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RESEARCH

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Surgical management of chronic subdural hematomas through single-burr hole craniostomy: is it sufficient?

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Abstract

Background: Symptomatic chronic subdural hematomas (CSDH) remain one of the most encountered forms of intracranial hemorrhages particularly in the elder patients, yet fortunately implies a good surgical prognosis. Burr hole evacuation under general anesthesia is the most commonly used neurosurgical technique for the management of CSDH. Clinical disagreement between many studies regarding the number of burr holes required to achieve the optimal surgical and clinical outcome has long existed. The objective of this study is to evaluate the prognosis and clinical outcome following the use of single-burr hole craniostomy technique in the aim of surgical evacuation of CSDH.

Results: This is a retrospective study of 30 patients, with symptomatic unilateral or bilateral CSDH managed by the authors strictly by single-burr hole evacuation with closed-system drainage on the corresponding site of the hematoma. Clinical outcome was then assessed at 1, 7, and 30 days after surgery using the Glasgow Coma Scale (GCS) and by comparing the Markwalder grade scale before surgery to 1 month following surgery; the pre- and post-operative radiological data, clinical neurological progress and the possible incidence of complications postoperatively were also recorded. Study duration was from August 2019 to October 2020. Our study included 18 (60%) male patients and 12 (40%) female patients. The main presenting symptom was altered level of consciousness noted in 29 (96.7%) patients; a history of a relevant head trauma was recorded in 11 patients (36.7%). The GCS showed a statistically highly significant improvement comparing the preoperative to the postoperative values throughout the follow-up intervals ($p = 0.001$); similarly, the Markwalder score significantly improved 1 month after surgery, where 17 (63%) patients were Markwalder grade 0, 9(33.3%) patients were grade 1, a single patient (3.7%) was grade 2, and none were Markwalder grade 3.

Conclusion: Our study concluded that single-burr hole craniostomy with closed-system drainage for the management of symptomatic CSDH would be a sufficient approach to achieve a good surgical outcome with a low complication rate. Larger series and further studies would be yet considered with longer follow-up periods.

Keywords: Chronic subdural hematoma, Burr hole craniostomy

Background

Chronic subdural hematoma (CSDH) remains one of the most common types of traumatic intracranial hematomas, taking place often in the elderly [5, 22] with an incidence of 8.2/100,000/year after the age of 70 years [1].

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It is described as a dark adjusted liquefied blood located between the dura mater and the arachnoid layer of the brain that appears as a crescentic subdural collection on the computed tomography (CT) scan images mostly hypodense (and occasionally of mixed densities including iso- or hyperdense in the presence of a subacute or an acute element, respectively) and essentially hyperintense in magnetic resonance imaging (MRI) [10, 17].

Surgical treatment has been widely approved as the most effective way to manage symptomatic CSDH, yet the optimal method has not been definitely established [10–12, 16].

Burr hole craniostomy (BHC), twist-drill craniostomy (TDC), and craniotomy have been the most commonly used surgical techniques for years. All these three techniques have approximately the same mortality rate (2%–4%), however, both craniotomy and TDC account for a significantly higher morbidity rate and a higher recurrence rate, respectively [22], suggesting that BHC is the preferred technique taking into consideration the simplicity of procedure, its efficacy and its operative risks, while craniotomy is more considered for symptomatic recurrences [24].

Generally, CSDH in adults is evacuated and flushed via a single- or two-burr hole craniostomy frequently followed by closed-system drainage [22]. However, definite indication considering number of burr holes is not yet agreed upon and it mostly relies upon neurosurgeon's preference.

This study aimed at the evaluation of the prognosis and clinical outcome following the use of single-BHC technique with closed-system drainage in the aim of surgical evacuation of CSDH.

Methods

This is a retrospective study on 30 patients with symptomatic unilateral or bilateral chronic subdural hematoma conducted in the period between August 2019 and October 2020. Patients enrolled in this study were followed up for at least 1 month after surgery.

Patients' inclusion criteria comprised patients with symptomatic unilateral or bilateral CSDH, with the radiological results confirming the diagnosis including CT scan of the brain and/or MRI, failed conservative management for candidate patients, and patients with unilocular CSDH.

On the other hand, the exclusion criteria involved patients with acute subdural hematomas, asymptomatic patients, patients who were candidates for conservative management trial with a hematoma thickness less than one centimeter in its maximum width on CT scan/MRI, patients with multilocular hematomas, and patients who were favored to undergo craniotomy surgery.

Patients' preoperative evaluation included the assessment of their demographics (age, sex), relevant past medical and surgical history including that of a relevant head trauma and other co-morbidities (including hypertension, diabetes mellitus, chronic alcoholism, and blood thinners), full history was obtained and recorded, general and neurological examination were also performed.

Preoperative clinical evaluation and assessment by both the GCS and the Markwalder grading scale [13], the latter classified the CSDH patients' neurological status on the basis of a grading scheme into 5 grades as follows:

Grade (G) 0: No neurological deficits.
G 1: Alert and oriented, mild symptoms (headache, absent or mild neurological deficits).
G 2: Disoriented with variable neurological deficits, hemiparesis.
G 3: Stuporous but maintaining a response to noxious stimuli, severe focal signs, hemiplegia.
G 4: Absent motor response, decerebrate or decorticate posturing.

Preoperative radiological evaluation involved non-contrasted CT scan and/or MRI of the brain and evaluating site and extension of the hematoma, the laterality, the degree of midline shift, and the density/intensity of the hematoma.

As for the timing of surgery, the patients are considered for surgical intervention whenever they manifest the clinical symptoms that require immediate surgery (for example motor weakness, deteriorated level of consciousness, symptoms and signs of increased intracranial tension), in this case, the surgical intervention should not be delayed regardless the age of the hematoma and subsequently the approach should be chosen (whether burr hole evacuation or craniotomy) according to the presence of an acute blood element in the subdural space, or presence of septations that makes it impossible to ensure complete evacuation through burr hole surgery and hence craniotomy is a must. On the other hand, completely liquefied symptomatic unilocular CSDH can be evacuated through burr hole craniostomy, subsequently, avoiding operating on an emergency basis in patients with minimal symptoms that could await while closely monitoring the patient is also into consideration to ensure complete liquefaction of the hematoma and promote the use of burr hole craniostomy.

An informed consent was obtained from all patients or by their first-degree relatives prior to surgery. A single burr hole on the corresponding site of the hematoma (unilateral or bilateral) was planned under general anesthesia in all patients.

A subcutaneous and subperiosteal local anesthesia infiltration was applied at the incision site using 10 milliliters (ml) lidocaine hydrochloride 2%.

A scalp incision between 3 and 4 cm down to the periosteum was done, followed by periosteal cutting using the diathermy knife allowing skull bone exposure. A single burr hole around 2 cm diameter using the Hudson brace and the Kerrison rongeur was then performed followed by dural cauterization using the bipolar cautery forceps. The burr hole should be placed at the site of the maximum thickness of the hematoma.

Cross-shaped durotomy using no. 11 knife was carried out before cauterizing the dural flap leaflets against the burr hole bony edges creating a circular dural defect, the outer vascular fibrous membrane of the hematoma has to be coagulated as well then opened to be able to evacuate the hematoma fluid, then, a generous non traumatizing irrigation of the subdural space by body temperature saline was performed allowing slow and steady drainage of the hematoma till the fluid comes out quite clear.

All patients had a closed-system drainage (EG vac, size 12, made in Egypt) applied where the sterile silicon catheter drain was placed outside the burr hole then exteriorized from the skin through a separate skin incision approximately one inch away, hemostasis of the scalp edges was then ensured followed by closure of the wound.

Patients were then transferred to the ward where they were requested to maintain a flat position for one day, while the drainage bag was kept below the level of the head with no negative pressure applied. Gradual head elevation followed prior to patient ambulation by the end of the second postoperative day and the drainage system was removed between the second and the third postoperative day according to the drainage volume and the radiological findings.

The postoperative evaluation included the assessment of the patients' neurological outcome through evaluation of the postoperative GCS for all patients at 1, 7 and 30 days postoperatively and in comparison to preoperative scores, the evaluation of their neurological condition progress, and the incidence of any postoperative neurological deterioration through the detection of an alteration in mental status or the worsening of the pre-existing symptoms or neurological deficit.

Finally, the assessment of the patients' Markwalder grading score was recorded one month postoperatively.

Patients were assessed by CT scan on the first postoperative day to ensure adequate evacuation of the CSDH (by detecting any residual hematoma and evaluating its maximal thickness in axial cuts and the number of CT cuts in which it appears), monitor the presence of any acute element, and assess the presence of subdural air to detect any possible upcoming postoperative hazard even while the neurological status of the patient is stable, then subsequent scans were done at 1 week to assess the postoperative brain re-expansion, the reduction of the subdural air, and to ensure the absence of any recollection or acute element in comparison to the CT scan on the first postoperative day; finally, complete absorption of the residual fluid on the CT scan was assessed one month after surgery. An immediate CT scan of the brain was performed upon any alteration of mental status or deterioration of patients' neurological condition noted throughout their follow-up course.

Data analysis was performed using the Statistical Package for Social Sciences, version 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Shapiro–Wilk test was used to evaluate normal distribution of numerical data. Numerical data were presented as mean and SD values. Categorical data were presented as numbers and percentages. Student's t test was used to assess the statistical significance of the difference between two study group mean. Categorical variables were compared using the Fisher's exact test. Paired t-test, Wilcoxon signed rank and McNemar tests were used to assess the statistical significance of the difference between paired numerical, ordinal and categorical data, respectively. P value less than 0.05 was considered statistically significant.

Results

All the patients' preoperative data were studied and analyzed. There were 18 (60%) males and 12 (40%) female patients. Their age ranged from 43 to 88 years, with a mean age of 67.37 (±13.46 SD) years.

The commonest recorded medical risk factor was hypertension which was noted in 19 cases (63.3%), followed by diabetes mellitus noted in 12 patients (40%); a history of a relevant head trauma was recorded in 11 patients (36.7%). Table 1 describes the demographic data and risk factors of the studied patients.

Table 2 describes that the main presenting symptom was an altered level of consciousness which was recorded in 29 (96.7%) patients that ranged from a slight state of confusion to a deeper state of coma (GCS 6), next headache was noted in 20 (66.7%) patients, followed by motor weakness in 16 (53.7%) patients. Convulsions and speech disturbance were recorded in 11 (36.7%) and in 6 (20%) patients, respectively.

The CSDH was unilateral in 16 (53.3%) patients and bilateral in 14 (46.7%). A midline shift was recorded in 22 patients, with 11 (36.7%) patients having a midline shift between 10 and 15 mm (mm). Table 3 describes the radiological criteria of the studied cases. This recorded preoperative "midline shift" showed complete resolution on the last follow-up CT scan one month after surgery in all patients.

By evaluating the study results, there was a statistically highly significant improvement regarding the GCS of the studied cases on comparing the preoperative to the postoperative values throughout the follow-up intervals ($p = 0.001$), taking into consideration a statistically significant value on comparing the improvement

Table 1 Demographic data and risk factors of the studied patients

	Number of patients	Percentage (%)
Sex		
Male	18	60.0
Female	12	40.0
Hypertension		
No	11	36.7
Yes	19	63.3
Diabetes Mellitus		
No	18	60.0
Yes	12	40.0
Cardiac		
No	20	66.7
Yes	10	33.3
Alcohol		
No	27	90.0
Yes	3	10.0
Blood thinners		
No	19	63.3
Yes	11	36.7
Smoker		
No	19	63.3
Yes	11	36.7
Trauma		
No	19	63.3
Yes	11	36.7

SD, standard deviation

Table 2 Preoperative presenting symptoms of the studied patients

	Number of patients	Percentage (%)
Altered level of consciousness		
No	1	3.3
Yes	29	96.7
Headache		
No	10	33.3
Yes	20	66.7
Convulsion		
No	19	63.3
Yes	11	36.7
Speech disturbance		
No	24	80.0
Yes	6	20.0
Motor weakness		
None	14	46.7
G1	2	6.7
G2	4	13.3
G3	5	16.7
G4	5	16.7

SD, standard deviation

Table 3 Preoperative CSDH laterality and degree of midline shift

	Number of patients	Percentage (%)
CSDH site		
Unilateral	16	53.3
Bilateral	14	46.7
Midline shift in mm		
None	8	26.7
< 5 mm	1	3.3
< 10 mm	6	20.0
10–15 mm	11	36.7
> 15 mm	4	13.3

SD, standard deviation

on the first postoperative day to the preoperative values ($p=0.024$) (Table 4).

Upon presentation, 25 (83.3%) cases were Markwalder grade 2 (45.8%) and 5 (16.7%) cases were Markwalder grade 3. Compared to the preoperative data, the Markwalder score significantly improved one month after surgery, there was a statistically highly significant improvement on comparing the preoperative values to those one month postoperatively ($p=0.001$); where 17 (63%) patients were Markwalder grade 0, 9 (33.3%) patients were grade 1, a single patient (3.7%) was grade 2, and none were Markwalder grade 3 (Table 5).

Studied cases presented with motor weakness preoperatively showed a statistically highly significant improvement on comparing the preoperative values or those recorded 1 day after surgery to those 1 month after surgery; also, a statistically significant improvement was noted on comparing the results at 1 week after surgery to 1 month postoperatively; however, the comparison between the preoperative values to 1 day or 1 week after surgery was statistically non-significant, and also on comparing the postoperative results at one day to those at 1 week (Table 6).

Six cases (20%) were presented with preoperative speech disturbance, an improvement was noted according to the data recorded 1 week after surgery, with the persistence of the symptom in a single case 1 month after surgery; however, though there was a considerable clinical improvement regarding speech function of the involved cases, yet the comparison between the preoperative values to those recorded 1 day, 1 week, and 1 month after surgery was statistically insignificant; the same on comparing the values on the first postoperative day to

Table 4 Comparison between GCS values preoperatively and throughout the postoperative follow-up period

	Mean	±SD	P*
GCS Pre	11.27	2.258	0.024
GCS 1 day Post	12.00	2.449	
GCS Pre	11.41	2.147	0.001
GCS 1 week Post	13.59	2.797	
GCS Pre	11.52	1.889	0.0001
GCS 1 month Post	14.81	0.396	
GCS 1 day Post	12.17	2.300	0.0001
GCS 1 week Post	13.59	2.797	
GCS 1 day Post	12.56	1.847	0.0001
GCS 1 month Post	14.81	0.396	
GCS 1 week Post	14.30	0.869	0.001
GCS 1 month Post	14.81	0.396	

Pre, preoperatively; Post, postoperatively; SD, standard deviation

* Paired t test

Table 5 Evaluation of Markwalder score preoperatively and 1 month postoperatively

	Group				p
	Pre		Post		
	N	Percentage (%)	N	Percentage (%)	
Markwalder grading scale					
0	0	0.0	17	63.0	0.001
1	0	0.0	9	33.3	
2	25	83.3	1	3.7	
3	5	16.7	0	0.0	

Pre, preoperatively; Post, postoperatively; N, number of patients

* Wilcoxon signed ranks test

1 week or 1 month after surgery, and on comparing the values recorded at 1 week to those 1 month after surgery (Table 7).

Hospitalization ranged from 4 days up to 14 days with a mean value of 6.59 (±2.46 SD).

Our study had an overall of three (10%) mortality cases, the first case was complicated by unilateral acute subdural hematoma diagnosed on the second postoperative day by sudden deterioration of the consciousness level (GCS 5/15) after initial postoperative recovery, urgent craniotomy and evacuation of the hematoma was performed yet the patient did not recover postoperatively and progressive deterioration took place following re-operation, then the patient deceased 2 weeks after surgery; the second case deceased on the 10th postoperative day following severe chest infection that failed to respond to medical treatment; finally a case deceased on the 5th postoperative day by massive acute non-haemorrhagic brain infarction. A single case (3.7%) of recurrence of the CSDH was recorded 3 weeks following surgery at the same site of the previously evacuated hematoma, this patient had progressive contralateral weakness after initial postoperative improvement, CT scan of the brain showed a recurrent subdural hematoma including an acute subdural element, and a re-do surgery through a craniotomy flap was successfully performed where a bleeding subdural vessel was encountered and controlled. The patient showed a satisfactory postoperative clinical outcome with progressive improvement of his preoperative motor deficit over the following 4 weeks.

A single patient had a postoperative superficial wound infection that was successfully cured in 1 week using oral antibiotics and frequent wound dressings.

Patients who presented preoperatively with motor weakness showed no statistically significant difference regarding the final study outcome compared to those who had no motor power affection before surgery as shown in

Table 6 Evaluation of motor power preoperatively and throughout the postoperative follow-up period

	Pre[a,b,c]		1 day post[d,e]		1 week post[f]		1 month post	
	N	Percentage (%)	N	Percentage (%)	N	Percentage (%)	N	Percentage (%)
Motor weakness[g]								
None	14	46.7	15	50.0	21	70.0	24	80.0
Grade 1	2	6.7	2	6.7	1	3.3	1	3.3
Grade 2	4	13.3	1	3.3	0	0.0	0	0.0
Grade 3	5	16.7	4	13.3	2	6.7	0	0.0
Grade 4	5	16.7	8	26.7	6	20.0	2	6.7

Pre, preoperatively; Post, postoperatively; *N*, number of patients

[a,b,c] Pre vs. 1 day $p=0.21$; pre vs. 1 week $p=0.11$; pre vs. 1 month $p=0.004$, respectively

[d,e] 1 day vs. 1 week $p=0.104$; 1 day vs. 1 month $p=0.002$, respectively

[f] 1 week vs. 1 month $p=0.028$

[g] Wilcoxon signed ranks test

Table 7 Evaluation of speech disturbance preoperatively and throughout the postoperative follow-up period

	Pre[a,b,c]		1 day post[d,e]		1 week post[f]		1 month post	
	N	Percentage (%)	*N*	Percentage (%)	*N*	Percentage (%)	*N*	Percentage (%)
Speech disturbance[g]								
No	24	80.0	24	80.0	28	93.3	26	96.3
Yes	6	20.0	6	20.0	2	6.7	1	3.7

Pre, preoperatively; Post, postoperatively; *N*, number of patients

[a,b,c] Pre vs. 1 day $p = 1.0$, pre vs. 1 week $p = 0.12$., pre vs. 1 month $p = 0.06$, respectively

[d,e] 1 day vs. 1 week $p = 0.125$, 1 day vs. 1 month $p = 0.06$, respectively

[f] 1 week vs. 1 month $p = 1.0$

[g] McNemar test

Table 8 Cases with and without preoperative motor weakness compared regarding final study outcomes

	Motor weakness Pre				*P*
	No		Yes		
	Mean	± SD	Mean	± SD	
Days of hospitalization	7.64	2.76	6.60	1.68	0.31*
GCS 1 month Post	14.73	0.47	14.88	0.34	0.35*

Pre, preoperatively; Post, postoperatively; SD, standard deviation; GCS, Glasgow Coma Scale

* Student's t test

** Fisher exact test

Tables 8, 9. This is in accordance with the same results considering patients presented with preoperative speech disturbance or epileptic fits in comparison to those who were not as shown in Tables 10, 11 and Tables 12, 13, respectively.

Discussion

CSDH is encountered more in elderly patients, commonly preceded by a recent history of head trauma, possibly trivial and unnoticed, usually between 3 to 4 weeks prior to presentation.

It seems the annual incidence of CSDH has been rising steadily over the past years. Lind and colleagues [12] reported an annual incidence of CSDH of 4.6 per 100,000 in 2003, in contrast to Cousseau and colleagues [3] who reported an annual incidence of 3.1 per 100,000 in 2001. This could be attributed to the rise in the older population with the medical technology development [19].

Various types of managements for CSDH are used including both conservative and surgical treatment; while conservative management is usually considered for completely asymptomatic cases, those with a small hematoma or moribund patients with significant co-morbidities, yet the literatures support the agreement that the surgical management is ideal for symptomatic CSDH [20, 26]. Surgical approaches include burr hole craniostomy with

Table 9 Cases with and without preoperative motor weakness compared regarding final study outcomes

	Motor weakness Pre				*P*
	Number	Percentage (%)	Number	Percentage (%)	
Speech 1 month					
No	10	90.9	16	100.0	0.4**
Yes	1	9.1	0	0.0	
Motor weakness 1 month Post					
Negative	11	100.0	13	81.3	0.24**
Positive	0	0.0	3	18.8	
Markwalder grading scale Post					
0	6	54.5	11	68.8	0.53**
1	5	45.5	4	25.0	
2	0	0.0	1	6.3	
Mortality					
No	11	78.6	16	100.0	0.09**
Yes	3	21.4	0	0.0	

Pre, preoperatively; Post, postoperatively; SD, standard deviation

* Student's t test

** Fisher exact test

Table 10 Cases with and without preoperative speech disturbance compared regarding final study outcomes

	Speech disturbance Pre				*P*
	No		Yes		
	Mean	± SD	Mean	± SD	
Days of hospitalization	6.78	2.66	5.83	1.33	0.409*
GCS 1 month Post	14.81	0.40	14.83	0.41	0.90*

Pre, preoperatively; Post, postoperatively; SD, standard deviation; GCS, Glasgow Coma Scale

* Student's t test

** Fisher exact test

Table 11 Cases with and without preoperative speech disturbance compared regarding final study outcomes

	Speech disturbance Pre				*P*
	No		Yes		
	Number	Percentage (%)	Number	Percentage (%)	
Speech 1 month Post					
No	21	100.0	5	83.3	0.22**
Yes	0	0.0	1	16.7	
Motor weakness 1 month Post					
None	18	85.7	6	100.0	1.0**
G1	1	4.8	0	0.0	
G4	2	9.5	0	0.0	
Markwalder grading scale Post					
0	14	66.7	3	50.0	0.71**
1	6	28.6	3	50.0	
2	1	4.8	0	0.0	
Mortality					
No	21	87.5	6	100.0	1.0**
Yes	3	12.5	0	0.0	

Pre, preoperatively; Post, postoperatively; SD, standard deviation; G, grade

* Student's t test

** Fisher exact test

Table 12 Cases with and without preoperative convulsions compared regarding final study outcomes

	Fits Pre				*P*
	No		Yes		
	Mean	±SD	Mean	±SD	
Days of hospitalization	6.78	2.67	6.27	2.15	0.60*
GCS 1 month Post	14.88	0.33	14.70	0.48	0.30*

Pre, preoperatively; Post, postoperatively; SD, standard deviation; GCS, Glasgow Coma Scale

* Student's t test

** Fisher exact test

Table 13 Cases with and without preoperative convulsions compared regarding final study outcomes

	Fits Pre				*P*
	No		Yes		
	Number	Percentage (%)	Number	Percentage (%)	
Speech 1 month Post					
No	16	94.1	10	100.0	1.0**
Yes	1	5.9	0	0.0	
Motor weakness 1 month Post					
None	16	94.1	8	80.0	0.12**
G1	1	5.9	0	0.0	
G4	0	0.0	2	20.0	
Markwalder grading scale Post					
0	12	70.6	5	50.0	0.395**
1	4	23.5	5	50.0	
2	1	5.9	0	0.0	
Mortality					
No	17	89.5	10	90.9	1.0**
Yes	2	10.5	1	9.1	

Pre, preoperatively; Post, postoperatively; SD, standard deviation; G, grade

* Student's t test

** Fisher exact test

or without drainage, twist-drill craniostomy with or without drainage, and craniotomy [6, 9, 21]. However, the ideal surgical technique remains controversial.

Considering the fact that most of the CSDH patients are among the fragile geriatric group, it is preferred to choose both the suitable and at the same time the least invasive technique for surgical intervention aiming at minimizing the surgical manipulations to reduce the incidence of complications, enhance recovery and reduce recurrence rate.

Recently, burr hole craniostomy has been supported in literature as the gold standard for surgical treatment of CSDH, a simple technique having an equivalent outcome as compared to craniotomy, but with significantly lower mortality and morbidity and a shorter hospitalization period [20].

Our study was conducted on 30 patients with symptomatic unilateral or bilateral chronic unilocular subdural hematoma as confirmed on preoperative CT scan and/or MRI to whom evacuation through single-burr hole craniostomy and closed-system drainage was performed and assessed.

The mean age of our study cases was 67.37 years. Several studies attributes this to the common pathological changes occurring around this age group [25]; there was a male predominance as of 60% males and 40% female patients. Some studies suggested that the frequently encountered male predominance could be due to the more vulnerability to trauma [5, 15].

On evaluating the clinical outcome in our study, the GCS of the studied cases has shown a statistically highly significant improvement throughout the follow-up intervals ($p = 0.001$) in comparison to the preoperative values, and a statistically significant value on comparing the preoperative values to those on the first postoperative day ($p = 0.024$). Similarly, 25 (83.3%) the Markwalder score values significantly improved 1 month after surgery, there was a statistically highly significant improvement regarding the Markwalder score on comparing the preoperative values to those 1 month postoperatively ($p = 0.001$).

Mersha and colleagues [14] stated that 95.9% of their study patients had good recovery, GCS 4 or GCS 5, by the end of their follow-up period, and there were 2% deaths. This was similar to another Dakurah and colleagues [4] study done in Accra, Ghana, where 93.8% had good recovery with a mortality rate of 2.0%.

Also, our study recorded a statistically highly significant improvement on comparing the preoperative motor power of our study cases presented with limb weakness to those recorded 1 month after surgery ($p = 0.004$).

While our results denoted no statistically significant difference regarding the final study outcome on comparing patients presented with motor weakness to those who had no motor power affection before surgery, Mersha and colleagues [14] described a statistically significant association between presence of preoperative extremity weakness and postoperative outcome with *P*-value of 0.042; they also reported a shorter mean hospital stay of 3.68 ± 2.6 days in comparison to our study result of 6.59 ± 2.46 days.

We found also that over 36.7% of the participants had a midline shift between 10 and 15 mm on the preoperative CT scan/MRI, while 13.3% had a midline shift above 15 mm. There was an association between midline shift more than 15 mm and preoperative motor weakness ($p = 0.04$), however, no statistical significance was noted between other presentations and the midline shift.

The mean operative time in our study was 41.7 min (ranging from 33 to 75 min), which is another advantage for the used approach. This surgical time was close to that recorded by Salama [18] (35 min), and Guzel and colleagues [7] (36.4 min).

Our study reported a single case (3.7%) of CSDH recurrence that was successfully managed through a re-do surgery; the overall mortality ratio was 10% including a case that was deceased on the tenth postoperative day following severe chest infection, and another case who had a massive acute non-haemorrhagic brain infarction after initial good recovery following surgery.

Belkhair and Pickett [2] suggested that using a single-burr hole craniostomy technique is as good as using two burr holes in evacuating CSDH, and the former was not associated with a higher recurrence rate compared to the latter.

Similarly, Han and colleagues [8] noted a higher recurrence rate in patients managed by two-burr hole craniostomy surgery in comparison to a single-burr hole craniostomy (6.82% and 1.89%, respectively); however, the number of burr holes as a risk factor of CSDH recurrence was not statistically significantly associated with postoperative recurrence rate ($p > 0.05$).

However, Taussky and colleagues [23] reported that single burr hole drainage was associated with a statistically significant higher rate of recurrence, a longer mean hospitalization period, and a higher rate of wound infection.

A theoretical explanation for higher recurrence rate of one-burr craniostomy suggested that the residual hematoma fluid contains large concentrations of fibrinolytic factors, inflammatory mediators, and vasoactive cytokines, and the complete evacuation of the CSDH, theoretically more achieved through the flush out of the subdural collection via two burr holes seems to be directly related to the success of surgical procedure [20].

Yamamoto and colleagues [26] demonstrated that drainage and irrigation through one burr hole is usually adequate to evacuate the hematoma even in multiple cavities concluding that multiplicity in CSDH mostly does not imply multiple closed cavities and that these cavities were in fact continuous with relatively wide routes of connections.

A single-burr hole craniostomy is hence less invasive method with a shorter operative time in contrast to a two-burr hole craniostomy surgery; however, it is often less efficient in cases of septated or acute (thick) subdural hematoma disallowing adequate evacuation.

Conclusion

Our study suggested that single-burr hole craniostomy with closed-system drainage for the management of symptomatic CSDH would be an effective and sufficient approach to achieve a favorable clinical and surgical outcome with a low recurrence or complication rate. Larger series and further randomized controlled trials with long-term evaluation would be necessary to demonstrate the impact of these findings.

Abbreviations

CSDH: Chronic subdural hematomas; GCS: Glasgow Coma Scale; CT: Computed tomography; MRI: Magnetic resonance imaging; BHC: Burr hole craniostomy; TDC: Twist drill craniostomy; G: Grade; ml: Milliliters; ANOVA: Analysis of variance; SPSS: Statistical Package for the Social Sciences; SD: Standard deviation; mm: Millimeters; *N*: Number of patients; Pre: Preoperatively; Post: Postoperatively.

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Authors' contributions

OE main author and corresponding author. AE: co-author. SE co-author. The study design, execution and follow-up of the clinical cases, data analysis and results formulation, and writing of the manuscript, were all the joint work of all the authors. All authors have approved the manuscript for submission. The manuscript has not been published, or submitted for publication elsewhere. All authors read and approved the final manuscript.

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Availability of data and materials
All the raw data and results of the statistical analysis are available with the authors and ready to be shared with authorized personnel upon request, however, for reasons of patency protection it was not submitted with the manuscript.

Declarations

Ethics approval and consent to participate
This research was conducted upon obtaining the approval of the ethical committee of the Faculty of Medicine, Ain Shams University, in June 2019. Reference number: Not available. Since this study involved human subjects, an informed written consent was signed and acquired from all the participants or their legal guardians in accordance with the ethical committee recommendations.

Consent for publication
Not applicable. This work was entirely carried out by the authors without any external contributions.

Competing interests
The authors declare that they have no competing interests.

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