, MD1

1Department of Neurological Surgery and 3Harborview Injury Prevention Research Center, University of Washington, Seattle, Washington; and 2Department of Neurological Surgery, University of Virginia Health System, Charlottesville, Virginia

OBJECTIVE Decompressive craniectomy (DC) is an effective, lifesaving option for reducing intracranial pressure (ICP) in traumatic brain injury (TBI), stroke, and other pathologies with elevated ICP. Most DCs are performed via a standard trauma flap shaped like a reverse question mark (RQM), which requires sacrificing the occipital and posterior auricular arteries and can be complicated by wound dehiscence and infections. The Ludwig Kempe hemispherectomy incision (Kempe) entails a T-shaped incision, one limb from the midline behind the hairline to the inion and the other limb from the root of the zygoma to the coronal suture. The authors’ objective in this study was to define their implementation of the Kempe incision for DC and craniotomy, report clinical outcomes, and quantify the volume of bone removed compared with the RQM incision.

METHODS A retrospective review of a single-surgeon experience with DC in TBI and stroke was performed. Patient demographics, imaging, and outcomes were collected for all DCs from 2015 to 2020, and the incisions were categorized as either Kempe or RQM. Preoperative and postoperative CT scans were obtained and processed using a combination of automatic segmentation (in Python and SimpleITK) with manual cleanup and further subselection in ITK-SNAP. The volume of bone removed was quantified, and the primary outcome was percentage of hemicranium removed. Postoperative surgical wound infections, estimated blood loss (EBL), and length of surgery were compared between the two groups as secondary outcomes. Cranioplasty data were collected.

RESULTS One hundred thirty-six patients were included in the analysis; there were 57 patients in the craniotomy group (44 patients with RQM incisions and 13 with Kempe incisions) and 79 in the craniectomy group (41 patients with RQM incisions and 38 Kempe incisions). The mean follow-up for the entire cohort was 251 ± 368 days. There was a difference in the amount of decompression between approaches in multivariate modeling (39% ± 11% of the hemicranium was removed via the Kempe incision vs 34% ± 10% via the RQM incision, p = 0.047), although this did not achieve significance in multivariate modeling. Wound infection rates, EBL, and length of surgery were comparable between the two incision types. No wound infections in either cohort were due to wound dehiscence. Cranioplasty outcomes were comparable between the two incision types.

CONCLUSIONS The Kempe incision for craniectomy or craniotomy is a safe, feasible, and effective alternative to the RQM. The authors advocate the Kempe incision in cases in which contralateral operative pathology or subsequent craniofacial/skull base repair is anticipated.

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KEYWORDS Kempe; craniectomy incision; traumatic brain injury; surgical technique; decompressive craniectomy; trauma; vascular disorders
Decompressive craniectomy (DC) is an effective, lifesaving treatment option for reducing intracranial pressure (ICP) in traumatic brain injury (TBI), stroke, and other pathological states with intracranial hypertension.1,2 Inadequate size of bony decompression can have devastating clinical consequences.3–5 Evidence has suggested that large DCs, defined in one study as 12 × 15 cm,6 result in better ICP control.7,8 Most DCs are performed via a standard trauma flap, shaped like a reverse question mark (RQM). This approach, unfortunately, requires sacrificing the occipital and posterior auricular arteries and can be complicated by wound infections or dehiscence, particularly along the gravity-dependent posterior margin of the incision.9,10 To combat wound issues associated with the RQM incision, military neurosurgeons10 have suggested implementation of the Ludwig Kempe hemispherectomy incision (Kempe),11 which entails a T-shaped incision aimed at maximizing decompression and preserving vascular pedicles to the scalp. Although those authors reported anecdotal improvements in clinical outcomes, there are no formal studies evaluating outcomes with use of the Kempe incision in DC or craniotomy.

Methods

After obtaining institutional review board approval, we retrospectively reviewed a single-surgeon (R.M.C.) case log spanning from July 2015 (2 years prior to the introduction of the Kempe incision) through February 2020. We included all patients who underwent craniotomy or craniectomy for TBI or stroke (ischemic and hemorrhagic), excluding patients with an underlying abscess, tumor, vascular malformation, or aneurysm, via either a standard RQM or Kempe hemispherectomy (Kempe) incision. Patients were categorized into the following four groups: Kempe craniectomy, RQM craniectomy, Kempe craniotomy, and RQM craniotomy.

Exclusion criteria for this study were 1) previous craniotomy on the side of pathology, 2) initial surgery at another hospital, 3) focused craniotomy or craniectomy for targeted clot evacuation, 4) predominantly epidural hematoma pathology, 5) subacute or chronic subdural hematoma treated via a small “cookie craniotomy,” and 6) bifrontal and posterior fossa pathologies and decompressions. We collected information on patient demographics, injury type and detail, clinical examination findings and presentation, operative details, and disposition for all patients. The primary outcome was percentage of hemicranium removed (only for craniectomy patients). Secondary outcomes included estimated blood loss (EBL), operative times, and rates of surgical infections (including both superficial infections that only required antibiotics with a bedside “ oversew” and those that required operative intervention for washout/craniectomy). We analyzed craniectomy and craniotomy patients separately. For craniectomy patients, we subsequently analyzed those who underwent cranioplasty for both incision types (Kempe cranioplasty and RQM cranioplasty) to determine if there were any differences in length of stay (LOS), implant type, and surgical morbidity/mortality.

Kempe Incision

Figure 1 shows our technique for implementing the Kempe incision. We prefer to shave the entire scalp so that the anatomical landmarks are clear for incisional planning, given the time-sensitive nature of many of these surgeries. We outline the T-shaped incision at this point to aid in head fixation. We place the Mayfield pins very specifically to enable a midline incision that extends posteriorly to the external occipital protuberance (Fig. 1A–D). It is quite natural for those accustomed to the RQM incision to misplace a posterior pin on the ipsilateral occipital surface. This must be avoided, but the head must also be safely secured with the pins. We make the second incision with efforts dedicated to preserve the superficial temporal artery (STA). If the STA bifurcation is low, often both the anterior and posterior branches can be preserved. If the bifurcation is high, we prefer to sacrifice the posterior branch, as the posterior scalp has significant perfusion via the occipital and/or posterior auricular arteries. We elevate two separate myocutaneous flaps. To hold these flaps in place, we fabricated a custom Kempe Leyla bar with a semiflexible, hemicircular post to which rubber bands are affixed, but bilateral traditional Leyla bars also work well (Fig. 1E and F). Prior to craniotomy or craniectomy, we clearly identify the sagittal sinus to orient the surgeon to the location of the superior sagittal sinus in order to avoid injury (craniotomy planned at least 2 cm lateral to the suture/sinus), and the asterion as surrogate for the approximate location of the transverse sinus–sagittal sinus junction. We also analyze data from preoperative CTA when available. Due to variability in the location of the transverse sinus–sagittal sinus junction,12 we plan our craniotomy or craniectomy two fingerbreadths (approximately 4 cm) above the asterion to avoid sinus injuries and remove additional bone, if needed, tailored to decompression of the pathology. The goal for each craniectomy was to perform as large and safe a decompression as possible. Since its implementation, we have used the Kempe incision in craniectomy or craniotomy when there was concern for 1) significant posterior pathology, 2) a particularly severe TBI or stroke, 3) contralateral pathology that might ultimately require operative intervention and a separate incision, or 4) significant facial fractures that might require a bicoronal incision for access and repair with the craniofacial team. Patients were not randomized.

RQM Incision

The standard RQM incision begins 1 cm anterior to the tragus at the root of the zygoma, posterior to the origin of the STA, which can often be palpated. The incision courses over the top of the ear and extends posteriorly to circumvent the parietal boss, then curves anteriorly toward the midline where it continues to the widow’s peak. With careful dissection through the temporoparietal fascia, we can preserve the main trunk of the STA, although a high bifurcation usually requires sacrifice of the posterior branch. We incise the temporalis muscle, including its fascia, and elevate a single myocutaneous flap anteriorly until we adequately expose the McCarty keyhole and root of the zygoma. We retract the flap with sutures, rubber bands, and a Leyla bar. The general goal for each crani-
ectomy was to perform as large and safe a decompression as possible. After implementation of the Kempe incisions, the RQM was chosen in cases in which none of the four previously mentioned concerns were present, or in particularly elderly, frail patients or those with morbidities for whom we felt that less EBL and shorter operating room time might be especially helpful.

Quantification of Decompression

To quantify the volume of decompression, we performed segmentation on both pre- and postoperative head CT scans (Fig. 2). As outlined above, we performed this analysis for the subset of patients who ultimately underwent a craniectomy.

We used a combination of automatic segmentation using Python and SimpleITK13,14 with manual cleanup and further subselection in ITK-SNAP.15 We first performed automatic image segmentation to extract the pixels representing bone from clinical CT DICOM using scripts written in Python along the SimpleITK toolkit. Images included in the analysis ranged in slice thickness from approximately 1 mm to 5 mm, with in-plane spacings of 0.24 mm to 0.52 mm. The first step in segmentation was using a global threshold–based method on an isotropically resampled (to the smallest spacing in the image series) version of the DICOM series. Specifically, for the majority of patients, we used a threshold between 500 and 1800 Hounsfield units (HU) and only included pixels that fell within these values, as we found that this empirically allowed for separation of the bone from soft tissues and higher-intensity artifactual components. For a small number of patients (n = 8) in whom there were significant missing sections of cranial bone on one of the preoperative or postoperative scans, the upper limit for thresholding was increased to 2000 HU, and for others the lower limit decreased to 300 HU. After thresholding, we used a sphere-based morphological closing operation to smooth the thresholded image and fill holes in the segmentation. We selected the largest connected component, using the connected threshold filter from SimpleITK, in the resulting binary image, to minimize small artifacts during further manual processing. We then resampled the data files to the original CT spacing for further processing in ITK-SNAP. Using ITK-SNAP, we subsequently performed a cleanup step where we manually removed any remaining artifactual components of the images, such as tubes, drains, or implanted hardware. To create a reproducible standard for all of the subsequent volume calculations, we drew a plane from the inferior aspect of the mastoid process through the superior orbit and only selected voxels that were above this plane. The

![FIG. 1. Example of a Kempe incision for DC. A–D: The incision entails a line along the midline, starting anteriorly behind the hairline and extending posterior to the inion. This line is perpendicular to a line from the root of the zygoma up approximately to the coronal suture. Mayfield pin placement must strategically avoid compromising the planned incision but with adequate pin purchase so as to avoid head slippage; traditional RQM incisions often include a pin overlying the ipsilateral posterior occipital region (white asterisk). E and F: Exposure afforded via a Kempe incision. Note that two separate myocutaneous flaps are elevated (E, white asterisks) and held under tension to an in-house, custom-designed retractor arch (F, black arrow), but two separate Leyla bars affixed on either side may be substituted. Figure is available in color online only.](image)
objective was to have the plane pass through the mastoid process and superior orbit symmetrically, but this was always an approximation. We then removed any bone below the occipital condyles to minimize any contributions from vertebral bone and to further create a reproducible processing pipeline. After this step, we calculated the volume in cubic millimeters using ITK-SNAP and exported this for further statistical analyses. For a subset of patients (n = 5), in order to use CT scans with thinner slice thicknesses or scans with fewer artifacts, we used intermediate cranioplasty scans before a final craniectomy that included a bone flap. Here, we removed the bone in the cranioplasty region using ITK-SNAP and used this as the postoperative craniectomy volume. If a sufficient-quality preoperative scan was not available, we used the same cranioplasty scan before and after bone flap removal for the pre- and postoperative volume calculation.

**Statistical Analysis**

We assessed the differences in patient characteristics between the surgery groups for statistical significance using Fisher’s exact test for categorical variables and the Mann-Whitney U-test for continuous/ordinal variables (Tables 1 and 2). We used multivariate linear regression to assess the significance of the effect of the Kempe incision on the primary outcome of hemicranium reduction and the secondary outcomes of EBL and length of surgery. We used propensity weighting to attempt to minimize any preexisting imbalance in presentation factors resulting from the nonrandomized treatment group allocation, specifically, age, sex, comorbidities, pathology, mechanism of injury, Glasgow Coma Scale (GCS) score on presentation, and the modified Rankin Scale (mRS) score on presentation. We calculated the propensity weights using the TWANG boosted-regression software available at the rand.org website and were successful in achieving statistical balance (p > 0.05) across these factors. We then standardized the resulting weights (sample average set to 1) so as not to alter the effective sample size. Although we observed some imbalance in operative factors, including preoperative bone volume and cranioplasty, none of these factors were sufficiently related to outcome to merit adjustment in the regression models. We assessed wound infection using unweighted exact logistic regression with the

**FIG. 2.** Segmentation and processing of data. A: Initial segmentation steps. The DICOM series was initially processed using SimpleITK in Python. An HU thresholding system was used to select pixels (most patients had a lower limit of 500 HU and an upper limit of 1800 HU; different thresholds were used in 8 patients as described Methods), and the resulting image subsequently undergoes a morphological closing operation to remove small holes and improve the continuity of the segmentation. The largest connected component was subsequently selected to reduce small artifacts on the CT images. The series was then written out as a NIFTI file for further processing in ITK-SNAP. Shown are the segmentations overlaid with the DICOM scans. B: Following the initial segmentation in Python with SimpleITK, the DICOM series and segmentation were loaded into ITK-Snap. A plane was drawn from the inferior tip of the mastoid process, or bottom of the image, to the bone in the superior orbit. The pixels above this plane were subsequently kept, and further manual cleanup is performed to remove residual artifacts such as drains and implanted hardware. One further manual cleanup step was removing pixels representing sections of the vertebral column below the occipital condyles to aid in standardizing images. The subsequent segmentation volume was used to estimate a volume in cubic millimeters in ITK-SNAP, and this was exported for further statistical analysis. Figure is available in color online only.
model adjusting directly for any potentially confounding presentation factors (for which there was ultimately no statistical evidence). An independent statistician performed the statistical analyses.

**Results**

The analysis included a total of 136 patients: 57 in the craniotomy group (44 with RQM incisions and 13 with Kempe incisions) and 79 in the craniectomy group (41 with RQM incisions and 38 with Kempe incisions). Figure 3 shows the penetrance of the Kempe incision for both the craniotomy and craniectomy procedures (separated on the y-axis by surgical procedure) performed over time (x-axis) for a single surgeon (R.M.C.). The mean follow-up for the entire cohort was 251 ± 368 days. The groups (Kempe and RQM) were similar for both craniotomy and craniectomy, although patients undergoing DC via the Kempe incision presented with more severe neurological examination findings according to both the GCS and mRS scores (Table 1 and Supplementary Table 1). There were no cases of injury to the venous sinuses during craniotomy or craniectomy, and there was no surgery-related major morbidity or mortality.

The primary outcome, the percentage of hemicranium removed during craniectomy, is shown in the fourth row of Table 2, with the parameters used to calculate it listed above. The Kempe incision enabled additional decompression in comparison with the RQM incision (p = 0.047), although this difference did not achieve statistical significance after accounting for differences in cohort characteristics. While there was a higher EBL in the Kempe craniotomy group than in the RQM craniotomy group (p = 0.033; Supplementary Table 2), this was not significant in adjusted modeling (Table 3). Neither unadjusted nor adjusted statistical modeling detected a significant difference in the remaining secondary outcomes of interest when comparing Kempe incisions with RQM incisions for both craniotomy and craniectomy. We compared additional outcomes, including LOS, changes in mRS and GCS scores from admission to discharge, and discharge disposition between the groups. Patients in the Kempe craniectomy group had a shorter follow-up than those in the RQM craniectomy group, consistent with the more recent introduction of the former incision into practice (Fig. 3).

Of the combined wound infections seen in the RQM craniotomy and craniectomy groups (total of 4), 1 was due to a diffuse superficial cellulitis/erythema, 2 were due to...
fluid collections seen on imaging coupled with elevated inflammatory markers, and 1 was due to purulent drainage from the inferior aspect of the incision (without frank dehiscence). Of the combined Kempe incision wound infections from the craniotomy and craniectomy cohort (total of 3), 1 was due to a diffuse superficial cellulitis/erythema throughout the entirety of the incision, and 2 were due to purulent drainage (one from the vertical limb of the incision and the other from the T-junction). Neither of the latter 2 patients had wound dehiscence.

The average time to cranioplasty was 3–4 months regardless of incision type (Table 4), and most were autologous. The duration of surgery was comparable between incision groups, as was EBL. There were 2 infections, both in the RQM group: one due to a delayed brain abscess (primary injury was gunshot wound) and the other due to erythema near the drain site (superficial cellulitis).

Discussion

We present the first clinical series comparing the Kempe incision with the conventional RQM incision for both craniotomy and craniectomy operations. Dr. Ludwig G. Kempe (1915–2012) was a German-born neurosurgeon, who served as chief of neurosurgery at Walter Reed General Hospital from 1965 to 1972. He published extensively on a range of topics, including pituitary adenoma, meningioma, aneurysm, trauma, and neuroanatomy, among others, culminating in a textbook, *Operative Neurosurgery*, with exquisite detail and illustrations for approaching neurosurgical operations. In the chapter for the hemispherectomy procedure to treat epilepsy, Dr. Kempe described what we are calling the Kempe incision, although, interestingly, its original description involved an osteoplastic bone flap strategy whereby the temporalis muscle attachment to the bone flap is maintained without dividing any temporalis muscle fibers at the base (to preserve the neurovascular bundle and thus prevent atrophy) and the craniotomy completed via undercutting the squamous temporal bone (this concept of an osteoplastic craniotomy is reported for the RQM incision in trauma and other applications such as the pterional craniotomy).
mention is made of other applications for the incision. It is not clear from the literature how, when, or why the Kempe incision was implemented in TBI, but the next reference appears to be in 2010, when military neurosurgeons described using the Kempe incision in a cohort of 90 craniotomies (24 of which were frontotemparoparietal DCs) for “blood supply preservation, large craniectomies to prevent brain strangulation over bone edges, minimal brain debridement, adequate brainstem decompression, and dural only substitutes for dural closure.”30 They did not present details of how many patients specifically had the Kempe incision or clinical outcomes.

In this series, we implemented the Kempe incision for craniootomy or craniectomy at our institution under the senior surgeon (R.M.C.). The impetus for this transition included 1) a military trainee (R.M.M.) joining the residency with observations of utilizing the incision abroad, 2) publication of the early military experience with the Kempe incision, and 3) discussions with neurosurgeons from South America with anecdotally positive experience using the incision for DC. After a period of experimentation, the senior surgeon found that the incision was quick and safe and provided excellent access to both unilateral decompression and contralateral pathology or facial fractures when either condition manifested in a delayed fashion. Importantly, the Kempe incision enables exposure of the sagittal suture and asterion; thus, cranial defect size can be tailored to the patient and pathology with confidence in knowing where the cerebral venous sinuses exist. We quantified craniectomy sizes using a novel, semiautomated technique for the craniectomy cohort and found larger sizes of decompression in univariate analysis but just a trend in multivariate analysis. We suspect that with a larger cohort, this relationship would persist statistically. Although not specifically analyzed, we found no problems with frontal decompression with the Kempe incision. This similar window likely stems from the anterior (behind hairline) and inferior (anterior to tragus) starting points of the incision being identical to those used in the RQM incision.

Interestingly, of the 9 total wound infections seen in the study, none involved wound dehiscence at the posterior limb of the RQM incision, at the T-junction of the Kempe incision, or elsewhere. These findings do not suggest superiority of the Kempe incision to the RQM incision and merely offer evidence that it is a safe alternative that may be useful in select cases. Our findings challenge the preconceived notion adopted by many neurosurgeons that T-shaped incisions are not safe from a wound healing perspective. In fact, an inverted T-shaped incision is the most commonly used approach for plastic surgeons performing mastopexy,30 an elective and aesthetic procedure geared at generating strict patient satisfaction. Dehiscence is described as a possible complication in large series (>2000 patients) with a rate of approximately 3%,31 although this seems comparable to alternative incision types.32 T-shaped incisions are also used for certain abdominal contouring procedures, namely, the fleur-de-lis abdominoplasty, whereby horizontal and vertical incisions are made to correct excessive soft tissue in both planes.33 Our data, although limited in number, are congruent with the idea that T-shaped incisions are reasonable.

### Table 4. Cranioplasty cohorts for RQM and Kempe incisions

<table>
<thead>
<tr>
<th>Cranioplasty</th>
<th>p</th>
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<tbody>
<tr>
<td>RQM (n = 28)</td>
<td></td>
</tr>
<tr>
<td>Kempe (n = 15)</td>
<td></td>
</tr>
<tr>
<td>Mean time to cranioplasty, days</td>
<td>116.5 ± 81.4</td>
</tr>
<tr>
<td>Cranioplasty graft</td>
<td></td>
</tr>
<tr>
<td>PEEK</td>
<td>3 (10.7)</td>
</tr>
<tr>
<td>Autologous</td>
<td>25 (89.3)</td>
</tr>
<tr>
<td>Mean duration of surgery, mins</td>
<td>113.7 ± 45.2</td>
</tr>
<tr>
<td>Mean EBL, mL</td>
<td>117.9 ± 86.3</td>
</tr>
<tr>
<td>Mean LOS, days</td>
<td>5.6 ± 8.2</td>
</tr>
<tr>
<td>Wound infection</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>26 (92.9)</td>
</tr>
<tr>
<td>Oral antibiotics &amp;/or oversew of wound</td>
<td>1 (3.6)</td>
</tr>
<tr>
<td>Washout surgery in OR</td>
<td>1 (3.6)</td>
</tr>
<tr>
<td>Mean follow-up from cranioplasty, days</td>
<td>432 ± 501</td>
</tr>
</tbody>
</table>

OR = operating room.
Values represent the number of patients (%) or mean ± SD.
* Excludes 10 patients who underwent cranioplasty during their primary hospitalization.

Although we currently use the incision in a majority of our cases, it is worth noting a few circumstances in which the Kempe incision provides particular benefit to the neurosurgeon, at least anecdotally in our experience: 1) if there is concern for bilateral pathology (Fig. 4), or 2) if there are complex facial fractures that might require a subsequent bifrontal craniotomy for orbital bandeau reconstruction (we believe the Kempe preserves more vascular supply). Also, 3) if there is predominantly posterior pathology (e.g., posterior parietal or occipital contusions with mass effect), we have found that the Kempe incision enables a more targeted decompression.

There are other incisions proposed in the literature as alternatives to the RQM incision, stemming from frustration with wound infection issues presumed to be related to decreased scalp flap vascularity. Lyon et al.34 described a modified C-shaped incision that curves posterior to the ear and behind the hairline, and is quicker, as it obviates manipulation of the preauricular temporalsis muscle. However, they presented no perioperative metrics or follow-up. Additionally, there is some concern that access to the floor of the middle fossa is more difficult to obtain. Yang et al.35 described an n-shaped incision (which essentially combines a perional incision “T’ed” into the modified C-shaped incision) for DC in 15 patients and compared the findings with those of 23 patients undergoing a standard RQM incision. The authors found that the n-shaped incision removed a larger area of bone (389.1 vs 318.7 cm²), resulted in higher volumes of brain protruding through the cranial defect (151.8 vs 116.2 cm³), and had shorter time intervals.
between skin incision and bone flap removal (23.3 vs 29.5 minutes). Unfortunately, they did not provide follow-up data or rates of wound infection. Veldeman et al. retrospectively reviewed 186 patients treated with cranioplasty after three types of DC incisions: RQM (n = 87), C-shaped or “altered posterior question mark” (n = 79), and n-shaped (n = 20). The authors used the latter incision when they needed to convert a pterional incision into a DC. They did not provide details on why they chose the classic RQM or the C-shaped incisions. Interestingly, the authors noted that the Kempe incision was abandoned at their institution prior to initiating the study due to “frequent wound healing issues at the intersection of both linear incisions,” but no data are reported on specific rates. All patients had at least 12 months of follow-up after cranioplasty, and the primary outcome was surgical site infection after cranioplasty, which was lower in the C-shaped incision group compared with the RQM incision group (6.3% vs 18.4%). Multivariate analysis found that only incision type predicted surgical site infection. Importantly, the two incisions (C-shaped and RQM) had comparable infection rates after the initial DC, suggesting that there might be something uniquely different about the cranioplasty recovery process. While these authors did not contribute any data to understanding the Kempe incision and its role within craniotomy, craniectomy, or cranioplasty, this does provide additional data suggesting inferiority of the RQM incision, likely due to worse scalp perfusion.

Limitations
A number of factors limit the implications of this study. First, this is a retrospective study, subject to selection bias for which propensity weighting cannot fully account. We tend to favor the Kempe incision for particularly severe cases that we think require large decompression, rendering it possible that patient severity influenced decompression size (not strictly the incision). We included GCS score at presentation in our multivariate models to try to account for this. Additionally, while we thoroughly reviewed patients’ medical charts for a history of wound infections or wound issues, a more properly designed structure would aim to capture craniotomy and craniectomy patients prospectively with specific attention to wound healing and scalp perfusion. It would be particularly useful to understand in a larger cohort the precise location within the wound where breakdown occurs (our series had no wound dehiscence captured), coupled with data on perfusion of the scalp. Indeed, the plastic surgeon community has used infrared thermography to understand the local perfusion while planning and performing reconstructive tissue flap surgery. A second limitation is that, despite the Kempe incision being associated with larger cranial defects, it is
not clear how much decompression is needed. This likely varies from patient to patient and depends on a multitude of factors (e.g., extent of primary brain injury). In other words, we do not show in this study whether the enlargement in craniectomy size has any meaningful benefits, although we suspect that it does in cases of posterior pathology (e.g., posterior temporal lobe contusions) in particular. Third, while limiting our report to a single-surgeon experience does remove some variability that can be seen among a surgical cohort treated by multiple surgeons, this also limits the applicability of the results, indicating the need for a larger, multisurgeon series to achieve external validity. Even with a single surgeon, with a uniform protocol for both the RQM and Kempe incisions, there is inherent variability based on patient anatomy (e.g., variable head shapes and locations of hairline, inion, zygoma). Finally, it would be useful to document the viability of both branches of the STA in all cases of craniotomy or craniectomy, especially since the general opinion in the literature is that wound infections stem from worse perfusion of the scalp. Future studies might aim to document STA integrity routinely in the operative report, identify both branches pre- and postoperatively using ultrasound, and/or obtain post-operative CTA studies to document patency. Ideally, this would also be coupled with actual perfusion data of the scalp, since a patent STA does not necessarily predict adequate tissue perfusion, due to other factors from surgery (e.g., tissue retraction). The Kempe incision requires familiarity with all aspects of its execution (e.g., positioning, pinning, scalp retraction, closure, potential cranioplasty). Beginning implementation might prolong operating room time, or lead to higher EBL, which is not ideal for frail patients in whom the goal is to minimize both. Another limitation of the incision is that it requires shaving the head (at least in our experience) to clearly see all relevant anatomy and plan accordingly. We strongly believe that doing so is critical in a majority of trauma patients to best survey the scalp for abrasions, contusions, or lacerations, but the incision may not be best for patients with more benign trauma mechanisms with an interest in hair-sparing approaches.

Conclusions

The Kempe incision is a safe, reasonable alternative to the RQM incision for craniectomy or craniotomy in patients with TBI or stroke. It may permit a larger cranial decompression, although future studies are needed to indicate whether this relationship maintains statistical significance in larger cohorts. Wound infection is not increased in Kempe compared with RQM incisions, and cranioplasty is feasible, with outcomes that are comparable to the traditional RQM incision.

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References


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Author Contributions
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Correspondence
Randall M. Chesnut: University of Washington, Harborview Medical Center, Seattle, WA. respub2@uw.edu.