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Evaluating the optimal number of burr-holes for treating chronic subdural haematomas: good results from a single burr-hole?

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ABSTRACT

Introduction. Chronic subdural haematomas (cSDH) are one of the most common types of traumatic intracranial lesion. Burr-hole craniostomy followed by closed-system drainage has become the treatment of choice. However, there is no definitive indication as to the number of burr-holes needed. Our aim was to to assess clinical and radiological outcomes taking into account the number of burr-holes made.

Material and methods. A retrospective single-centre-study was performed including patients treated for cSDH by performing burr-hole craniostomy from 2012 to 2018. After collecting data regarding demographics, comorbidities, and clinical and radiological records, haematomas were grouped depending on the number of burr-holes made (Group 1: single burr-hole; Group 2: double burr-holes). Clinical and radiological outcomes were statistically compared between groups, as well as the main complications.

Results. After collecting 171 patients, 205 cSDHs were analysed. 173 were treated with a single burr-hole (we called these Group 1) and 32 with double burr-holes (Group 2). No differences in preoperative characteristics were found between the groups, except for diabetes mellitus and previous antiplatelet/anticoagulation treatment. No radiological differences were found regarding haematoma volume ($p = 0.7$) or thickness ($p = 0.3$). Surgical site infection ($p = 0.13$), recurrence ($p = 0.6$), acute rebleeding ($p = 0.25$) and mortality ($p = 0.94$) were assessed without evidencing statistically significant differences. At the time of hospital discharge, most patients showed a remarkable clinical improvement, regardless of the number of burr-holes made ($p = 0.7$).

Conclusions. This study suggests that cSDH can be efficiently evacuated by a single burr-hole craniostomy, a less invasive and shorter surgical procedure with quite good clinical outcomes and a low rate of complications.

Key words: chronic subdural haematoma, burr-hole, craniostomy, traumatic brain injury

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Introduction

Chronic subdural haematoma (cSDH) is one of the most common types of traumatic intracranial injury. There is a variable incidence of 5.3–13.5 patients per 100,000 people per year, and it most commonly occurs in the elderly [1]. Major risk factors for developing cSDH include brain atrophy, alcohol abuse, dehydration, and coagulopathies including anticoagulation and antiplatelet therapies [2, 3]. The pathophysiology of cSDH is thought to be due to an initial acute haematoma which forms fragile neomembranes secondary to an inflammatory response; microhaemorrhages into these membranes cause expansion and extend this pathology over time [4, 5].

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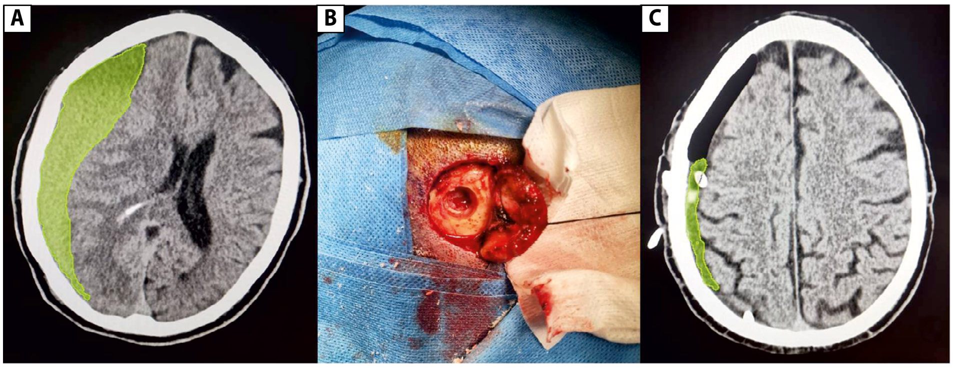

Figure 1. One burr-hole craniostomy procedure: intraoperative image (**B**) and volumetric assessment through presurgical (**A**) and postsurgical CT (**C**)

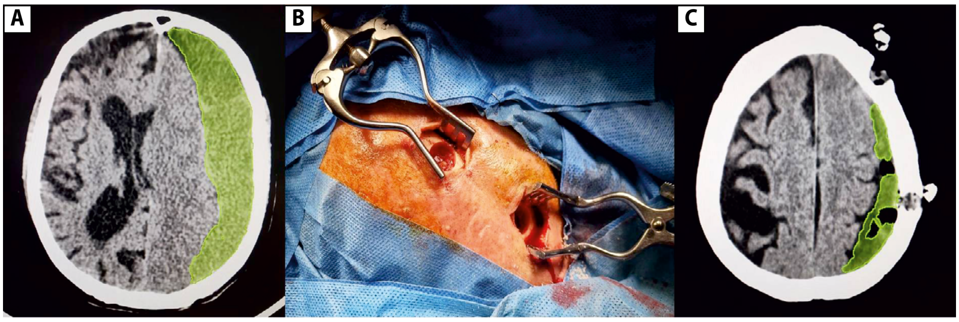

Figure 2. Two burr-hole craniostomy procedure: intraoperative image (**A**) and volumetric assessment through presurgical (**B**) and postsurgical CT (**C**)

Surgical treatment has long been accepted as the most effective way to manage cSDH, although it is known that small ones can reabsorb without intervention, especially in asymptomatic or paucisymptomatic patients [6]. Even though there is general agreement on a surgical indication, the optimal surgical method has yet to be obtained [7–11].

Techniques such as craniotomy, burr-hole craniostomy, or twist-drill craniostomy have been used for several years in the treatment of cSDH [12, 13]. Burr-hole craniostomy, frequently followed by closed-system drainage, has become the procedure of choice due to the efficacy, few risks and simplicity of the technique [14–17]. However, the postoperative recurrence rate of this procedure ranges from 8.3% to 26.5%. There is no definitive indication as to the number of burr-holes needed to obtain the best surgical results, and the number used depends on the individual neurosurgeon's preference [18–22].

We aimed to study retrospectively the association between the number of burr-holes and patient outcomes by analysing results in a series of 171 patients treated in our centre over six years.

Clinical rationale for the study

The aim of this study was to analyse the association between the number of burr-holes and the clinical outcome of patients. We also wanted to discuss the main complications related to surgical site infections, recurrences and acute rebleedings that require reintervention.

Material and methods

A retrospective single-centre study was performed from 2012 to 2018 in a third level University Hospital after collecting data from all patients diagnosed with cSDH and analysing those treated by a burr-hole craniostomy. Ethical approval was not necessary for the preparation of this article.

Patients had been clinically assessed by the respective neurosurgeon on call, and a definitive diagnosis of cSDH had been made by cranial computed tomography (CT). Anticoagulant or antiplatelet therapies had been then withdrawn and anticoagulation states had been medically reversed.

Performing burr-hole craniostomy was the agreed method for the treatment of cSDH in our centre. Surgery was performed under local anaesthesia with conscious sedation. The skin incision was marked in the calculated haematoma greatest thickness area (or one in a frontal location and another in a parietal location in cases of a double burr-hole). A 14 mm perforator drill was used to make either one or two burr-holes according to the surgeon's choice (depending on experience, beliefs or skills) (Figs. 1 and 2). Subdural haematomas were evacuated by performing warm saline irrigation through the burr-holes until the irrigation return became clear. At the

Table 1. Markwalder Grading System

Markwalder Grading System (MGS)	
Grade 0	Neurologically normal
Grade I	Alert and orientated, mild symptoms such as headache, or mild neurological deficits such as reflex asymmetry
Grade II	Drowsy or disoriented or variable neurological deficit such as hemiparesis
Grade III	Stuporous but responding appropriately to noxious stimuli and several focal signs such as hemiplegia
Grade IV	Comatose with absent motor responses to painful stimuli, decerebrate or decorticate posturing

end of the procedure, closed-system subdural drainage was placed in every case.

Postoperatively, all patients were kept lying flat in bed for 24 hours and a brain CT was performed before removing subdural drainages at that time. Our steroid policy included for all patients an intravenous regimen of dexamethasone 4 mg every eight hours, maintained on the first postoperative day and gradually reduced until complete withdrawal (4 mg/12 h per 3 to 5 days, then 2 mg/12 h over the same period, then 2 mg/12 h per 3 to 5 days, and finally 1 mg/24 h per 3 to 5 days); in most cases, withdrawal was performed once the patient had returned home. In none of our patients was tranexamic acid (TXA) applied in a protocolised manner.

We deemed patients diagnosed with cSDH and treated using this technique to be our population of interest and they were included in our study. Patients treated through craniotomy or twist-drill craniostomy or cases without postoperative subdural drainage were excluded. Cases with postoperative diagnosis of an epidural collection or an infection were also excluded. Recurrences of cSDH that required a new operation less than six months after the first one were considered as a complication of the initial procedure (inadequate drainage) and were not included as a new haematoma in our series. It is important to note that bilateral chronic subdural haematomas were included as two separate haemorrhages.

Demographic data, previous medication, patient comorbidities, preoperative symptoms, clinical evolution after treatment and length of hospital stay were extracted from medical records and patients were neurologically classified preoperatively and postoperatively according to the Markwalder Grading System (MGS) (Tab. 1) [23] and the Glasgow Coma Scale (GCS). We also evaluated postoperative functional status one month after discharge according to the Glasgow Outcome Scale Extended (GOS-E).

As we mentioned previously, brain CT was performed preoperatively and 24 hours after surgical procedure in all cases, assessing laterality and thickness of the haematoma, midline deviation and the presence of membranes. Presurgical and postsurgical cSDH volumes were measured with a StealthStation™ S8 Surgical Navigation (Medtronic™, Minneapolis, MN, USA) (Figs. 1 and 2).

Patients were grouped depending on the number of burr-holes made (i.e. one or two) and then the clinical and radiological variables previously described were studied in both groups. Statistical analysis was assessed by Student t-test and chi-square test using SPSS software (version 20.0; SPSS Inc.) and the level of significance determined for the study was $p \leq 0.05$.

Results

Preoperative characteristics

In the study period, 171 patients with cSDH were operated on by performing the burr-hole craniostomy technique described above. Thirty-four of them had a bilateral cSDH, bringing the total of haematomas included in the analysis to 205; 173 of them were treated through a single burr-hole (Group 1) and 32 through a double burr-hole (Group 2).

The mean age was 79 years with a prevalence of males over females (2:1); no significant differences were found between groups. The main comorbidities studied (hypertension, diabetes mellitus, atrial fibrillation, stroke, dementia and ischaemic heart disease) were also similar in both groups, except for diabetes mellitus which was significantly more prevalent in Group 2 (12.7% *vs.* 28%, p = 0.02). Interestingly, in the group of patients treated with a single burr-hole (Group 1), we found a greater prevalence of antiplatelet/anticoagulation therapies (47.4% *vs.* 25%, p = 0.018) (Tab. 2).

There were no differences in clinical presentation (Tab. 2), resulting in motor impairment being the most frequent symptom in both groups (38% in Group 1 *vs.* 53% in Group 2, p = 0.11), followed by cognitive impairment (p = 0.6), gait disturbance (p = 0.2), headache (p = 0.09), language impairment (p = 0.07), and consciousness disturbance (p = 0.2). In order to evaluate patients according to the presurgical Markwalder Grading System (MGS), we grouped the five MGS grades (0–4) into three groups: mild (MGS 0–1), moderate (MGS 2), and severe (MGS 3–4). An initial mild MGS was found in 19% of patients in Group 1 and 9% of patients in Group 2; a moderate MGS was assessed in 67% of Group 1 and 75% of Group 2; and severe MGS was assessed in 14% of Group 1 and 16% of Group 2. No statistically significant differences were found (p = 0.42) (Tab. 2).

Regarding preoperative radiological findings, we did not find any differences in haematoma thickness (1.8 cm in Group 1 *vs.* 2 cm in Group 2), laterality (a left side prevalence in both groups), midline deviation (6.6 mm *vs.* 10.2 mm) or the presence of membranes (76% *vs.* 88%) when comparing both groups (Tab. 2).

Table 2. Preoperative characteristics

	One burr-hole	Two burr-holes	P-value
Mean age [years]	79	80	0.5
Male gender	114 (66%)	22 (69%)	0.75
Comorbidities			
Hypertension	58%	65.6%	0.44
Atrial fibrillation	17.3%	6.25%	0.11
Diabetes mellitus	12.7%	28%	0.02
Ischaemic heart disease	11%	6.3%	0.42
Dementia	10.4%	3%	0.19
Stroke	5.8%	3%	0.5
Antiplatelet/anticoagulant therapy	47.4%	25%	0.018
Symptoms			
Motor impairment	38%	53%	0.11
Cognitive impairment	36%	41%	0.6
Gait disturbance	33%	22%	0.2
Headache	30%	16%	0.09
Lenguage impairment	17%	38%	0.07
Consciousness disturbance	14%	6%	0.2
Markwalder Scale			
0–1	19%	9%	0.42
2	67%	65%	
3–4	14%	16%	
Radiological characteristics			
Preoperative haematoma thickness (mm)	18	20	0.49
Midline deviation	6.6	10.2	0.09
Presence of membranes	76%	88%	0.32

Table 3. Postoperative outcomes

	One burr-hole	Two burr-holes	P-value
Hospital stay [days]	6.9	7.3	0.7
Radiological outcome			
Haematoma thickness [mm]	9.5	9.1	0.3
Haematoma volume reduction	37%	57%	0.7
Complications			
Recurrence	12.7%	9.4%	0.6
Rebleeding	4%	0	0.25
Surgical site infection	1.73%	6.25%	0.13
Mortality	2.9%	3.1%	0.94

Radiological outcomes

We assessed a reduction of cSDH thickness to be similar in both treatment groups (0.95 cm in Group 1 *vs.* 0.91 cm in Group 2, $p = 0.3$) (Tab. 3). Furthermore, we measured the preoperative and postoperative cSDH volume, which demonstrated a greater volume reduction in the two burr-holes group (57%) compared to the one burr-hole group (37%), although these differences were not significant (Tab. 3).

Also in terms of radiological findings, it is important to highlight that the presence of membranes was not related to higher complication rates or worse clinical outcomes in this series.

Clinical outcomes

Average hospital stay was very similar in both groups (6.9 days in Group 1 *vs.* 7.3 days in Group 2) without any statistically significant difference. It is also important to highlight

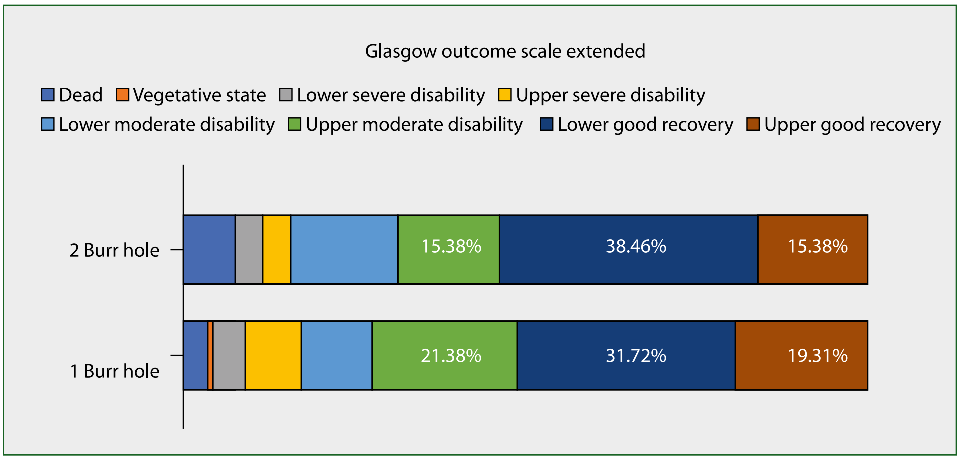

Figure 3. Glasgow Outcome Scale Extended (GOS-E), one month after discharge

Table 4. Comparison between different surgical techniques for cSDH treatment

Surgical technique	Advantages	Disadvantages
Twist-drill craniostomy	• Less invasive • Less than 1 hour of procedure • Low rate of complications • Shorter hospital stay	• High rate of recurrence
Burr-hole craniostomy	• Less invasive • Around 1 hour of procedure • Low rate of complications • Shorter hospital stay	• Procedure in operating room • Slightly high rate of recurrence
Craniotomy	• Low rate of recurrence	• More invasive • Around 2–4 hours of procedure • High rate of complications • Longer hospital stay
Others (i.e. middle meningeal artery embolisation, subdural shunt)	• May be useful in multiple recurrences	• More invasive • Insufficient evidence

that the mode was three days, representing the admission days in the majority of patients. At the time of hospital discharge, most patients showed a remarkable clinical improvement, with 81% of them showing a mild MGS regardless of the number of burr-holes made ($p = 0.7$) (Tab. 3).

In terms of complications, we observed a greater proportion of cSDH recurrences and acute rebleedings in patients treated with one burr-hole, and a greater proportion of surgical site infections in patients treated with two burr-holes, although neither of these differences was statistically significant. Mortality was similar in both groups (2.9% *vs.* 3.1%, $p = 0.94$) (Tab. 3).

Finally, we reevaluated patients one month after discharge according to the GOS-E scale, finding a good (GOS-E 6, 7 and 8) neurological result in 72% of the patients in Group 1 and 69% of the patients in Group 2 (Fig. 3), underlining the good clinical outcomes achieved in both treatment groups.

Discussion

A chronic subdural haematoma is one of the most frequent pathologies in neurosurgical practice. As we show in our series, prevalence is higher in elderly men, and according to epidemiological studies, its annual incidence is increasing due to the ageing of the population and the greater use of anticoagulant and antiplatelet therapies [1, 2, 24].

Despite this high prevalence, there is no real consensus on the best treatment for these haematomas. Published studies show a great discrepancy between those who advocate conservative treatment and those who promote urgent surgical evacuation [6, 10, 25–27]. Surgery is advised in those cSDHs of large thickness (usually greater than 1 cm) and those producing neurological deterioration. However, there is no consensus among neurosurgeons when we look for the best technique and modality of surgical treatment [7–9, 11–13] (Tab. 4).

Table 5. Summary of all articles comparing one burr-hole to two burr-hole craniostomy (*metaanalysis of previous studies)

Publication	No. of total cSDHs	Conclusions
Taussky et al. (2008)	97	Higher rate of recurrence for one burr-hole group
Lee et al. (2009)	57	No significant differences between one or two burr-holes
Han et al. (2009)	205	No significant differences in recurrence between one or two burr-holes
Kansal et al. (2010)	267	No significant differences in recurrence between one or two burr-holes
Belkhair et al. (2013)	713*	Single burr-hole as good as double burr-hole in evacuating cSDH, and is not associated with a higher revision rate
Gernsback et al. (2016)	261	Number of burr-holes does not affect recurrence risk
Heringer et al. (2017)	179	Number of burr-holes does not alter rates of recurrence or complications
Sánchez et al. (2019)	205	cSDH can be evacuated by a single burr-hole with a good clinical outcome and low complications rate

Burr-hole craniostomy with closed-system drainage is the treatment of choice for most neurosurgeons since it is a simple procedure with good clinical results and a low complications rate. Weigel et al. have demonstrated that this technique delivers the best cure-to-complication ratio [28]. Nevertheless, there is unresolved debate surrounding the optimal number of burr-holes needed, and the best place for the drainage placement [14–16, 29–38].

Regarding the number of burr-holes, some surgeons advocate a single burr-hole as sufficient to wash out the haematoma, based on the hypothesis that all haematoma cavities are continuous with wide routes of connection. On the other hand, others claim that this practice is associated with a higher recurrence rate and advocate making two burr-holes in order to facilitate the drainage of more volume of the haematoma, although the prolonged surgical time and the greater invasiveness of this technique can increase rebleeding and infection rates (Tab. 5) [19–22].

Our study, supporting the results of Belkhair and Picket published in 2013, suggests that the number of burr-holes is not associated with the postoperative clinical outcome or with the complications rate [18]. Tabaddor et al. also demonstrated for this purpose that clinical improvement occurred when the subdural pressure was reduced to close to zero, usually after removing nearly 20% of the collection [39].

Therefore, we can assert that irrigation through a single burr-hole is enough to obtain good surgical results with fewer complications in cSDH patients (Tab. 5) [19–21].

We must discuss observed trends in both groups in relation to complications, although they were not statistically significant. It is important to note that the lack of significance may be due to limitations of our retrospective study. First of all, in one burr-hole patients, higher percentages of recurrence and rebleeding were observed compared to two burr-hole patients. These higher postoperative recurrence rates, as described in previous studies, could be associated with the less evacuated volume and the large concentrations of vasoactive cytokines and fibrinolytic factors which perpetuate the inflammatory cascade of the residual haematoma fluid, conditions which favour the cSDH regrowing [4, 5, 22, 34, 40–44].

In relation to rebleeding, we must highlight the greater proportion of patients with antiplatelet or anticoagulation therapy in the single burr-hole group. This difference was statistically significant, and could indicate why neurosurgeons tend to avoid making two burr-holes in patients with bleeding risk factors, such as coagulopathies [45]. In the two burr-holes group, we also observed more surgical site infections. This trend is not surprising, because two burr-holes mean a longer surgical time and an extra wound, and rates could also be influenced by the greater proportion of diabetic patients in this group, considering their inherently higher infection rate with worse wound healing [46].

To the best of our knowledge, this is the first study comparing volumetric results obtained in operated upon cSDH patients through a single or a double burr-hole. We consider these results as opening up future areas of study. Currently, we are also analysing whether higher evacuated volumes in two-burr-hole patients could be correlated with lower doses of postoperative steroids. If this hypothesis was to be confirmed, we might consider looking for patients who could benefit from two burr holes, such as diabetics, since if we get a low residual haematoma volume we could reduce or even avoid the use of steroids in these patients and, consequently, avoid steroid-related complications such as infections and glycaemic decompensation.

Finally, we admit the limitations of our study, mainly its retrospective design and the size of groups analysed that may have limited the potential to obtain statistically significant differences.

Clinical implications/future directions

The results of this study suggest that cSDH can be efficiently evacuated by a single burr-hole craniostomy, a less invasive and shorter surgical procedure with quite good clinical outcomes and a low complications rate.

The relevance of lower residual haematoma volumes obtained by performing a two burr-hole craniostomy, and the relationship with postoperative management in these patients, should be evaluated in future studies.

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