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ORIGINAL ARTICLE - BRAIN TRAUMA

Twist drill craniostomy vs burr hole drainage of chronic subdural hematoma: a systematic review and meta-analysis

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Abstract

Introduction There is a clinical equipoise between burr hole drainage (BHD) or twist drill craniotomy (TDC) as initial surgical intervention in patients with chronic subdural hematoma (cSDH). Moreover, the impact of type of postoperative drainage is not well elucidated. We performed a systematic review and meta-analysis comparing outcomes following BHD and TDC for initial surgical management in cSDH and to understand the impact of negative suction drainage with TDC.

Methods A literature search was conducted according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for studies that directly compared TDC and BHD. The following outcomes were compared between TDC and BHD: mortality, recurrence, reoperations, complications, and cure rates. Subgroup analysis was performed to determine impact of negative suction drainage with TDC.

Results Sixteen articles ($n=1{,}235$; TDC: 663; BHD: 591) met inclusion criteria. Although complications (OR: 0.68, 95% CI: 0.38–1.23, $p=0.21$; $I^2=31\%$), recurrence (OR: 1.16, 95% CI: 0.84–1.62, $p=0.37$; $I^2=28\%$), cure (OR: 1.11, 95% CI: 0.72–1.72, $p=0.64$, $I^2=34\%$), and mortality rates (OR: 1.20, 95% CI: 0.60–2.41; $p=0.61$; $I^2=0\%$) were not significantly different between the two groups, TDC was associated with a higher reoperations than BHD (OR: 1.48, 95% CI:1.01–2.16, $p=0.04$; $I^2=41\%$). Subgroup analysis demonstrated that TDC with negative suction drainage conferred equivalent reoperation rates as BHD (OR: 0.75, 95% CI: 0.24–2.35; $p=0.62$; $I^2=65\%$); however, TDC without negative suction was associated with higher reoperations (OR: 1.62, 95% CI: 1.08–2.42; $p=0.02$; $I^2=40\%$).

Conclusion A systematic review and meta-analysis of available literature directly comparing TDC and BHD for primary evacuation of cSDH did not demonstrate clear superiority of either technique, although reoperations may be higher following TDC. Use of negative suction drainage with TDC may lead to similar rates of reoperation as BHD.

Keywords Chronic subdural hematoma · Subdural drainage · Literature review · Craniotomy · Burr hole · Twist drill

Introduction

Chronic subdural hematoma (cSDH) is a common neurological disease, with an overall population incidence ranging from 1.72 to 20.6 per 100,000 persons per year and an even higher incidence in the elderly. [24, 36] Morbidity and mortality in patients with cSDH may range anywhere between 0–25 and 0–32%, respectively. [7] Neurological outcomes are often poor in up to 20% of patients, resulting in significant disability. [3] Although surgical evacuation is the mainstay of treatment in symptomatic cases, consensus for an optimal surgical strategy is commonly debated. [36] Perioperative mortality may range anywhere between 1.2 and 11%; a common complication is reaccumulation which may be as high as 70%, although reaccumulation requiring reoperation is usually only 10–20%. [3, 6, 9, 13, 16, 20, 30]

Being less invasive, burr hole drainage (BHD) and twist drill craniostomy (TDC) are commonly utilized for initial hematoma evacuation, with open craniotomy reserved as a second-line surgical strategy. Although TDC offers advantages such as being minimally invasive and able to be

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performed at the bedside which may be helpful in elderly patients with comorbidities, BHC is traditionally preferred and more commonly performed due to some evidence of superior safety and efficacy [33]. However, recent evidence-based systematic reviews by Ducruet et al. [6] and Almenawer et al. [1] have brought TDC back into the fold, demonstrating non-inferiority in morbidity, mortality, and recurrence rates. Due to variability in TDC technique and availability of more studies directly comparing outcomes between the two approaches, an updated comparison is warranted. Also, the impact of the type of subdural drainage utilized with TDC has not been well elucidated. In this study, we performed an updated systematic review and meta-analysis comparing outcomes following BHD and TDC for initial surgical management in patients with cSDH. We further aimed to compare any difference in outcomes between BHD and TDC based on the type of drainage system used with TDC. Our working hypothesis was that a negative suction drainage system would lead to equivalence in outcomes between TDC and BHD, while BHD would be superior to TDC with conventional closed drainage.

Methods

Literature search strategy and selection criteria

This systematic review was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Review and Meta-analysis) guidelines [19]. The literature search strategy was designed around the PICO format: Is there a difference in surgical outcomes (outcome) between patients undergoing TDC (intervention) and BHD (comparator) among patients with cSDH (population of interest)? A detailed electronic search using Ovid Medline/PubMed, Ovid Embase, Ovid Scopus and Cochrane Central Register of Controlled Trials, and Cochrane Database of Systematic Reviews was performed using keywords "Chronic Subdural Hematoma" or "Subdural Hematoma" or "Subdural Hemorrhage" or "Subdural Bleeding," " Burr Hole" or "Twist Drill" or " Burr Hole" and "Twist Drill," or "Craniotomy" or "Craniectomy" or "Craniostomy" or "Evacuation" or "Evacuation" or "Trepan" or "Trephine," from their dates of inception to August 14, 2020. The search strategy was designed by a master's level librarian with input from the study's principal investigator (Supplement 1). Title and abstract screening followed by full-text evaluation was performed independently by two study co-authors (K.Y. and A.G.). The following were used as inclusion criteria: (1) cohort studies or clinical trials directly comparing outcomes following *primary* TDC and BHD among patients with cSDH and (2) studies reporting one or more of the following outcomes following drainage: mortality, morbidity (complications), reoperations, cure, and recurrence rates. Studies using non-human species, case reports or series with ≤ 5 patients, reviews, and letters to the editor were excluded.

Definition of TDC and BHD

Twist drill craniostomy was defined as a percutaneous bedside procedure performed with a hand-held manual twist drill to create a bony opening for evacuation. In the TDC arm, the size of the opening is usually < 1 cm. [5, 10, 11, 17, 21, 23, 26, 27, 31] Burr hole drainage was defined as drainage with wider openings (of size ≥ 1 cm) created with larger operating room drills.

Outcomes of interest

Morbidity was defined as any complication with the exception of recurrence. Mortality was defined as death during or following surgery. Both mortality and morbidity were determined from time of surgery to last follow-up (although length of follow-up was variable, with minimum being 2–4 weeks). All hematoma reaccumulations were defined as recurrence, while reoperations were specifically defined as only those reaccumulations that warranted further evacuation due to symptoms or clinical worsening. Cure was defined as attainment of full autonomy at last follow-up (grade 0 or 1 in Markwalder [18] classification or grade 5 on Glasgow Coma Scale [14]).

Data extraction and critical appraisal

In addition to above mentioned outcomes, the following data were extracted from included studies: author, year of publication, study design (prospective or retrospective, observational study vs clinical trial), country, number of institutions and surgeons, surgical technique for TDC and BHD (size of needle or port system, type of anesthesia, drainage system, etc.), number of patients, mean age of the cohort, sex distribution, and follow-up period. Risk of bias was evaluated using the Newcastle–Ottawa Scale (NOS) for observational studies and Cochrane Risk-of-bias tool for randomized controlled trials. [12, 22] Publication bias was determined using funnel plots. The grade of recommendation, assessment, development, and evaluation (GRADE) approach was used to assess limitations in study design, consistency, evidence directness, the precision of results, and publication bias. [2] The GRADEpro guideline development tool was used to create a summary of findings (SoF) table (http://gradepro.org/).

Statistical analysis

All data analyses were performed using Review Manager 5.4.1. Odds ratios (ORs) were used to pool effect

estimates for binary outcomes using the Mantel–Haenszel summary statistics and the results visualized as forest plots. Heterogeneity was estimated using the I^2 statistic, with substantial heterogeneity defined as $I^2 > 50\%$. A fixed-effects model was applied with $I^2 < 50\%$. Based on the type of drainage system utilized with TDC (negative suction vs other closed drainage system), we introduced subgroups to assess variation in effect size between TDC and BHD. All p-values were 2-sided with statistical significance defined as $p \leq 0.05$.

Results

A total of 675 results were obtained from the initial electronic search. Following initial title, abstract screening, and full-text evaluation, 4 RCTs [10, 11, 21, 33] and 12 observational studies [4, 5, 8, 15, 17, 23, 25–27, 29, 31, 35] with a total of 1235 patients (TDC: $n = 663$; BHD: $n = 591$) were included for qualitative and quantitative comparison. Figure 1 demonstrates the PRISMA search strategy. Follow-up was variable and ranged between 2 weeks and 2 years. The mean (SD) age for TDC and BHD cohorts was 69 (5.5) and 67 (5.4) years, respectively. Study characteristics are presented in Tables 1, 2, 3. Within the TDC group, mean

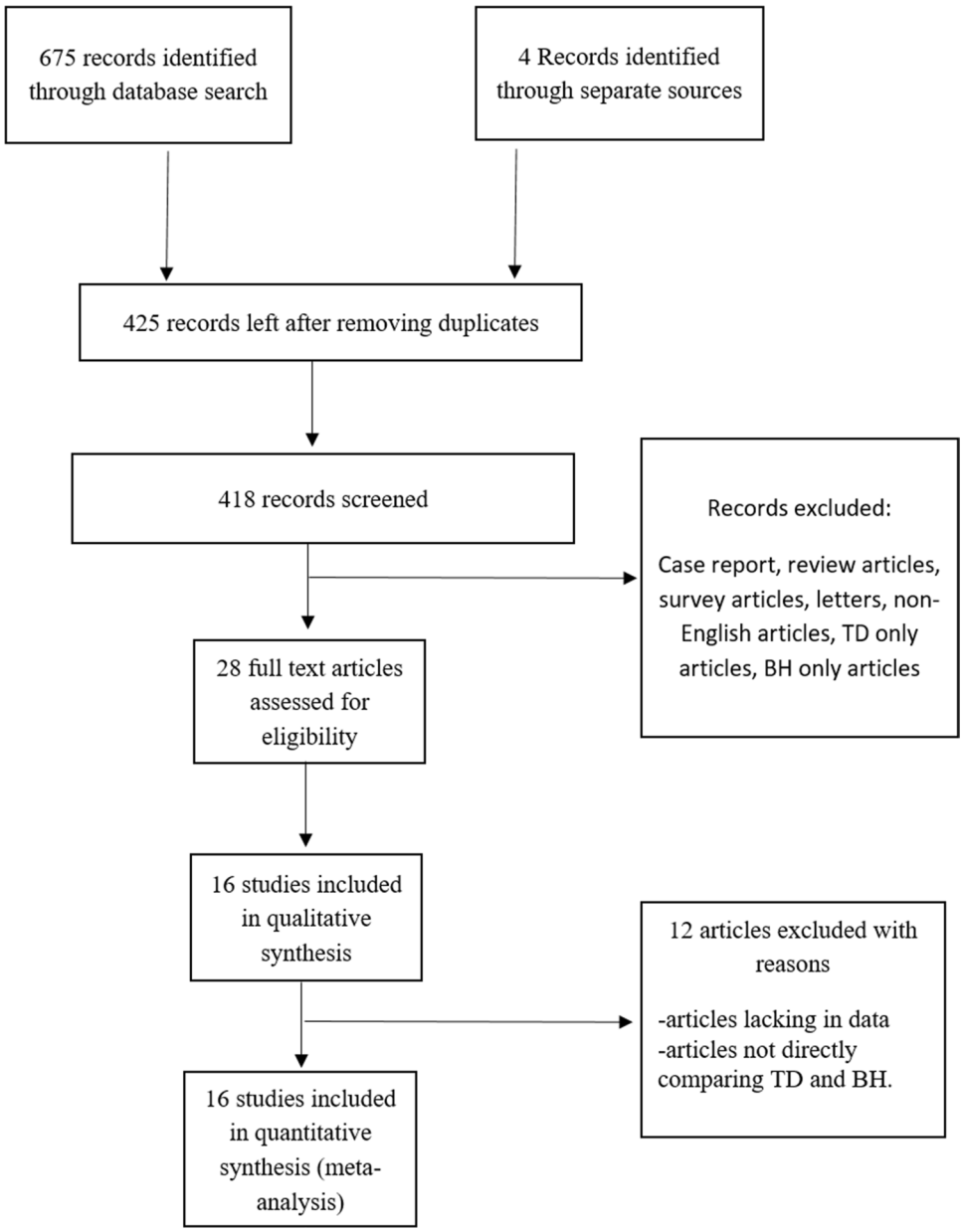


Fig. 1 PRISMA search strategy

Table 1 Study characteristics

Author	Year	Study type	Country	No. of institutions	No. of surgeons	N	Mean age	Females (%)	Follow-up
Bhatty G B	1996	Observational	India	Single	Single	100	60	9	51 for 1 year; 7 for 2 years; 3 for 2–4 years
Certo F	2019	Observational	Italy	Single	Multi	45		37.8	14.8 months
Garber S	2016	Observational	USA	Single	Multi	102		34	
Gokmen M	2008	RCT	Turkey	Single	Multi	70	67	22.9	1, 3, and 6 months
Goyal R	2018	RCT	India	Single	Multi	40		15	1, 3, and 6 months
Kim G	2020	Observational	Korea	Single	Multi	65	68.6	44.6	
Lee S J	2016	Observational	Korea	Single	Single	86			> 3 months
Muzii V	2005	RCT	Italy	Single	Single	46	77.5	34.8	0, 1, or 2 months
Rughani A	2010	Observational	USA	Single	Multi	42		34	
Smely C	1997	Observational	Germany	Single		66		36.4	
Thavara B D	2019	Observational	India	Single	Multi	109		26.6	
Wang K	2017	Observational	China	Single	Multi	83	67.7	20.5	3 months
Wang Q	2016	Observational	China	Single	Multi	121			2 to 4 weeks
Williams G	2001	Observational	USA	Single	Multi	62	62	24.2	
Xu C	2018	RCT	China	Single	Multi	40		17.5	0, 2 days, 3 months
Xu M	2020	Observational	China	Single	Multi	158	65.88	15.2	3 months

Table 2 Cohort characteristics

Author	Twist drill craniostomy(TDC)					Burr hole drainage (BHD)				
	N	Mean age	Females (%)	Follow-up	Drain use (Y/N)	N	Mean age	Females (%)	Follow-up	Drain use (Y/N)
Bhatty G B	84					35				
Certo F	15	75.7	40%	10.9 months	Y	30	76.75	36.70	16.7	Y
Garber S	15	76.7	26.7		Y	87	69.4	41.4		Y in 95.4%
Gokmen M	38				Y	32				Y
Goyal R	20	60.45	15		Y	20	62.85	15		Y
Kim G	48	67.9	41.67		Y	17	70.6	52.94		Y
Lee S J	68	67.9	105		Y	18	63.5	33.33		Y
Muzii V	22	78.7	36.4		Y	24	76.3	33.33		Y
Rughani A	21	73	34	66.8 days	Y	21	73.3	34	45 days	Y
Smely C	33	69.7	36.36	81 days	Y	33	70	36.36	82 days	Y
Thavara B D	46	73.36	30.43		Y	63	61.39	23.81		Y
Wang K	38	68.2	26.31	3 months	Y	45	67.3	15.55	3 months	Y
Wang Q	68	69.49	16.2	2–4 wks	Y	53	66.67	17	2–4 wks	Y
Williams G	11	63		5 wks	Y	51	57.4 Y 63 N	7.4 Y 11.4 N	5 wks	14 Y 37 N
Xu C	20	66.2	20	3 months	Y	20	66	15	3 months	Y
Xu M	116	65.3	14.85	3 months	Y	42	67.5	27.27	3 months	Y

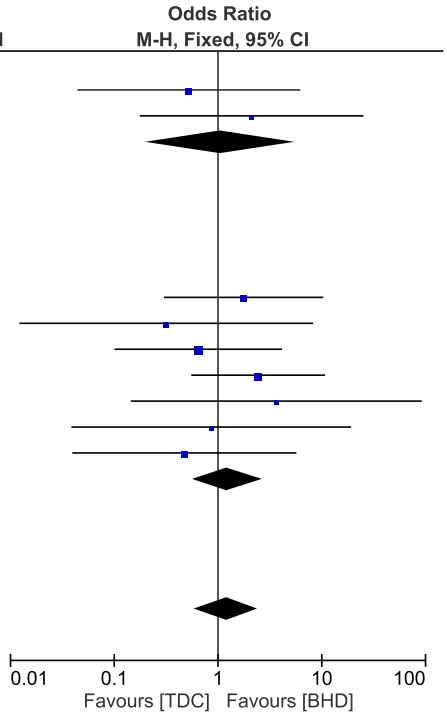
(± SD) duration of drainage was 2.6 ± 0.8 days (13 studies, $n = 544$) vs 2.5 ± 1.2 days for BHD (12 studies, $n = 407$). Size of bone opening ranged from 3 to 5.8 mm for TDC (9 studies, $n = 323$) vs 10 to 25 mm for BHD. Two studies ($n = 88$) reported using a negative suction drainage system in the TDC arm, [21, 26] while passive drainage was utilized with BHD across all studies. Nine studies ($n = 490$) reported on use of active irrigation with TDC, of which 6 ($n = 336$) reported it to be used as part of their protocol, while 3 studies ($n = 154$) reported it as not being used. For

Table 3 Surgical technique

Author	TDC technique	BHD technique
Bhatty G B	16-gauge brain needle; irrigation sterile antibiotic solution	
Certo F	Local anesthesia; irrigation with isotonic solution 5 mm size; subdural percutaneous drain for 48–72 h Integra™ subdural evacuation port	General anesthesia (50%) and local anesthesia (50%) with sedation; conventional single burr hole; subdural drain for 48–72 h; irrigation with isotonic solution
Garber S	Local anesthesia; one-quarter inch drill; subdural drain	General anesthesia; conventional two burr holes; subdural drain ($n=83$); no drain ($n=4$)
Gokmen M	Anesthesia used according to patient status; 4.5 mm drill; 12 French soft bag drains; no irrigation; subdural drain for 48 h	Anesthesia used according to patient status; 13 mm drill; irrigation with saline; single burr hole; 12 French soft bag drains; subdural drain for 48 h
Goyal R	Local anesthesia; 4 mm drill; soft ventricular catheter to irrigate with saline; two TDC	Local with sedation; 15 mm; 5F feeding tube for subdural irrigation with saline; two burr holes
Kim G	Local anesthesia; subdural drain for 3.8 days; no irrigation	Local with sedation; single burr hole; 15 mm drill; Subdural drain for 3.4 days
Lee S J	Local anesthesia; 5 mm drill; subdural drain for 3.2 days; no irrigation	General anesthesia; subdural drain for 3.4 days; no irrigation; single burr hole
Muzii V	Local anesthesia; 5 mm; subdural drain with suction; 65.3 h	Local anesthesia; subdural drain for 38.8 h; irrigation with saline; single or two burr holes; 10 mm
Rughani A	18 in local anesthesia and 3 in general; 5.8 mm drill; SEPS 6 mm port 18-gauge needle with suction bulb; subdural drain for 2 days	4 in local anesthesia and 17 in general; irrigation with saline; conventional one or two burr holes; ventriculostomy catheter subdural drain for 1.8 days
Smely C	Local anesthesia; 5 mm; CORDIS closed system drain; subdural drain 3.1 days; flushing with saline if drainage gets block	Local anesthesia; 11 mm; 1–2 perforated 14 Robinson drainage tube with closed system drain for 5.7 days; flushing with saline if drainage gets block; single burr hole
Thavara B D	Local anesthesia; 10 FG closed system subdural drain for 24 h	General anesthesia; 25 mm; subdural drain for 24 h; irrigation with saline through 10FG infant feeding tube; single burr hole
Wang K	Local anesthesia; 3 mm; YL-1 puncture needle; closed external ventricular subdural drain; 3.1 days	Local anesthesia; 13 mm; external ventricular subdural drain; single burr hole; 2.5 days
Wang Q	Local anesthesia; 3 mm; YL-1 puncture needle; closed system subdural drain for 2 days; irrigation	General anesthesia; closed system subdural drain for 2 days; irrigation with saline; single burr hole; 10 mm
Williams G	Local anesthesia; closed system subdural drain; 24–48 h	Local anesthesia; 15 mm; closed system subdural drain ($n=14$); no drain ($n=37$); irrigated with saline; single burr hole; 24–48 h
Xu C	2 cm minimally invasive puncture needle; closed system subdural drain for 48 h	15 mm; closed system subdural drain for 48 h; single burr hole; irrigation with warm saline
Xu M	Local anesthesia; YL-1 puncture needle; closed system subdural drain for 2–4 days; irrigation with saline	Classic burr hole with drain

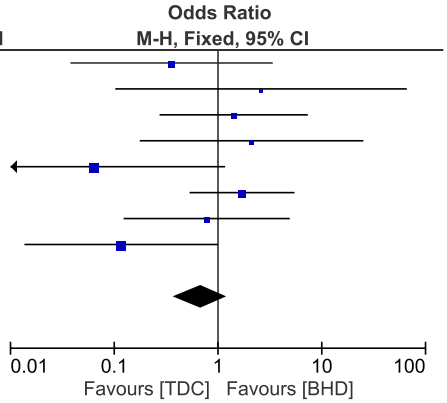
a

Study or Subgroup	Twist drill Events	Total	Burr-hole Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
1.1.1 TDC with negative suction						
Muzzi 2005	1	22	2	24	12.6%	0.52 [0.04, 6.22]
Rughani 2010	2	21	1	21	6.3%	2.11 [0.18, 25.17]
Subtotal (95% CI)		**43**		**45**	**18.9%**	**1.05 [0.20, 5.50]**
Total events	3		3			
Heterogeneity: Chi² = 0.61, df = 1 (P = 0.44); I² = 0%						
Test for overall effect: Z = 0.06 (P = 0.96)						
1.1.2 TDC without negative suction						
Gokmen 2008	4	38	2	32	13.4%	1.76 [0.30, 10.33]
Goyal 2018	0	20	1	20	10.1%	0.32 [0.01, 8.26]
Smely 1997	2	33	3	33	19.5%	0.65 [0.10, 4.14]
Thavara 2019	5	46	3	63	15.6%	2.44 [0.55, 10.77]
Wang 2017	1	38	0	45	3.1%	3.64 [0.14, 91.99]
Williams 2001	0	11	2	51	6.2%	0.86 [0.04, 19.17]
Xu C 2018	1	20	2	20	13.1%	0.47 [0.04, 5.69]
Subtotal (95% CI)		**206**		**264**	**81.1%**	**1.24 [0.57, 2.66]**
Total events	13		13			
Heterogeneity: Chi² = 3.15, df = 6 (P = 0.79); I² = 0%						
Test for overall effect: Z = 0.54 (P = 0.59)						
Total (95% CI)		**249**		**309**	**100.0%**	**1.20 [0.60, 2.41]**
Total events	16		16			
Heterogeneity: Chi² = 3.79, df = 8 (P = 0.88); I² = 0%						
Test for overall effect: Z = 0.52 (P = 0.61)						
Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.86), I² = 0%						



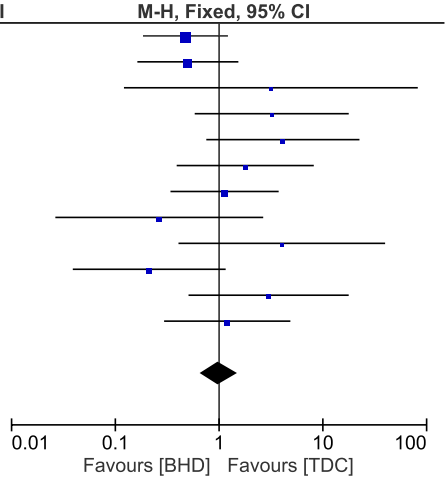
b

Study or Subgroup	Twist drill Events	Total	Burr-hole Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Certo 2019	1	15	5	30	11.6%	0.36 [0.04, 3.37]
Gokmen 2008	1	38	0	32	1.9%	2.60 [0.10, 66.05]
Goyal 2018	4	20	3	20	8.9%	1.42 [0.27, 7.34]
Rughani 2010	2	21	1	21	3.4%	2.11 [0.18, 25.17]
Smely 1997	0	33	6	33	23.8%	0.06 [0.00, 1.17]
Thavara 2019	7	46	6	63	16.0%	1.71 [0.53, 5.46]
Wang 2017	2	38	3	45	9.7%	0.78 [0.12, 4.92]
Wang Q 2016	1	68	6	53	24.7%	0.12 [0.01, 1.00]
Total (95% CI)		**279**		**297**	**100.0%**	**0.68 [0.38, 1.23]**
Total events	18		30			
Heterogeneity: Chi² = 10.07, df = 7 (P = 0.18); I² = 31%						
Test for overall effect: Z = 1.27 (P = 0.21)						



c

Study or Subgroup	Twist drill Events	Total	Burr-hole Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Bhatty 1996	55	84	28	35	29.1%	0.47 [0.18, 1.22]
Gokmen 2008	26	38	26	32	19.0%	0.50 [0.16, 1.53]
Goyal 2018	20	20	19	20	1.0%	3.15 [0.12, 82.16]
Kim 2020	45	48	14	17	2.8%	3.21 [0.58, 17.75]
Muzzi 2005	20	22	17	24	3.2%	4.12 [0.75, 22.52]
Smely 1997	30	33	28	33	5.4%	1.79 [0.39, 8.17]
Thavara 2019	30	36	31	38	10.7%	1.13 [0.34, 3.75]
Wang 2017	35	38	44	45	6.8%	0.27 [0.03, 2.66]
Wang Q 2016	67	68	50	53	1.8%	4.02 [0.41, 39.80]
Williams 2001	4	7	44	51	9.7%	0.21 [0.04, 1.16]
Xu C 2018	18	20	15	20	3.2%	3.00 [0.51, 17.74]
Xu M 2020	109	116	39	42	7.4%	1.20 [0.30, 4.86]
Total (95% CI)		**530**		**410**	**100.0%**	**0.99 [0.66, 1.49]**
Total events	459		355			
Heterogeneity: Chi² = 16.83, df = 11 (P = 0.11); I² = 35%						
Test for overall effect: Z = 0.03 (P = 0.98)						



◂**Fig. 2** Forest plots comparing odds of **A** mortality, **B** complications, and **C** cure rates following twist drill craniostomy vs burr hole drainage. TDC, twist drill craniostomy; BHD, burr hole drainage

the BHD cohort, use of active irrigation was reported by 11 studies, of which 10 ($n=347$) reported it as part of the protocol, while 1 study ($n=18$) reported it to be not used. Ten studies ($n=362$) reported using single burr hole in the BHD arm, and two ($n=107$) reported using double burr holes, while two studies ($n=77$) failed to clarify usage of single or double burr hole technique. Two reported ($n=45$) usage of both single or double burr hole techniques used in BHD arm.

Mortality

Following analysis of 9 studies ($n=558$; 249 in TDC and 309 in BHD), we did not observe a statistically significant difference in mortality between TDC and BHD (OR: 1.20, 95% CI: 0.60–2.41; $p=0.61$; $I^2=0\%$) (Fig. 2A).

Subgroup analysis for usage of negative suction with TDC did not reveal any statistically significant differences in mortality for the two subgroups (negative suction: OR: 1.05, 95% CI: 0.20–5.50; $p=0.96$; $I^2=0\%$; closed drainage: OR: 1.24, 95% CI: 0.57–2.66; $p=0.59$; $I^2=0\%$).

Meta-analysis of 4 RCTs ($n=196$; 100 in TDC and 96 in BHD) did not demonstrate a statistically significant difference in mortality between TDC and BHD (OR: 0.81, 95% CI: 0.27–2.41; $p=0.70$; $I^2=0\%$) (Fig. 4A).

Complications

From an analysis of 8 studies ($n=576$; 279 in TDC and 297 in BHD), we did not observe a statistically significant difference in overall recurrence (OR: 0.68, 95% CI: 0.38–1.23, $p=0.21$; $I^2=31\%$) (Fig. 2B).

Cure rate

From an analysis of 12 studies ($n=940$; 530 in TDC and 410 in BHD), we did not observe a statistically significant difference in overall cure rate (OR: 0.99, 95% CI: 0.66–1.49, $p=0.98$, $I^2=35\%$) (Fig. 2C).

Meta-analysis of 4 RCTs ($n=196$; 100 in TDC and 96 in BHD) did not demonstrate a statistically significant difference in between TDC and BHD (OR: 1.34, 95% CI: 0.64–2.79; $p=0.44$; $I^2=47\%$) (Fig. 4B).

Recurrence

From an analysis of 16 studies ($n=1235$; 663 in TDC and 591 in BHD), we did not observe a statistically significant difference in overall recurrence (OR: 1.16, 95% CI: 0.84–1.62, $p=0.37$; $I^2=28\%$) (Fig. 3A).

Further subgroup analysis confirmed these findings and did not reveal any statistically significant differences in outcomes for the two subgroups (negative suction: OR: 0.64, 95% CI: 0.21–1.99; $p=0.44$; $I^2=54\%$; closed drainage: OR: 1.23, 95% CI: 0.87–1.75; $p=0.24$; $I^2=28\%$).

Meta-analysis of 4 RCTs ($n=196$; 100 in TDC and 96 in BHD) did not demonstrate a statistically significant difference in recurrence between TDC and BHD (OR: 0.89, 95% CI: 0.40–1.98; $p=0.77$; $I^2=17\%$) (Fig. 4C).

Reoperations

From an analysis of 14 studies ($n=1012$; 499 in TDC and 532 in BHD), TDC was associated with a slightly higher rate of reoperations performed for reaccumulation as compared to BHD (16.23% vs 11.46%; OR: 1.48, 95% CI: 1.01–2.16, $p=0.04$; $I^2=41\%$) (Fig. 3B).

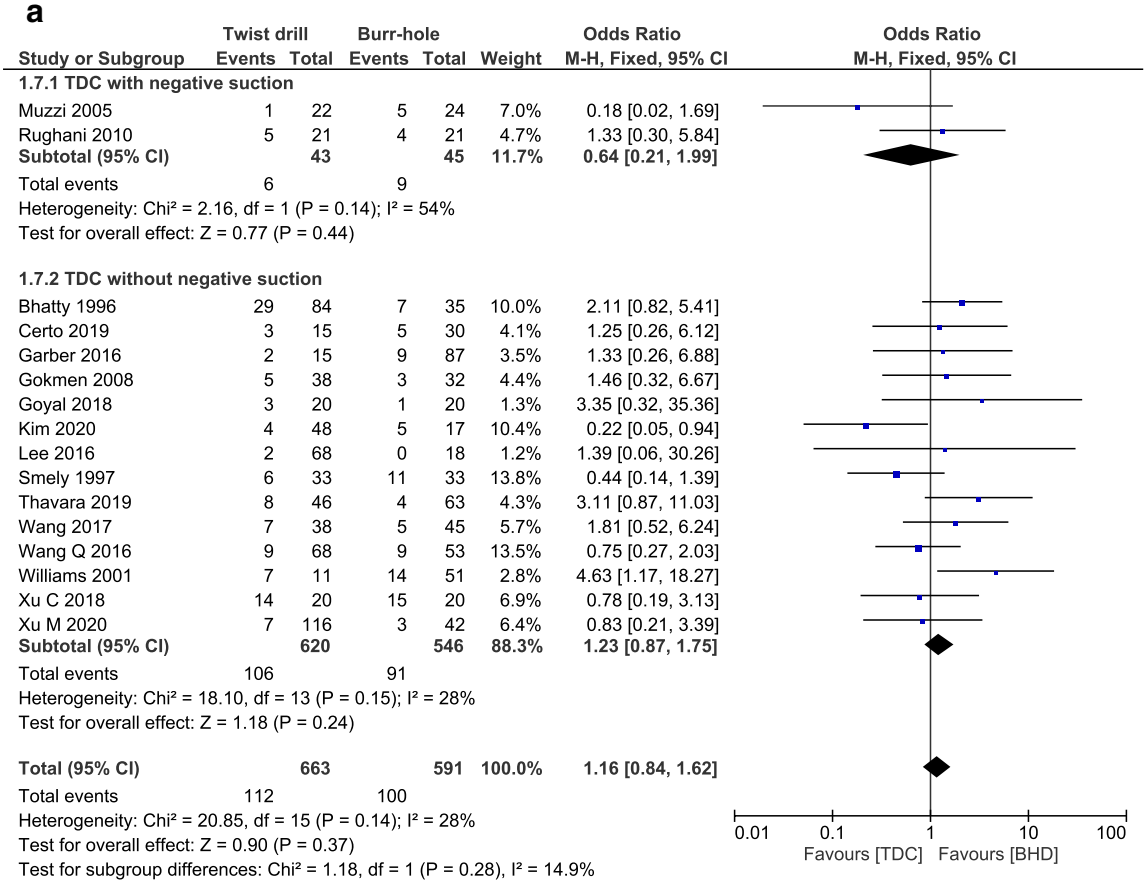
Further, subgroup analysis revealed that the reoperation rate was similar between TDC with negative suction and BHD (OR: 0.75, 95% CI: 0.24–2.35; $p=0.62$; $I^2=65\%$) but was significantly higher for TDC without negative suction when compared to burr hole drainage (OR: 1.62, 95% CI: 1.08–2.42; $p=0.02$; $I^2=40\%$).

Meta-analysis of 4 RCTs ($n=196$; 100 in TDC and 96 in BHD) did not demonstrate a statistically significant difference in reoperations between TDC and BHD (OR: 0.78, 95% CI: 0.32–1.90; $p=0.59$; $I^2=32\%$) (Fig. 4D).

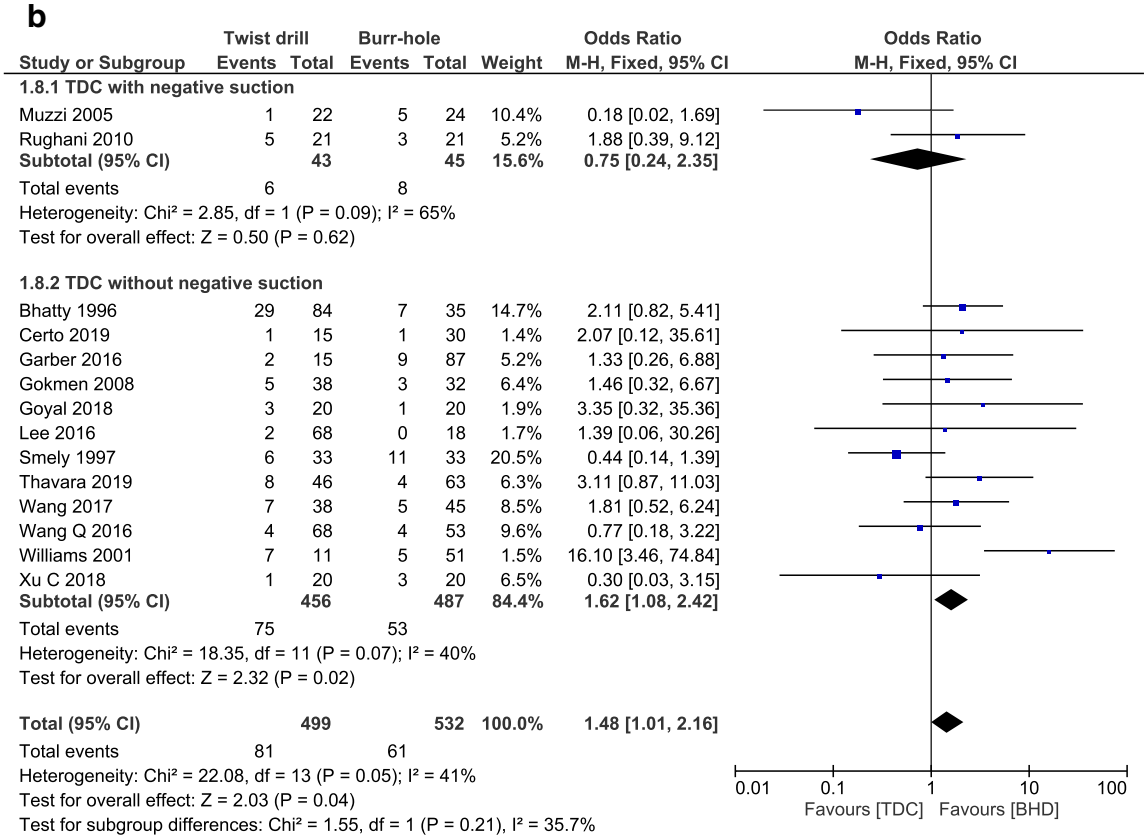
Critical appraisal

Study quality assessment using the Newcastle–Ottawa Scale (NOS) revealed high quality/low risk of bias for most observational studies with the exception of two studies which were of moderate quality. A low risk of bias was found for RCTs using the Cochrane tool (Supplement 2, Tables 1–2). Funnel plots were generated for publication bias, and no apparent asymmetry was found on visual inspection. Strength of evidence, assessed using the GRADE approach, was low for recurrence and cure and very low for mortality, reoperation, and complication. The GRADE summary of findings are summarized in Table 4.

a


Twist drill
Burr-hole
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI
M-H, Fixed, 95% CI
1.7.1 TDC with negative suction
Muzzi 2005 1 22 5 24 7.0% 0.18 [0.02, 1.69]
Rughani 2010 5 21 4 21 4.7% 1.33 [0.30, 5.84]
Subtotal (95% CI) 43 45 11.7% 0.64 [0.21, 1.99]
Total events 6 9
Heterogeneity: Chi² = 2.16, df = 1 (P = 0.14); I² = 54%
Test for overall effect: Z = 0.77 (P = 0.44)
1.7.2 TDC without negative suction
Bhatty 1996 29 84 7 35 10.0% 2.11 [0.82, 5.41]
Certo 2019 3 15 5 30 4.1% 1.25 [0.26, 6.12]
Garber 2016 2 15 9 87 3.5% 1.33 [0.26, 6.88]
Gokmen 2008 5 38 3 32 4.4% 1.46 [0.32, 6.67]
Goyal 2018 3 20 1 20 1.3% 3.35 [0.32, 35.36]
Kim 2020 4 48 5 17 10.4% 0.22 [0.05, 0.94]
Lee 2016 2 68 0 18 1.2% 1.39 [0.06, 30.26]
Smely 1997 6 33 11 33 13.8% 0.44 [0.14, 1.39]
Thavara 2019 8 46 4 63 4.3% 3.11 [0.87, 11.03]
Wang 2017 7 38 5 45 5.7% 1.81 [0.52, 6.24]
Wang Q 2016 9 68 9 53 13.5% 0.75 [0.27, 2.03]
Williams 2001 7 11 14 51 2.8% 4.63 [1.17, 18.27]
Xu C 2018 14 20 15 20 6.9% 0.78 [0.19, 3.13]
Xu M 2020 7 116 3 42 6.4% 0.83 [0.21, 3.39]
Subtotal (95% CI) 620 546 88.3% 1.23 [0.87, 1.75]
Total events 106 91
Heterogeneity: Chi² = 18.10, df = 13 (P = 0.15); I² = 28%
Test for overall effect: Z = 1.18 (P = 0.24)
Total (95% CI) 663 591 100.0% 1.16 [0.84, 1.62]
Total events 112 100
Heterogeneity: Chi² = 20.85, df = 15 (P = 0.14); I² = 28%
Test for overall effect: Z = 0.90 (P = 0.37)
Test for subgroup differences: Chi² = 1.18, df = 1 (P = 0.28), I² = 14.9%
0.01 0.1 1 10 100
Favours [TDC] Favours [BHD]

b


Twist drill
Burr-hole
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI
M-H, Fixed, 95% CI
1.8.1 TDC with negative suction
Muzzi 2005 1 22 5 24 10.4% 0.18 [0.02, 1.69]
Rughani 2010 5 21 3 21 5.2% 1.88 [0.39, 9.12]
Subtotal (95% CI) 43 45 15.6% 0.75 [0.24, 2.35]
Total events 6 8
Heterogeneity: Chi² = 2.85, df = 1 (P = 0.09); I² = 65%
Test for overall effect: Z = 0.50 (P = 0.62)
1.8.2 TDC without negative suction
Bhatty 1996 29 84 7 35 14.7% 2.11 [0.82, 5.41]
Certo 2019 1 15 1 30 1.4% 2.07 [0.12, 35.61]
Garber 2016 2 15 9 87 5.2% 1.33 [0.26, 6.88]
Gokmen 2008 5 38 3 32 6.4% 1.46 [0.32, 6.67]
Goyal 2018 3 20 1 20 1.9% 3.35 [0.32, 35.36]
Lee 2016 2 68 0 18 1.7% 1.39 [0.06, 30.26]
Smely 1997 6 33 11 33 20.5% 0.44 [0.14, 1.39]
Thavara 2019 8 46 4 63 6.3% 3.11 [0.87, 11.03]
Wang 2017 7 38 5 45 8.5% 1.81 [0.52, 6.24]
Wang Q 2016 4 68 4 53 9.6% 0.77 [0.18, 3.22]
Williams 2001 7 11 5 51 1.5% 16.10 [3.46, 74.84]
Xu C 2018 1 20 3 20 6.5% 0.30 [0.03, 3.15]
Subtotal (95% CI) 456 487 84.4% 1.62 [1.08, 2.42]
Total events 75 53
Heterogeneity: Chi² = 18.35, df = 11 (P = 0.07); I² = 40%
Test for overall effect: Z = 2.32 (P = 0.02)
Total (95% CI) 499 532 100.0% 1.48 [1.01, 2.16]
Total events 81 61
Heterogeneity: Chi² = 22.08, df = 13 (P = 0.05); I² = 41%
Test for overall effect: Z = 2.03 (P = 0.04)
Test for subgroup differences: Chi² = 1.55, df = 1 (P = 0.21), I² = 35.7%
0.01 0.1 1 10 100
Favours [TDC] Favours [BHD]

◂**Fig. 3** Forest plots comparing odds of **A** recurrence and **B** reoperation following twist drill craniostomy vs burr hole drainage. TDC, twist drill craniostomy; BH, burr hole drainage

Discussion

The present systematic review and meta-analysis did not demonstrate a significantly different outcome profiles between TDC and BHD, with the exception of a possibly higher reoperation rate with TDC. A higher

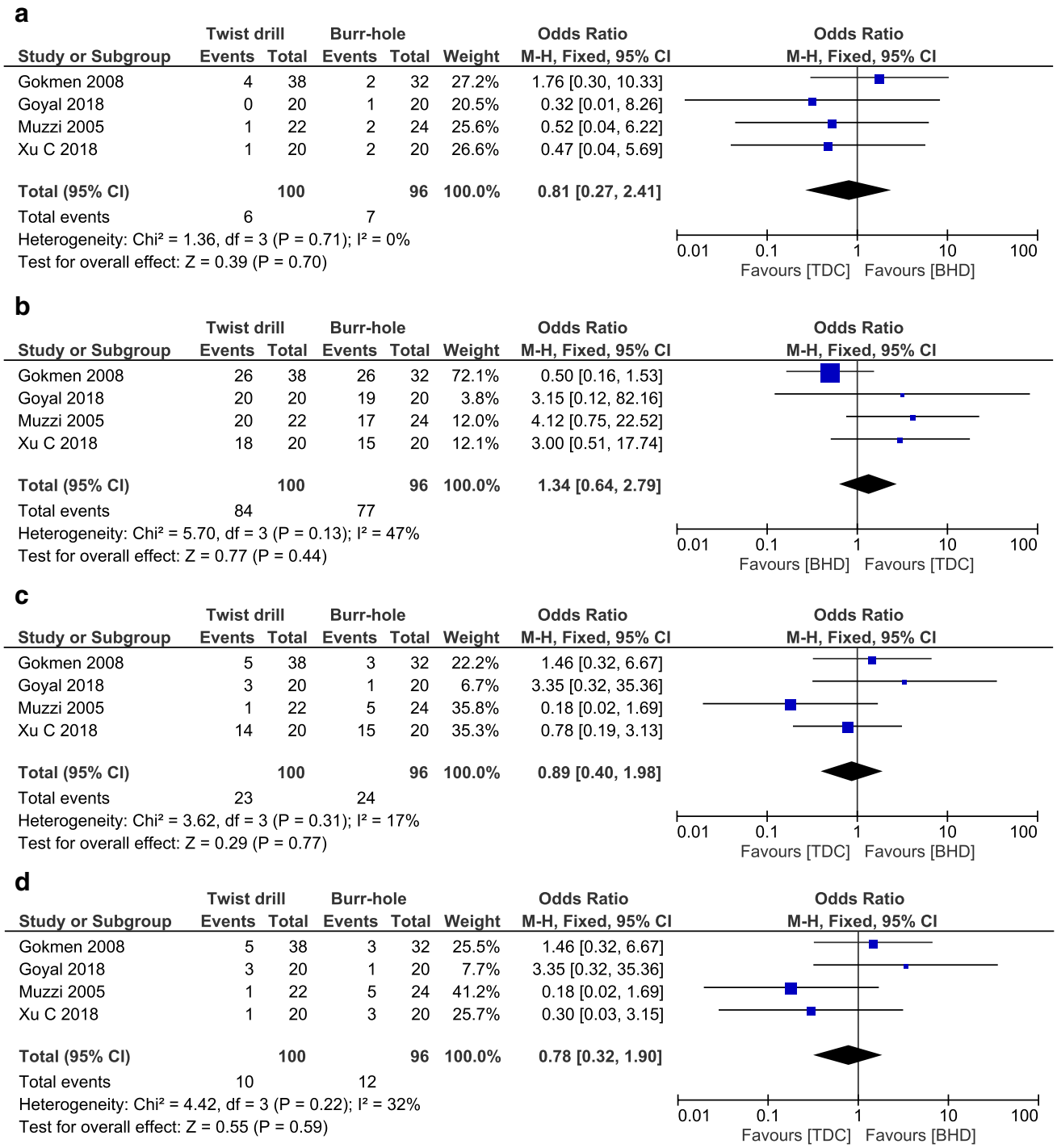


Fig. 4 Meta-analysis of 4 RCTs (**A**, **B**, **C**, **D**)

Table 4 GRADE summary of findings (SoF) table

Outcomes	No of participants (studies)	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with burr hole drainage	**Risk difference with twist drill craniostomy**
Mortality	553 (9 observational studies)	⨁◯◯◯ Very low	**OR 1.22** (0.61 to 2.46)	52 per 1,000	**11 more per 1,000** (20 fewer to 67 more)
Recurrence	1249 (16 observational studies)	⨁⨁◯◯ Low	**OR 1.17** (0.84 to 1.64)	169 per 1,000	**23 more per 1,000** (23 fewer to 81 more)
Reoperation	1026 (14 observational studies)	⨁◯◯◯ Very low	**OR 1.50** (1.02 to 2.19)	115 per 1,000	**48 more per 1,000** (2 more to 106 more)
Complications	571 (8 observational studies)	⨁◯◯◯ Very low	**OR 0.71** (0.39 to 1.29)	101 per 1,000	**27 fewer per 1,000** (59 fewer to 26 more)
Cure	940 (12 observational studies)	⨁⨁◯◯ Low	**OR 1.11** (0.72 to 1.72)	890 per 1,000	**10 more per 1,000** (36 fewer to 43 more)

The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

CI confidence interval, *OR* odds ratio

GRADE Working Group grades of evidence

High certainty: True effect lies close to that of the estimate of the effect

Moderate certainty: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: The true effect may be substantially different from the estimate of the effect

Very low certainty: The true effect is likely to be substantially different from the estimate of effect

complication rate was observed with BHD, but this was not found to be statistically significant. As opposed to previously conducted meta-analyses, it is important to note that only studies with direct comparisons were included in our study and subgroup analysis was performed to determine the effect of type of postoperative drainage. [1, 6] Further, only primary evacuations were included, and efficacy for drainage of recurrent hematomas was not evaluated. While the overall rate of recurrence was not significantly different, reaccumulations requiring reoperation as perceived by the groups reporting their results were higher with TDC. These findings point to the possible existence of a potential trade-off between inadequate drainage and greater surgical invasiveness, as determined by the size of the bone opening. Previous meta-analyses by Almenawer et al. and Teles et al. have suggested that drain usage following evacuation was associated with a significantly lower recurrence rate. [1, 28] Recurrence was also found to be lower with the utilization of a two-burr hole technique as opposed to a single burr hole. [19] Therefore, an adequate decompression supplemented with postoperative drainage may be the cornerstone of a good clinical outcome, as opposed to choice between different surgical techniques, which may be dictated by patient age, baseline functional status, and comorbidities. Another postulated reason for higher recurrence with TDC or single burr hole drainage is suggested to be challenges with drainage of multiloculated cSDH. [6]

Although the overall results demonstrated a higher rate of re-evacuation with TDC, subgroup analysis demonstrated that TDC with negative suction was associated with similar reoperation rates as BHD. Therefore, given that TDC may be performed at the bedside as opposed to BHD and may offer similar outcomes when used with negative suction, it may be a reasonable option to consider for elderly patients with comorbidities who may be less suitable surgical candidates. For the same reason, it may also be important to consider from a cost-saving perspective. With the exception of recurrence requiring reoperation, our findings are consistent with findings from previous meta-analyses by Almenawer et al. and Ducruet et al. which demonstrated no significant difference in outcomes such as mortality, morbidity, cure, and recurrence (reaccumulation) rates following BHD or TDC for cSDH evacuation. [1, 6] However, a systematic review published in 2003 that pooled data indirectly from 48 studies followed by a decision analysis study also suggested a higher recurrence rate with percutaneous drainage, which is consistent with our findings. [32]

The lack of uniform outcomes reporting in patients undergoing surgical evacuation of cSDH is important to consider. [34] For instance, many studies within our meta-analysis defined recurrence as a clinically significant hematoma reaccumulation that warranted re-evacuation [8, 10, 11, 17, 27, 29], while others measured any reaccumulations as a recurrence. [4, 5, 21, 23, 25, 26, 31, 33] Heterogeneity in outcomes reporting was also significant due to highly variable duration of postoperative follow-up ranging from 4 weeks to 4 years.

Limitations

There were some important limitations to the present systematic review and meta-analysis. Due to the observational nature of most included studies, we observed a low strength of evidence for all outcomes on GRADE evaluation. As mentioned previously, we observed heterogeneity in outcomes reporting, and all outcomes of interest were not reported consistently in all included studies. Many outcomes were also difficult to interpret due to the highly variable length of follow-up across studies. Hospital and procedure costs, as well as resource utilization, were not evaluated in included studies. It was also not possible to exclude the effect of heterogeneity in surgical technique on outcomes, as the size of TDC opening reported was also variable. Cure rates across studies were reported using multiple different functional assessment scales. In addition, given that this was a meta-analysis, the effect of confounders such as age, sex, anticoagulation, steroid use, and other comorbidities could not be adjusted via multivariable analysis. Only two studies ($n = 88$) reported usage of a negative suction device with TDC, which limits the strength and generalizability of findings obtained from subgroup analysis. Furthermore, we could not able to find studies reporting BHC with active drainage (negative suction) that fit in our inclusion criteria; therefore, we were not able to do BHC with active drainage vs TDC with or without active drainage subgroup meta-analysis.

Conclusion

An updated systematic review and meta-analysis of available literature directly comparing TDC and BHD for initial evacuation of cSDH did not demonstrate clear superiority of either technique, although reoperations may be higher following TDC. Usage of negative suction drainage with TDC may lead to similar rates of reoperation as BHD. Further improvement in TDC techniques may improve overall drainage and prevent clinically significant reaccumulation warranting reoperation.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-021-05019-3.

Author contribution K.Y.: Conception and design, data collection, data analysis, and writing original draft.

A.G.: Conception and design, data collection, data analysis, and writing and revising original draft.

J.V.G.: Study supervision, revising, and approving final draft.

Data availability Supplemental data included.

Code availability Not applicable.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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Comments:

Chronic Subdural Hematoma (CSDH) is one of the most frequent neurosurgical diagnosis. Nevertheless, the optimal treatment regimen is yet to be defined. Twist-drill Craniostomy (TDC) and Burr-hole Drainage (BHD) are the two most frequently used surgical treatment techniques, with countless reports in literature as to the pros and cons of each of these. Nevertheless, there is currently no consensus as to which of these techniques is the superior.

I commend the authors for this systematic review and meta-analysis, providing solid data on the current evidence level in terms of BHD versus TDC in CSDH. Further, this work raises essential questions as to lack of evidence when it comes to the optimal drainage of patients with CSDH, highlighting the need for more research/evidence in the treatment of this patient category.

Jiri Bartek
Stockholm, Sweden

This publication describes a systematic review and meta-analysis of CSDH treatment using classical burr hole craniostomy vs twist drill technique. The study is methodologically sound and is a nicely performed study on a - for neurosurgeons - very important subject. It adds to the growing evidence that the way a CDSH is drained is less important as long as drainage is performed for a yet undetermined time period.

Frantz Poulsen
Denmark