Egyptian Journal of Neurosurgery

RESEARCH

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Evaluating the retro-auricular incision versus reversed question mark incision and *Kempe's 'T-bar' incision* for decompressive hemicraniectomy

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Abstract

Background: The proper decompression for hemicraniectomy depends on intraoperative surgical technique, so the skin incision, on the other hand, is an important variable throughout hemicraniectomy, and there are a variety of cutaneous incisions, including the Kempe T shaped, the reversed question mark and the retro-auricular incisions. We aim to compare those three types of incisions and assess their effects on the surgical outcomes regarding the skull defect size, survived beyond 1 week, post-operative complications and mortality rates.

Results: A retrospective study included 180 patients were separated into three age- and sex-matched groups according to the type of incision used for their hemicraniectomy. Data including age, sex, causes of surgery, comorbidities, the incision type, the defect area of the skull, intraoperative time and estimated blood loss were recruited for all patients. The mortality and morbidity rates at 3 months post-surgery were documented for all patients. There was a significant difference in the operative time, and the intraoperative measures of blood loss, and insignificant differences in the surviving rate after 1-week post-surgery among the three group patients. There were significant differences between the first and third patient groups compared to the second group regarding wound complications, while the first and third groups were comparable.

Conclusions: The retro-auricular incision is a safe preferable substitute for the reversed question mark and Kempe T-shaped incisions in decompressive hemicraniectomy, due to the better blood flow maintaining, lower rate of post-operative wound complications.

Keywords: Decompressive craniectomy, Kempe "T," incision, Reversed question mark incision, Retro-auricular incision

Background

Hemicraniectomy is a surgical operation that includes removing a piece of the skull vault over a swollen brain to alleviate the excessive intracranial pressure (ICP) that has not responded to medication. Hemicraniectomy is most frequently used to treat traumatic brain injury (TBI) or middle cerebral artery (MCA) infarction, although it has also been utilized to treat aneurysmal subarachnoid hemorrhage and venous infarction [1, 2].

Surgery was regularly used to manage traumatic brain damage based on subjective criteria or the surgeon's prior experience [3]. If the neurological condition revealed the emergence of a prolonged increase in ICP, surgical removal should be considered. To assess the progression of intracerebral haemorrhage (ICH) and brain edema, imaging should be undertaken as soon as possible. In image studies, an increase in the ICH size indicates that it should be surgically removed. Decompression may

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increase intracranial space, preventing an increase in ICP and brain herniation [4]. The size of the bone flap removed is a significant factor in the outcome. The anterior–posterior (AP) diameter of the free bone flap should be at least 12 cm (preferably 15 cm), and the superior edge should be 1.5 cm distant from the midline [5, 6]. In order to achieve appropriate decompression for hemicraniectomy, the intraoperative surgical technique is critical, so kin incision, on the other hand, could play a crucial role in the entire hemicraniectomy [7].

The traditional reversed question mark (RQM) flap is the most frequently used technical skin incision technique. It is indicated in cases of pathologically increased ICP, brain tissue ischemia and brain herniation, most commonly in malignant MCA occlusion syndrome. The incision begins at the temporal level and continues upward to ensure enough blood supply to the flap through the superficial temporal artery (STA). In one plane, the temporalis muscle is dissected and attached to the flap. This method has the benefit that the vast majority of neurosurgeons are conversant with anatomical features; nevertheless, the blood supply in the posterior portion of the flap is limited, resulting in several problems, including dehiscent wounds or skin necrosis. Indeed, varied scalp extensions to the incisions outside edge accomplish the required decompression size [8].

Kempe's incision is another sort of craniotomy incision utilized to prevent harm to the blood vessels, whereas the three-leaf clover incision is used to dissect the temporalis muscle *en bloc* to enhance the cosmetic shape. It involves a T-shaped incision with one arm running from the midline beneath the hairline to the inion and the other from the zygoma's root to the sagittal suture [9, 10].

An alternative incision, termed the retro-auricular (RA) incision, has been offered as a method to maintain vascular supply. The scalp is a highly vascular organ fed mostly by external carotid artery branches. The RA incision has a higher probability of preserving these veins than the RQM incision, as many scalp arteries, including the posterior auricular artery (PAA), superficial temporal artery (STA) and branches of the occipital artery (OA), are in danger of damage during the RQM incision [11–13]. In cases of craniectomy with RQM incision, the incidence of wound dehiscence, infection, necrosis and re-surgery increases in severely sick patients with impaired nutrition, movement and wound healing [14–16].

As mentioned above although the proper decompression for hemicraniectomy depends on intraoperative surgical technique, skin incisions, on the other hand, are important variable throughout the surgery [7]; accordingly, our study aims to compare three types of incisions of hemicraniectomy RA, RQM and Kempe T-shaped incision and to assess the type of incision in terms of its effect on the surgical outcomes regarding the skull defect size for each incision, survived beyond 1 week, post-operative general and wound complications and mortality rates.

Methods

A retrospective study was authorized by the Institutional Review Board of Menoufia University's Faculty of Medicine. The study enrolled 180 patients who underwent hemicraniectomy (HC) at our institution between July 2017 and October 2021.

All cases that underwent unilateral DC with ages below 80 years with different causes of the malignant increase in the ICP, involving TBI, MCA infarction, multiple territory infarctions, intracerebral hemorrhage (ICH) with or without intraventricular hemorrhage (IVH) and cerebellar hemorrhage with or without IVH were included in the present study. Patients without post-operative imaging, those who have sustained gunshot wounds to the head, those who have undergone bilateral craniectomy and those who have undergone hemicraniectomy concurrently with other surgeries, cases with bilateral dilated non-reactive pupils at the time of examination and patients presented by lost brain stem reflexes at the time of examination were excluded from the study.

Patients were separated into three age- and sex-matched groups according to the type of incision used for their hemicraniectomy procedure: group 1 included 80 patients who went to RQM incision, group 2 included 50 patients who went to RA incision and group 3 included 50 patients who went to Kempe T-shaped craniectomy. The surgical technique of unilateral DC was done according to the general principles of large skin incision with wide craniotomy, dural opening and augmentation. The craniotomy flap was preserved in the abdominal subcutaneous tissue.

The type of incision was selected based on the preferences of the surgeon who performed the surgery and his experience, and since most neurosurgeons are accustomed to the anatomical structures of RQM incision, it is the commonly used incision in such cases [8], so the majority of cases in the present study underwent hemicraniectomy surgery via RQM incision.

Data including age, sex, causes of surgery, comorbidities, the incision type, the defect area of the skull, intra-operative time and estimated blood loss (EBL) were collected for all patients. All survivors received at least three months of follow-up. Patients who survived after one-week post-surgery were evaluated for complications, wound infection, mortality and morbidity rates. The Glasgow Coma Scale (GCS) was used to evaluate the patients in the post-operative and follow-up periods.

Surgical techniques

The reverse question mark scalp incision

Starting 1–2 cm anterior to the tragus at the root of the zygoma, curves are posteriorly above and gently behind the ear toward the asterion. After that, the incision softly curves around the parietal eminence to the midline and then onward to the hairline. The scalp is incised, and temporalis muscle with a myocutaneous flap of scalp is reflected anteriorly [8], as in Fig. 1.

Kempe T-shaped incision

Starting anteriorly from the hairline to the inion, the scalp was incised above the sagittal suture with a "T-bar" extension starting 1–2 cm anterior to the tragus at the temporal root of the zygoma and extended superiorly to meet the midline sagittal incision approximately 1 cm behind the coronal suture [9, 10], as in Fig. 2.

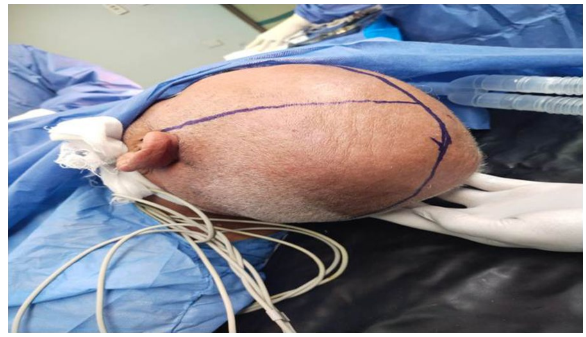

Fig. 2 Anteriorly from the hairline to the inion, the scalp was incised above the sagittal suture with a "T-bar" extension starting 1–2 cm anterior to the tragus at the temporal root of the zygoma and extended superiorly to meet the midline sagittal incision approximately 1 cm behind the coronal suture

The RA incision

It begins at the ipsilateral mastoid's tip, softly curved superior and medial, the incision curves posteriorly to the parietal eminence and eventually joins the midline and extending anteriorly till the hairline. This enables for simultaneous myofascial and scalp flap mobility while reducing the potential of injury to the STA, PAA and OA while still allowing for enough calvarial exposure [17], as in Fig. 3.

Statistical analysis

The data were tabulated and analyzed on an IBM-compatible computer using SPSS (Social Science Software Statistical Package) version 16. There were two sorts of statistics employed: descriptive statistics such as percentage (%), mean and standard deviation, and analytical statistics such as Student's t test, post hoc test (used to find significant differences between three or more groups) and ANOVA (F test used to assess group variance when the means are greater than the group observation variance). If the p-value is greater than 0.05, this means that it is not significant; if the p-value is equal to or less than 0.05, this means that it is significant [18].

Results

Between the three groups, there were no significant variations in sex, age, etiology, comorbidities. Trauma was the most often encountered etiology for patients receiving DHC, followed by inter-parenchymal hemorrhages (IPH) and infarction among all patient groups (Table 1).

A significant difference was detected of surface defect areas among patients of the three groups as it was 117 ± 15.2 cm^2 among RA incision group and 101 ± 18.6 among patients who went to RQM incisions, while it was 132 ± 14.9 in patients who went to Kempe T-shaped incision (Table 2).

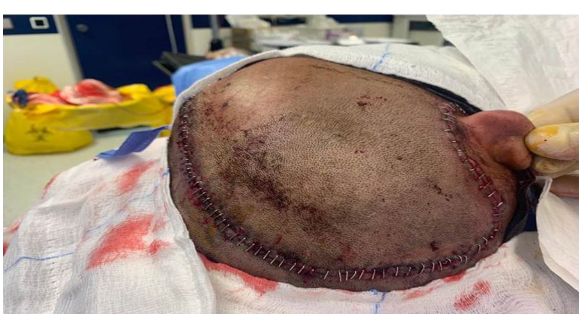

Fig. 1 RQM incision: starting 1–2 cm anterior to the tragus at the root of the zygoma, the large reverse question mark scalp incision curves posteriorly above and gently behind the ear toward the asterion. After that, the incision softly curves around the parietal eminence to the midline and then onward to the hairline

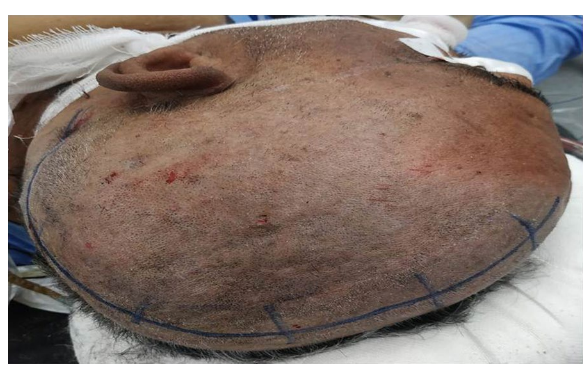

Fig. 3 The RA incision begins at the ipsilateral mastoid's tip, softly curved superior and medial, curves posterior to the parietal eminence, eventually joins the midline

Table 1 Demographic and clinical characteristics of patient groupings

Variable	RQM (*n* = 80)	RA (*n* = 50)	Kempe (*n* = 50)	*P* value
Age (M ± SD)	45 ± 10.5	42 ± 12.2	50 ± 8.3	0.73
Sex (males) *N* (%)	(40) 50%	(23) 46%	(26) 52%	0.98
Comorbidity: N (%)				
HTN	(42) 52.5%	(23) 46%	(21) 42%	0.62
DM	(16) 20%	(12) 24%	(13) 26%	0.81
Obesity	(12) 15%	(8) 16%	(11) 22%	0.13
Smoking	(10) 12.5%	(7) 14%	(5) 10%	0.27
Causes N (%)				
Infarction	(14) 17.5%	(8) 16%	(9) 18%	0.12
Trauma	(48) 60%	(28) 56%	(29) 58%	0.78
IPH	(16) 20%	(11) 22%	(10) 20%	0.65
SDE	(2) 2.5%	(3) 6%	(2) 4%	0.23

HTN: hypertension; DM: diabetes mellitus; IPH: intraparenchymal hemorrhage; SDH: subdural hematoma; SAH: subarachnoid hemorrhage; CVA: cerebrovascular accident. The values in bold are statistically significant

Table 2 Outcome variables among patient groupings

Variable	RQM (*n* = 80) (M ± SD)	RA (*n* = 50) (M ± SD)	Kempe (*n* = 50) (M ± SD)	Post hoc test *P* value
DHC defect area (cm^2)	101 ± 18.6	117 ± 15.2	132 ± 14.9	P1 = 0.03 P2 = 0.01 P3 = 0.05
Operative time (min)	122 ± 36.7	155 ± 43.8	190 ± 49.5	P1 = 0.9 P2 = 0.03 P3 = 0.01
EBL (mL)	274 ± 190	350 ± 330	410 ± 345	P1 = 0.04 P2 = 0.03 P3 = 0.02
Surviving > 1 week *N* (%)	(72) 90%	(46) 92%	(45) 90%	P1 = 0.1 P2 = 0.9 P3 = 0.3

DHC = Decompressive hemicraniectomy. EBL = Estimated blood loss

There were significant differences among patients of the 3 groups as regards the operative time, the intraoperative measures of EBL, as it was higher among patients' group who went to RA and Kempe incisions than those who went to RQM incision, and insignificant differences in the surviving rate after one-week post-surgery, as it was 90% among patients who went to RQM and Kempe incisions, while it was 92% among patients who went to RA incision (Table 2).

There were insignificant differences between the three groups of patients regarding general complications. There was a substantial difference between the first and third patient groups compared to the second group regarding wound complications, and mortality rates throughout the 3-month period of follow-up, while the first and third groups were comparable (Table 3).

About 8 patients in the first (RQM) group developed wound complications as 6 developed wound dehiscence post-surgery, 2 developed subdural empyema, and only 4 of them needed re-surgery due to the complications, this was comparable with patients of the third group who went to Kempe incision as 7 patients developed wound complications, 5 of them developed wound dehiscence post-surgery and 2 developed subdural empyema and only 2 of them needed re-surgery; however, among the 2^{nd} (RA) group, there was only one patient who developed wound dehiscence post-surgery, and no patients needed re-surgery (Table 3).

Discussion

Although that proper decompression for hemicraniectomy depends on intraoperative surgical technique, skin incision, on the other hand, is an important factor that plays a critical role in the surgical outcomes [8], as different skin incisions vary regarding the defect size in the skull, the extension of the exposed area, the time of operations, the estimation of blood loss and, respectively, wound and post-operative complications and mortality rates [7].

This study is one of the first that aims to assess the type of incision for hemicraniectomy in terms of its effect on the surgical outcomes through its relation to multiple

Table 3 Mortality rates and post-operative complications among patients groups

Variable	RQM (*n* = 80)	RA (*n* = 50)	Kempe (*n* = 50)	*P* value
All complications *N* (%)	(32)40%	(19)38%	(20)40%	P1 = 0.5 P2 = 0.9 P3 = 0.1
Wound complications *N* (%)	(8)10%	(2)4%	(4)8%	P1 = 0.02 P2 = 0.8 P3 = 0.02
Mortality rate *N* (%)	(8)10%	(2)4%	(5)10%	P1 = 0.01 P2 = 0.45 P3 = 0.01
Complications				
Wound dehiscence	(6)7.5%)	(1)2%	(5)10%	P1 = 0.001 P2 = 0.24 P3 = 0.01
Subdural empyema	(2)2.5%	(0)0%	(2)4%	P1 = 0.01 P2 = 0.43 P3 = 0.01
Cases went to re-surgery post-complications	(4)5%	(0)0%	(2)4%	P1 = 0.001 P2 = 0.45 P3 = 0.67

variables as the defect size in the skull, the extension of the exposed area, the time of operations, the estimation of blood loss, wound and post-operative complications, and the present study was included a large sample of patients compared to other studies.

Hemicraniectomy surgery can be accomplished through a variety of cutaneous incisions, including the Kempe "T," the enlarged RQM and the RA [19].

While an enlarged RQM incision improves bone exposure, it often leads to thrombosis of the posterior auricular and occipital arteries, preserving the STA and its branches (anterior and parietal) essential for skin angiogenesis and wound healing. Additionally, due to the compression caused by the patient's head in the supine position, healing issues in the posterior (occipital) portion of the incision may occur [20].

Although the T incision technique, which consists of two straight incisions, may damage the parietal branch, it retains the anterior branch of the STA, as well as the posterior auricular and occipital arteries, resulting in greater flap vascularization. It also eliminates the possibility of wound compression causing healing issues. The temporalis muscle can be raised with the skin flap in a single layer or separately [19].

The RA incision is a different incision that maximizes calvarium exposure to maximize hemicranium excision while reducing wound-related problems. The incision of the RA starts from the gently curved superior mastoid tip, medial tip and posterior arches of the parietal leader and finally joins the midline. This mechanism facilitates simultaneous fascia and scalp movement while minimizing the risk of PAA, STA and OA injury while providing adequate calvarial exposure. The keyhole and temporal root of the zygoma can be seen, giving access to the floor of the middle cranial fossa [17].

The present study compares the 3 types of hemicraniectomy incisions among 180 patients regarding the skull defect size for each incision, surviving rate after one-week post-surgery, post-operative general and wound complications and mortality rates. Our results reveal a significant difference in the surface defect areas the intra-operative time, and EBL among patients of the three groups as it was higher among patients' group who went to RA and Kempe incisions than those who went to RQM incision. There were insignificant differences regarding the survival rate after one-week post-surgery. That comes in agreement with the study performed by Dowlati et al. [17], as they reported the increased operative time for the RA incision compared to the operative time of RQM incision with significant differences among both groups regarding the EBL ($P=0.025$).

Mouchtouris et al. [21] discovered that patients who underwent RA incision had a considerably greater hemicraniectomy defect surface area than those with RQM incision, with significantly longer operative time and estimated blood loss (EBL).

In another way, Abecassis et al. [16] reported in their study non-significant differences in surface defect areas among patients who went to RQM (34 ± 10) versus those who went to Kempe incision (39 ± 11). Also, they demonstrated that across the two-incision designs, the duration of surgery and EBL were comparable.

Our results documented significant differences among the three groups of patients regarding wound complications and mortality rates throughout the 3-month period of follow-up, as these measures were comparable among patients who went to RQM and Kempe incision, while we showed a lower rate of wound complications and mortality rates among patients' group who went to RA incision.

Among patients of the first RQM group, about 6 patients developed wound dehiscence post-surgery and 2 developed subdural empyema, and only 4 of them needed re-surgery after cranioplasty due to the complications; however, in the 2nd RA group patients, only one patient developed wound dehiscence post-cranioplasty, and no patients needed re-surgery; finally, among patients who went to Kempe incision 5 patients developed wound dehiscence post-surgery and 2 developed subdural empyema and only 2 of them needed re-surgery.

Similar results were documented by studies performed by Dowlati [17] and Mouchtouris [21] as they reported significant differences among both groups (went to RA and RQM incision) regarding wound complications. Moreover, they reported that of the eight patients in the RQM who developed wound complications, seven of the eight patients in the RQM group who suffered wound problems had an associated underlying infection, compared to one patient in the RA group who developed superficial wound dehiscence without an associated underlying infection, despite the fact that two other patients experienced epidural or subdural empyema without dehiscence of the accompanying incision. As a result, the proportion of patients with wound dehiscence differed significantly between the RQM and RA groups (11.1% vs. 2.3%; $P=0.463$).

In another way, Abecassis et al. [16] reported in their study that there was no evidence of wound infections among both groups of patients who went to RQM and Kempe incision and that the surgical outcomes regarding wound dehiscence were comparable between the two types of the incision.

Another study performed by Ragel et al. [22] demonstrated a higher rate of RQM incision wound failure in patients with complex scalp injuries or patients requiring large craniotomies when compared to Kempe incision wound failure when the scalp arterial blood supply source is preserved.

Safari et al. [23] concluded the notable distinctions between Kempe and RQM incisions in terms of blood flow maintenance, as Kempe incision is recommended for keeping a better blood supply to the scalp, resulting in improved follicular density and cosmetic effects.

Finally, we could conclude that according to vascular compromise of the flap in RQM incision is associated with a high risk of post-operative wound dehiscence and subsequent infection due to poor circulation, and despite the advantage of the Kempe incision regarding maintaining cerebral blood flow and lower incidence of post-operative complications compared to RQM incision [22–25], the RA incision is considered the best when compared to RQM and Kempe incisions' regarding the maintaining of the blood flow, lower rate of post-operative complications and the need for re-surgery.

Conclusions

Since skin incision plays a critical role in the hemicraniectomy procedure, as it affects the surgical outcomes through its influence on multiple variables, we can conclude that the RA incision is a safe substitute for the RQM and Kempe T-shaped incisions as regards to maintaining the blood flow, lower rate of post-operative wound complications and the need for re-surgery, and also, it is a more obvious incision used during revision surgery and/or post-cranioplasty.

Abbreviations

RQM: Reversed question mark; HC: Hemicraniectomy; RA: Retro-auricular; AP: Antero-posterior; ICP: Intracranial pressure; ICH: Inter-cerebral hemorrhage; TBI: Traumatic brain injury; PAA: Posterior auricular artery; STA: Superficial temporal artery; OA: Occipital artery; MCA: Middle cerebral artery; DHC: Decompressive hemicraniectomy; IVH: Intraventricular hemorrhage; EBL: Estimated blood loss; GOS: Glasgow Outcome Scale.

Acknowledgements

Not applicable.

Author contributions

SD and EM designed the study. SD, EM and AA acquired the study data. SD and AA contributed to the materials or analysis tools. SD wrote the manuscript. All authors read and approved the final manuscript.

Funding

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

The research protocol was approved by ethical committee in faculty of medicine Menoufia University in its monthly session dated July 24, 2017. An informed written consent was obtained from each patient.

Consent for publication

The manuscript not includes details, images or videos relating to individual participants.

Competing interests

The authors declare that they have no competing interests.

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Received: 12 January 2022 Accepted: 17 April 2022
Published online: 23 May 2022

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