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# Burr hole craniostomy *vs.* minicraniotomy of chronic subdural hematoma: a systematic review and meta-analysis

Y.-W. HUANG[1], X.-S. YIN[2], Z.-P. LI[1]

[1]Department of Neurosurgery, [2]Department of Immunology, Mianyang Central Hospital, School of Medicine, University of Electronic Science and Technology of China, Mianyang, Sichuan, People's Republic of China.

**Abstract. – OBJECTIVE: Surgery is the mainstay of treatment for chronic subdural hematoma (CSDH). However, the best surgical method is still controversial. Three different methods including burr hole craniostomy (BHC), minicraniotomy (MC), and twist drill craniostomy (TDC) are commonly utilized. Besides, large craniotomy, trephine craniotomy [TC (single or double)], small craniotomy, and endoscopic removal are befittingly used in some situations, too. Hence, we performed a systematic review and meta-analysis to compare the effects between BHC and MC for surgical treatment in CSDH.**

**MATERIALS AND METHODS: A literature research was conducted according to the PRISMA (the Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for studies that directly compared BHC and MC for CSDH. The following endpoints were compared between BHC and MC: recurrence rate, reoperation rate, duration of operation, days of hospital treatment, postoperative complications, mortality, and rate of good outcome.**

**RESULTS: Thirteen papers [n = 3,559 (3,580 operation sites), BHC: 1,936 operation sites, MC: 1,644 operation sites] met the inclusion criteria. The recurrence rate (OR: 0.56, 95% CI: 0.34-0.91, $p = 0.02$; $I^2 = 66\%$) was lower and the reoperation rate was also significantly lower (OR: 0.45, 95% CI: 0.25-0.81, $p = 0.008$; $I^2 = 72\%$) in the BHC group compared with the MC group. The duration of operation (MD: -20.15 min, 95% CI: -28.99 to -11.31, $p < 0.00001$; $I^2 = 0\%$) was significantly shorter in the BHC group compared with the MC group. Nevertheless, there was no statistically significant difference between the two groups in mortality (OR: 1.22, 95% CI: 0.92-1.61, $p = 0.16$; $I^2 = 38\%$), postoperative complications (OR: 0.68, 95% CI: 0.033-1.37, $p = 0.28$; $I^2 = 82\%$), days of hospital treatment (MD: 1.59, 95% CI: -10.44 to 13.62, $p = 0.14$; $I^2 = 85\%$) and rate of good outcome (OR: 1.40, 95% CI: 0.94-2.08, $p = 0.10$; $I^2 = 0\%$).**

**CONCLUSIONS: A systematic review and meta-analysis of the included literature showed that BHC reduces the recurrence rate, reoperation rate and duration of operation compared to MC. BHC is much more minimal invasive when compared to MC. More invasions may signify more post-operative complications, which may cause the increasing rate of recurrence and reoperation. No significant difference in mortality, post-operative complications, days of hospital treatment and rate of good outcome was observed between the two groups.**

*Key Words:*
Chronic subdural hematoma, Burr hole craniostomy, Minicraniotomy, Recurrence, Surgical technique.

## Introduction

Chronic subdural hematoma (CSDH) is one of the most frequently occurring intracranial hemorrhages in the field of neurosurgery. The estimated incidence is 8.2-20.6/100,000 every year. In the people over 65 years old, this incidence rises to 58/100,000/y. Because of a growing elderly citizens, the incidence of CSDH seems to be increasing[1-4]. Although an acceptance that CSDH requires surgical drainage is widely known, there is still an ongoing controversy about which surgical method offers optimal results[5].

The most frequent surgical method is the burr hole craniostomy (BHC) due to its minimal invasive. However, an alternative to this is the minicraniotomy (MC), which has the advantages of good visual field of the subdural space and the potential reduction of recurrence and hemorrhagic complications[6]. Previous data has shown that BHC has the best cure-to-complication ratio[7]. Yet, there is no direct evidence to support any claim to superiority of these surgical techniques and a head-to-head comparison of the BHC and MC has not been performed to date. To determine whether the different surgical procedure influences recur-

*Corresponding Author:* Huang Yongwei, MD; e-mail: 525654934@qq.com

rence rate and other outcome endpoints, we performed this study to evaluate the clinical effectiveness of BHC *vs.* MC in treating CSDH using meta-analysis, aiming at providing medical evidence for choosing the optimal surgical methods.

## Materials and Methods

This systematic review and meta-analysis was based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines[8] **(Supplementary Table I)**.

### Literature Search and Exclusion Criteria

A comprehensive literature was selected from the PubMed, Embase, and Cochrane databases from inception until June 1, 2022 in English only. Clinicaltrials.gov and WHO-ICTRP were also searched. We systematically searched electronic databases, by controlled vocabulary (i.e., MeSH and Emtree) and keywords. Search terms included chronic subdural hematoma, burr hole, craniotomy and their variants. In the first stage of screening, titles and abstracts were screened for relevant studies. Subsequently, the full texts were downloaded and assessed for eligibility. This process was carried out independently by two researchers (Y.-W. Huang and X.-S. Yin). Disagreements were resolved by discussion and by a third-party adjudication, if necessary.

Retrospective and prospective non-randomized controlled trials, pre- and post- intervention studies, observational and cohort studies, and post-hoc analyses of observed data from trials were included if a comparision of BHC and MC was reported.

### Article Evaluation and Data Extraction

The Newcastle-Ottawa Scale (NOS) was used for quality evaluation of retrospective and cohort studies. The extracted data included the first author, year of publication, country, study design, participants, average age (y), male-%, surgical methods, diameter of bone flap, metric used for outcomes, follow-up, recurrence rate, reoperation rate, duration of operation, postoperative complications, days of hospital treatment and the rate of good outcome.

### Statistical Analysis

RevMan 5.3 software (Cochrane Collaboration Review Manager, available at: revman.cochrane.org) was used to perform the analysis. The binary outcomes were expressed as odds ratio (OR) and 95% confidence interval (CI), and the continuous variables were expressed as mean difference (MD) and 95% CI. Statistical heterogeneity was analyzed using the Cochran Q test ($p < 0.1$ or $I^2 > 50\%$ were considered to represent significant heterogeneity). $p < 0.05$ was considered to indicate statistical significance.

Heterogeneity between variable groups due to the inclusion of non-randomized studies was analyzed by using the general inverse variance method based on data adjusted for potential confounders.

### Ethics

This study is a systematic review and meta-analysis that does not involve human participation. Informed consent and ethical approval were not required.

## Results

### Literature Search

896 records were yielded by searching the databases, and after 254 duplicate results removed, a total of 39 case reports, 58 conference abstracts, 17 commentaries and 50 reviews were excluded. 478 records were available for screening the title and abstract. In total, 14 full-text articles were evaluated. Two studies from which relevant data could not be extracted were excluded[9,10]. One study was found manually[11]. Thirteen studies[11-23] met the inclusion criteria and were included in the present analysis.

### Characteristics of Included Studies

Baseline characteristics of the included studies are summarized in Table I. One study[23] was prospective, and 12 studies were retrospective cohort studies. The largest study[12] included 1,003 patients (560 BHC *vs.* 443 MC), while the smallest study[19] included 87 patients (57 BHC *vs.* 30 MC).

### Analysis of Data

Two studies[19,23] reported the duration of operation (136 BHC cases and 114 MC cases). The duration of operation was significantly shorter in the BHC group compared with the MC group (MD: -20.15 min, 95% CI: -28.99 to -11.31, $p < 0.00001$; $I^2 = 0\%$) (Figure 1).

Nine studies[13-16,19-23] reported the recurrence rate (147 out of 1,233 BHC cases and 157 out of 963 MC cases). The recurrence rate was lower

**Table I.** Baseline characteristics of the included studies.

| Author | Year of Publication | Country | Study Design | Partici-pants | Average age (y) | Male (%) | Surgical methods | Diameter of surgical methods | Metric Used for Outcome | Follow-up |
|---|---|---|---|---|---|---|---|---|---|---|
| Lee et al[18] | 2004 | Germany | Single center retrospectively | 159 | 69 | 62.9 | BHC: drainage; without membranectomy<br>MC: drainage; partial membranectomy | BHC: 12 mm<br>MC: 30 mm | Markwalder | — |
| Lee et al[19] | 2009 | Korea | Single center retrospectively | 87 | 65.2 (median) | 74.7 | 1&2 BHC: drainage; with/without membranectomy<br>MC: drainage; irrigation | BHC: 10 mm<br>MC: 30 mm | Markwalder | — |
| White et al[13] | 2010 | UK | Single center retrospectively | 246 | 67.7 | 69 | BHC: drainage<br>MC: drainage | BHC: -<br>MC: 30-50 mm | GOS | 3 months |
| Kim et al[20] | 2011 | Korea | Single center retrospectively | 275 | 66.6 | 74.5 | BHC: drainage<br>MC: drainage; partial membranectomy | BHC: -<br>MC: 30-40 mm | Markwalder | 6 months (average) |
| Regan et al[17] | 2015 | USA | Single center retrospectively | 119 | 70 | 63 | BHC: irrigation; with membranectomy<br>MC: with membranectomy | BHC: -<br>MC: 50-70 mm | GOS, Rankin disability | — |
| Hussain et al[11] | 2017 | UK | Single center retrospectively | 267 | 76 (median) | — | — | — | Mortality | — |
| Starvinou et al[15] | 2017 | Germany | Single center retrospectively | 227 | 72.4 (median) | 68.7 | BHC: irrigation; drainage;<br>MC: irrigation; drainage; with membranectomy | — | Recurrence | 1 month |
| Haron et al[21] | 2019 | Australia | Single center retrospectively | 368 | — | — | BHC: irrigation; partial drainage;<br>MC: irrigation; partial drainage; | BHC: -<br>MC: 30 mm | Recurrence | 12 months |
| Shim et al[16] | 2019 | Korea | Single center retrospectively | 75 | 74.2 | 76 | BHC: drainage;<br>MC: irrigation; closed-system drainage; | BHC: -<br>MC: 30-50 mm | Recurrence<br>Average hospital stay | — |
| Gazzeri et al[22] | 2020 | Italy | Single center retrospectively | 414 | 76.3 | 66.2 | BHC: subdural and subgaleal drainage;<br>MC: subdural and subgaleal drainage; | BHC: -<br>MC: 50-70 mm | GCS, Recurrence | — |
| Vemula et al[14] | 2020 | India | Single center retrospectively | 156 | — | 85.9 | BHC: drainage;<br>MC: drainage; | BHC: -<br>MC: 30 mm | GOS, Mortality, Average hospital stay | — |
| Zolfaghari et al[12] | 2021 | Sweden | Multicenter retrospectively | 1003 | 74.9 (median) | 68.2 | BHC: drainage;<br>MC: irrigation; drainage; | — | 30-day mortality, recurrence, complications | 12 months |
| Duerinck et al[23] | 2022 | Belgium | multicenter prospectively | 163 | 73.8 (median) | 65.6 | BHC: irrigation;<br>MC: irrigation; | — | Markwalder, mRS | 6 months (median) |

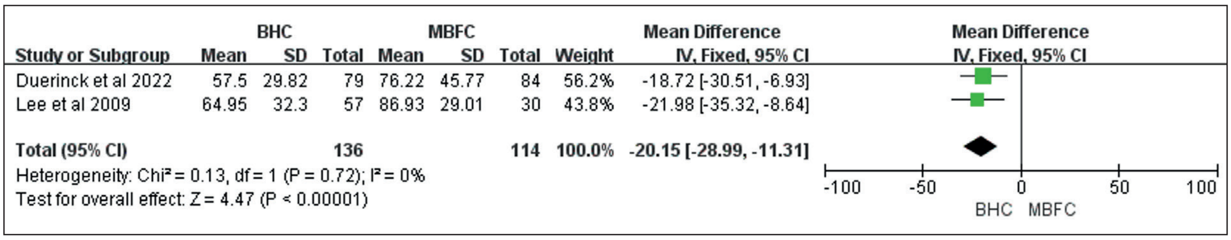


**Figure 1.** Forest plot analyzing the effects of BHC and MC on the duration of operation.

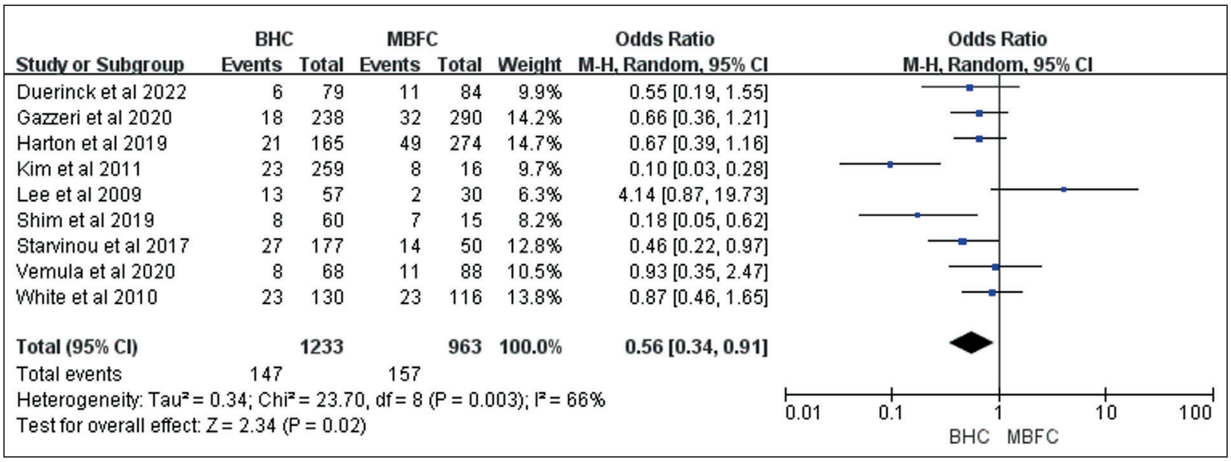


**Figure 2.** Forest plot analyzing the effects of BHC and MC on the recurrence rate.

in the BHC group compared with the MC group (OR: 0.56, 95% CI: 0.34-0.91, $p = 0.02$; $I^2 = 66\%$) (Figure 2).

The reoperation rate was reported in eight studies[12,13,16-18,20,22,23] (124 out of 1,425 BHC cases and 141 out of 1,143 MC cases). The reoperation rate was significantly lower in the BHC group compared with the MC group (OR: 0.45, 95% CI: 0.25-0.81, $p = 0.008$; $I^2 = 72\%$) (Figure 3).

Seven studies[12, 13,17,19,20,22,23] reported postoperative complications (167 out of 1,380 BHC cases and 214 out of 1,038 MC cases). Postoperative complications in both groups mainly included non-surgical complications (seizure, cardiac fail-

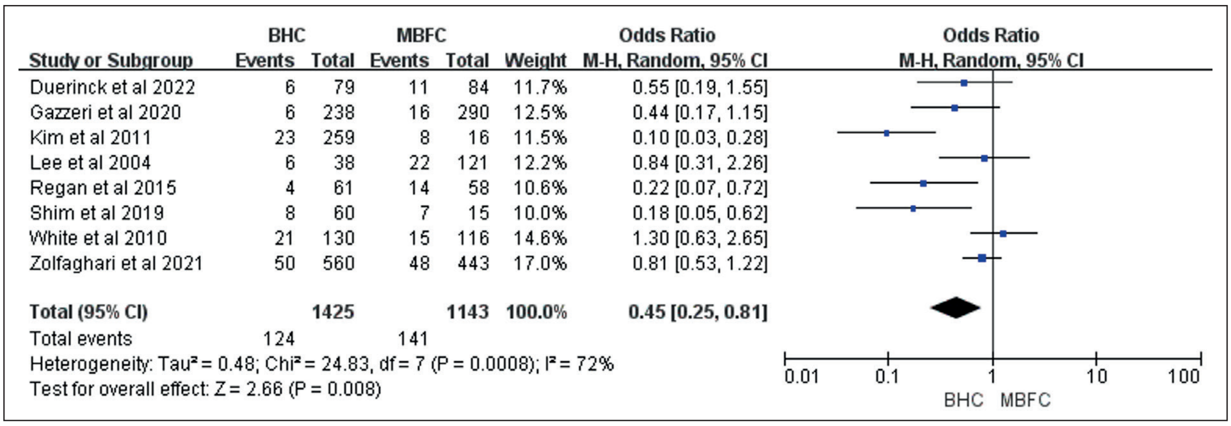


**Figure 3.** Forest plot analyzing the effects of BHC and MC on the reoperation rate.

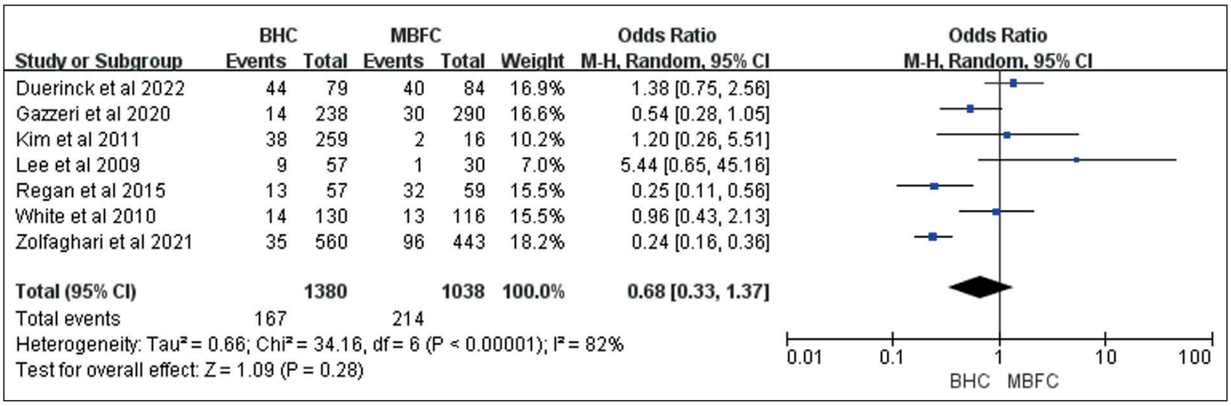


**Figure 4.** Forest plot analyzing the effects of BHC and MC on the post-operative complications.

ure, stroke, pneumonia, renal failure) and surgical complications (acute subdural hematoma extradural hematoma, intraparenchymal hemorrhage, cerebral edema, misplaced drain, hydrocephalus, infection (subdural empyema). Pooled analysis did not reveal a statistical difference in postoperative complications between the BHC group and the MC group (OR: 0.68, 95% CI: 0.033-1.37, $p$ = 0.28; $I^2$ = 82%). The postoperative complication rate in BHC group was lower than that of MC group (12% *vs.* 21%) (Figure 4).

Nine studies[11-14,17,20-23] reported the mortality (171 out of 1,769 BHC cases and 95 out of 1,428 MC cases). Although there was no statistically significant difference between the two groups in mortality (OR: 1.22, 95% CI: 0.92-1.61, $p$ = 0.16; $I^2$ = 38%), the mortality in MC group was lower than that of BHC group (6.6% *vs.* 9.9%) (Figure 5).

Three studies[16,19,20] reported the days of hospital treatment (376 BHC cases and 61 MC cases). There was no statistically significant difference between the two groups in days of hospital treatment (MD: 1.59, 95% CI: -10.44 to 13.62, $p$ = 0.14; $I^2$ = 85%) (Figure 6).

Five studies[13,14,17,20,23] reported the rate of good outcome (459 out of 544 BHC cases and 261 out of 337 MC cases). No statistically significant difference was found between the two groups in the rate of good outcome (OR: 1.40, 95% CI: 0.94-2.08, $p$ = 0.10; $I^2$ = 0%), but BHC group and MC group had a higher rate of good outcome (84% *vs.* 77%) (Figure 7).

### *Risk of Bias*

Most of the aforementioned studies had an overall moderate risk of bias, as assessed by the NOS, with a mean of 5.16 stars and a standard deviation (SD) of 1.77 stars. The assessment of included studies is available in **Supplementary Table II.**

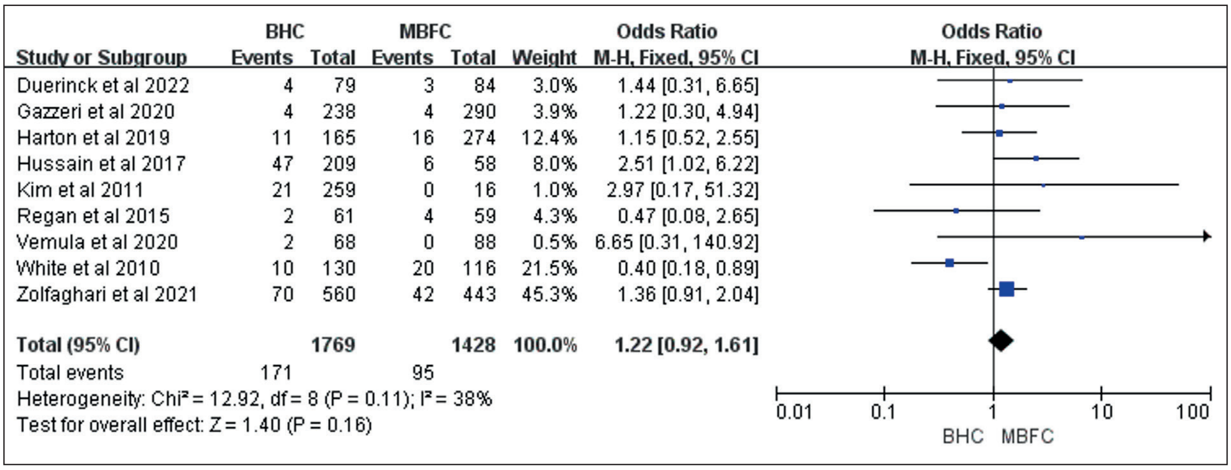


**Figure 5.** Forest plot analyzing the effects of BHC and MC on the mortality.

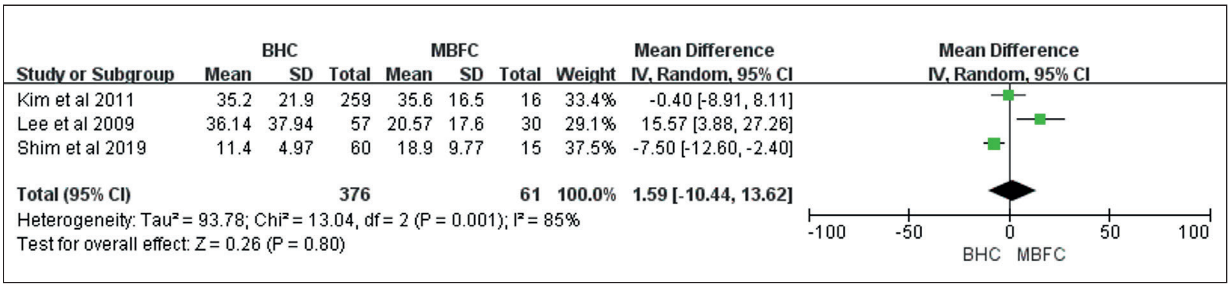


**Figure 6.** Forest plot analyzing the effects of BHC and MC on the days of hospital treatment.

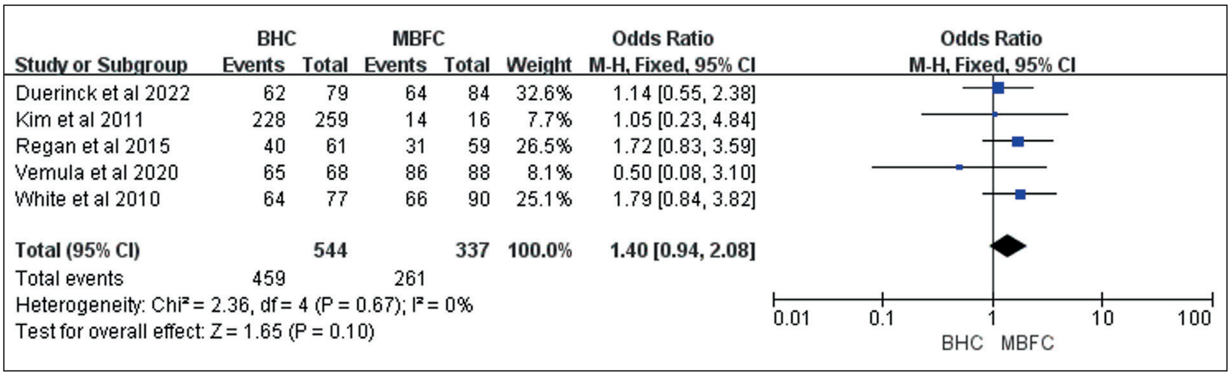


**Figure 7.** Forest plot analyzing the effects of BHC and MC on the rate of good outcome.

## Discussion

CSDH was first described in 1656 by Guénot[24]. It is one of the most frequently occurring neurosurgical pathologies[23] and easy to treat. The estimated incidence is 8.2-20.6/100,000/y. In the people over 65 years old, this incidence rises to 58/100,000/y, and because of growing elderly citizens, the incidence of CSDH seems to be increasing[1-4]. CSDH is considered a hematoma cavity consisted of outer and inner membranes. On the outer membrane, there are fragile vessels that are usually the reason for recurrent multifocal bleeding[25]. Excessive activation of the coagulation and fibrinolytic systems and high expression of tissue-type fibrinogen activator in the hematoma are considered possible reasons for the inability to coagulate[26]. The main risk factor of CSDH is potential traumatic brain injury. Besides, diabetes, antiplatelet drugs, liver insufficiency, and hemodialysis may also cause this illness. The most frequent clinical symptom is the headache. Head computed tomography (CT) scan is necessary for diagnosis. Sometimes magnetic resonance imaging (MRI) is required. CT scanning remains the basic diagnostic procedure for CSDH, and MRI has advantage of distinguishing the stages of subdural hematoma. For the sake of patients with mild occupying effects and mild clinical symptoms, drug conservative treatment is feasible, whereas surgical treatment is the first choice for patients with significant occupying effects in the clinical[27].

The most frequent surgical method is the BHC due to its minimal invasive. However, an alternative to this is the MC with a good visual field of the subdural space[6]. Because the hematoma membrane is considered to be the cause of rebleeding and recurrence of CSDH, surgical techniques that can remove the hematoma membrane are particularly important. The present systematic review and meta-analysis demonstrated a significantly different outcome profiles (including recurrence rate, reoperation rate and duration of operation) between BHC and MC. A higher postoperative complication rate was observed in MC (MC 21% *vs.* BHC 12%), but this was not found to be statistically significant ($p = 0.28$). The same results were observed in mortality ($p = 0.16$, MC 9.9% *vs.* BHC 6.6%) and in the rate of good outcome ($p = 0.10$). A lower good outcome rate was observed in MC group (MC 77% *vs.* BHC 84%).

Several studies[12,13,21,22] had demonstrated that BHC had no advantages regarding the rate of recurrence compared with MC. This is opposite to our findings. However, some other studies[16-18] found that BHC would be sufficient to evacuate CSDH with lower recurrence rate. Our findings are consistent with literature which demonstrated that lower recurrence rate in BHC group compared with MC. Although MC did not have significant advantages considering of recurrence rate, some studies[13,16,19,21] suggested that MC should be considered as one of the effective alternatives in the management of symptomatic CSDH. In fact, in some cases, such as hematoma with solid portion or multiple septa, MC was also needed. Nevertheless, one study[12] showed that MC was significantly associated with medical complications and serious surgical post-operative complications which is consistent with our findings. Therefore, more attention should be paid to post-operative complications by using this surgical technique.

### *Limitations*

Some limitations to this meta-analysis are as follows: first, available studies are mainly retrospective or prospective studies other than randomized, matched studies between the two groups; second, the uniform outcomes reporting in patients undergoing surgery of CSDH is important to consider. Despite these limitations, we believe that the results of our meta-analysis may be useful to surgeons in their choice of surgical treatment technique of CSDH; third, heterogeneity in outcomes reporting was also significant due to highly variable duration of postoperative follow-up and year of publication.

## Conclusions

To our knowledge, this is the first meta-analysis assessing the clinical effect between BHC and MC in the treatment of CSDH. BHC reduces the recurrence rate, reoperation rate and duration of operation compared to MC. BHC is much more minimal invasive when compared to MC. More invasions may signify more post-operative complications, which may cause the increasing rate of recurrence and reoperation. No significant difference in mortality, postoperative complications, days of hospital treatment and rate of good outcomes were observed between the two groups. Although no randomized double-blind studies have been conducted, the available studies reflect the actual situation in the clinic and assist clinical decision makers.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

### Acknowledgements

None.

### Data Availability

Supplementary materials associated with this article can be found in the online version.

### Authors' Contributions

Y.-W. Huang: acquisition of data, analysis and interpretation of data, and drafting the article. X.-S. Yin: critical revision of the manuscript for important intellectual content. Z.-P. Li: conception and design of the study and critical revision of the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript.

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