

Effectiveness of a single burr hole as a surgical technique for the management of chronic subdural hematoma: A clinical case series study

GEORGE FOTAKOPOULOS¹, CHARALAMPOS GATOS¹, VASILIKI EPAMEINONDAS GEORGAKOPOULOU²,
DEMETRIOS A. SPANDIDOS³, NIKOLAOS TRAKAS⁴, PAGONA SKLAPANI⁴ and KOSTAS N. FOUNTAS¹

¹Department of Neurosurgery, General University Hospital of Larisa, School of Medicine, University of Thessaly, 41221 Larisa, Greece;

²Department of Pathophysiology, National and Kapodistrian University of Athens, 11527 Athens, Greece;

³Laboratory of Clinical Virology, School of Medicine, University of Crete, 71003 Heraklion, Greece;

⁴Department of Biochemistry, Sismanogleio Hospital, 15126 Athens, Greece

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Abstract. Chronic subdural haematoma (chSDH) commonly affects the elderly population, and a number of factors are related to its recurrence. As regards the procedure, the percentage of its involvement in the chSDH recurrence must be clarified. Thus, the present study aimed to investigate the factors related to chSDH recurrence and to determine the efficacy and contribution of the single burr hole technique in preventing hematoma recurrence. The present study represents a single-center, retrospective study of chSDH cases who underwent surgical evacuation via single burr hole technique. Statistical analyses were executed using the Statistical Package for the Social Sciences. The Shapiro-Wilk test was used for the evaluation of the normality of the distribution of variables. Fisher's exact test was used for the categorical variables, and continuous data were evaluated with the Mann-Whitney U test. In total, 166 patients were divided into two groups: Group A (154 patients, 92.8%) without hematoma recurrence, and Group B (12 patients, 7.2%) with hematoma recurrence. All patients were re-operated on, only when they had clinical and radiological deterioration. In the present study, the hematoma recurrence rate using single burr hole surgery for chSDH evacuation was 7.2%, and was relatively small compared with other procedures reported in the literature. Overall, the patients who underwent single burr hole surgery for chSDH evacuation had an increased risk of hematoma recurrence, when this was in combination with anticoagulant use, history of a brain stroke event, and mixed hematoma density observed in CT scans. Notably, in the case

of recurrence, the potential interval for recurrence was 16 days following the initial surgical evacuation of the hematoma.

Introduction

Chronic subdural haematoma (chSDH) commonly affects the elderly population, with the incidence reaching 7.4% in patients >70 years old (1-3). Although the prognosis of symptomatic chSDH after surgical evacuation is usually favorable, the recurrence rate in several studies was reported to reach up to 34%, with hematoma management being challenging for the neurosurgeon (2-5). In the literature, numerous factors were revealed to be related to chSDH recurrence, including Glasgow Coma Scale (GCS) at admission, anticoagulant therapy, history of dementia and stroke, hematoma volume, and surgical technique (6-8).

With regard to surgical approaches, craniotomy with subsequent membranectomy, twist drill craniostomy, and single or two burr hole craniotomy with or without enlargement, +/- irrigation and drainage have been reported in the literature with different rates of hematoma recurrence and surgical outcome (2,5,6,8,9). In addition, middle meningeal artery embolization (eMMA) for the management of symptomatic chSDH, which is a more recent strategy for devascularization, has been proposed as an alternative technique (10,11). However, this method may be effective only for asymptomatic and/or limited chSDH with no clear surgical indication (11,12). Additionally, the direct procedural costs of eMMA are greater compared with chSDH surgical evacuation (13).

As regards the procedure of single burr hole surgery, the percentage of its involvement in chSDH recurrence warrants clarification. Thus, the present study aimed to investigate the factors related to chSDH recurrence and to evaluate the efficacy and contribution of the single burr hole technique in preventing hematoma recurrence.

Patients and methods

Study design and population. The present study represents a single-center, retrospective study of chSDH cases. All

Correspondence to: Dr George Fotakopoulos, Department of Neurosurgery, General University Hospital of Larisa, School of Medicine, University of Thessaly, Mezourlo 1, 41221 Larisa, Greece
E-mail: gftakop@yahoo.gr

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Table I. Baseline demographic characteristics of patients with chSDH.

Parameters	All patients	Group A	Group B	P-value
Patients, n (%)	166 (100.0)	154 (92.8)	12 (7.2)	
Age, mean $\pm$ SD (years)	75.8 $\pm$ 10	75.5 $\pm$ 10	79.5 $\pm$ 9	0.141
Sex (male), n (%)	126 (75.9)	118 (71.0)	8 (4.8)	0.437
Anticoagulant use, n (%)	53 (31.9)	49 (29.5)	4 (2.4)	0.914
Type of anesthesia, n (%)				
General, n (%)	86 (51.8)	77 (46.3)	9 (5.4)	0.095
Dexmedetomidine sedation, n (%)	80 (48.1)	77 (46.3)	3 (1.8)	
History of previous head trauma event, n (%)	145 (87.3)	135 (81.3)	10 (6.0)	0.664
History of brain stroke event, n (%)	52 (31.3)	49 (29.5)	3 (1.8)	0.624
Presurgical imaging findings				
Laterality				
Left, n (%)	78 (46.9)	72 (43.3)	6 (3.6)	0.231
Right, n (%)	58 (34.9)	56 (33.7)	2 (1.2)	
Bilateral, n (%)	30 (18.0)	26 (15.6)	4 (2.4)	
Hematoma density				
Hypodense, n (%)	36 (21.6)	35 (21.0)	1 (0.6)	0.244
Isodense, n (%)	46 (27.7)	41 (24.6)	5 (3.0)	0.262
Hyperdense, n (%)	12 (7.2)	10 (6.0)	2 (1.2)	0.190
Mixed density, n (%)	72 (43.3)	68 (40.9)	4 (2.4)	0.466
Hematoma thickness, mean $\pm$ SD (mm)	16.5 $\pm$ 3.7	15.8 $\pm$ 2.5	25.2 $\pm$ 4.9	0.001
Midline shift, mean $\pm$ SD (mm)	9.5 $\pm$ 1.9	9.2 $\pm$ 1.4	13.6 $\pm$ 3.2	0.001
Neurological findings at admission				
Positive pronator drift test, n (%)	154 (92.7)	142 (85.5)	12 (7.2)	0.315
Gait disturbances, n (%)	107 (64.4)	98 (59.0)	9 (5.4)	0.428
Speech disturbances related to chSDH, n (%)	80 (48.1)	72 (43.3)	8 (4.8)	0.184
Post-surgical (24-h) imaging findings				
Hematoma thickness, mean $\pm$ SD (mm)	7.8 $\pm$ 2.5	7.4 $\pm$ 1.7	12.8 $\pm$ 5.0	0.001
Midline shift, mean $\pm$ SD (mm)	3.0 $\pm$ 1.0	3.0 $\pm$ 0.8	3.9 $\pm$ 2.3	0.438
Post-surgical (2-month) imaging findings				
Hematoma thickness, mean $\pm$ SD (mm)	8.2 $\pm$ 3.6	7.4 $\pm$ 1.7	18.9 $\pm$ 4.8	0.001
Midline shift, mean $\pm$ SD (mm)	3.4 $\pm$ 1.8	3.0 $\pm$ 0.8	9.1 $\pm$ 2.1	0.001
Diabetes mellitus, n (%)	38 (22.8)	37 (22.2)	1 (0.6)	0.213
Hypertension, n (%)	42 (25.3)	40 (24.0)	2 (1.2)	0.475
Dementia, n (%)	29 (17.5)	28 (16.8)	1 (0.6)	0.387
Recurrence interval, mean $\pm$ SD (days)	1.3 $\pm$ 6.4	0.0 $\pm$ 0.0	18.8 $\pm$ 16.5	0.001

ChSDH, chronic subdural hematoma; SD, standard deviation.

included patients underwent surgical evacuation for chSDH with single burr hole technique at the University Hospital of Larisa, (Larisa, Greece) between January 2015 and December 2021. The Institutional Review Board of the School of Medicine and the School of Health Sciences in the University of Thessaly approved the present study (approval no. 2591/25-02-2022), and the decision for approval was finalized by the 33rd General Assembly session on February 28, 2022.

In total, 166 patients (mean age, 75.8 years; 126 men and 40 women) were admitted to the University Hospital of Larisa with chSDH and 12 (7.2%) were re-operated for hematoma recurrence during the follow-up. Data collection

was performed, reviewed and analyzed by two physicians (GF and CG), based on the following inclusion criteria: Patients >8 years of age that underwent surgical hematoma evacuation with single burr hole technique between 2015 and 2021. The exclusion criteria included: Cases with incomplete medical files, cases lost to follow-up, or cases in which another surgical technique was used. All participants had a regular follow-up for 1 to 10 years from the day of discharge from the hospital. Patient outcomes were evaluated using a computed tomography (CT) scan and a complete neurological examination at 24 h post-admission. Following discharge from the hospital the patients were examined at 15 days and at 1, 2 and 3 months.

Table II. Outcomes of patients after chronic subdural hematoma.

Parameters	All patients	Group A	Group B	P-value
Recurrence interval, mean $\pm$ SD (days)	1.3 $\pm$ 6.4	0.0 $\pm$ 0.0	18.8 $\pm$ 16.5	0.001
Neurological improvement, n (%)	157 (94.5)	148 (96.1)	9 (75)	0.002
Mortality, n (%)	4 (2.4)	3 (1.8)	1 (8.3)	0.165

SD, standard deviation.

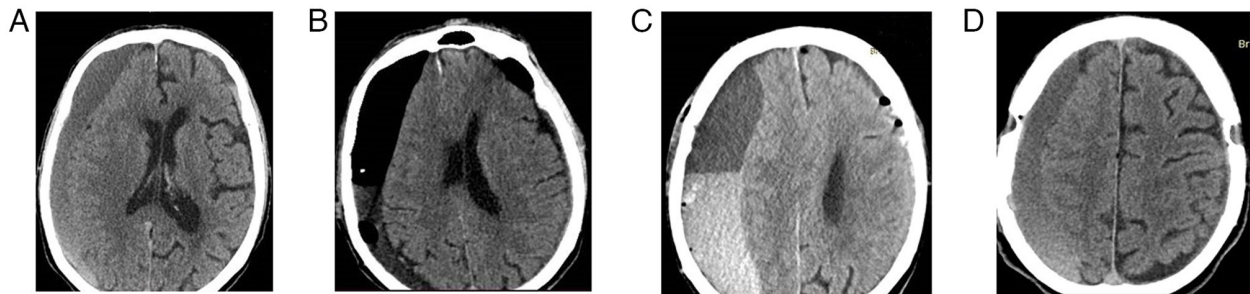


Figure 1. (A) A pre-surgical CT scan (axial view) revealed a bilateral chronic subdural hematoma in a male 75-year old patient admitted to the Emergency Department of the General University Hospital of Larisa (Larissa, Greece) (referral from the peripheral hospital), with left hemiparesis, headache, dizziness, heart disease treated with antiplatelet medication. Due to hemiparesis the patient had an abnormal gait, with instability that emerged from 24 h from onset of symptoms. (B) A 24-h post-surgical CT scan (axial view) after the first bilateral hematoma removal, under general anesthesia, with a single burr hole technique used at both sites. (C) A CT scan (axial view) performed a month later revealed a new hematoma forming on the right side of the brain, and the patient was re-admitted to the ED of the General University Hospital of Larisa, with symptoms of dizziness, headache and hemiparesis. (D) A 24-h post-surgical CT scan (axial view) after the recurrence of the hematoma at the right side, 30 days later, following surgical evacuation under local anesthesia (dexmedetomidine sedation), using a single burr hole technique again. ED, Emergency Department, CT, computed tomography.

Neurological improvement was characterized by the clinical advancement in mild hemiparesis, cognitive function and disorientation, as per the Medical Research Council (MRC) muscle strength scale. In addition, to compare both groups, outcome measurements such as postoperative mortality (within the first 30 days after treatment) were collected. All patients were re-operated on only when they exhibited clinical and radiological deterioration.

Procedure. All surgical procedures were performed under general anesthesia or dexmedetomidine sedation in a supine position. The single burr hole was drilled over the maximum thickness of the hematoma. The dura matter was opened in a cruciate manner and coagulated. The external capsule of the hematoma was coagulated and incised. The subdural collection was then removed and evacuated with a closed external ventricular drainage system operating in gravity conditions placed at a low height below the patient's bed.

Statistical analysis. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS version 11; SPSS, Inc.). Data are presented as the mean $\pm$ standard deviation. The Shapiro-Wilk test was used for the evaluation of the normality of the distribution of variables. Fisher's exact test was used for the categorical variables, and continuous data were evaluated with the Mann-Whitney U test. Receiver operating characteristic (ROC) analysis was performed to reveal the implementation of the single burr hole technique for the surgical evacuation of chSDH in recognition

of unfavorable outcomes (neurological improvement). $P < 0.05$ was considered to indicate a statistically significant difference.

Results

The patients were divided into two groups: Group A included patients treated with surgical hematoma evacuation without recurrence, and Group B included those who were re-operated on for hematoma recurrence. These groups were identified based on the following demographic, clinical, and radiographic data that were retrieved from the medical archives when available: Age, sex, anticoagulant therapy, type of anesthesia (general or dexmedetomidine sedation), history of previous head trauma or brain stroke event, presurgical imaging findings (laterality, hematoma density and thickness, midline shift), neurological findings upon admission (pronator drift test, gait and speech disturbances related to chSDH), post-surgical imaging findings, history of diabetes and hypertension, as well as dementia and recurrence interval (Table I). A case that was evaluated is presented in Fig. 1.

In total, 166 patients who underwent single burr hole surgery for chSDH evacuation were enrolled in the present study. Group A consisted of 154 patients (92.8%) and 12 patients (7.2%) were included in Group B. Of the 166 included patients, 126 (75.9%) were males, and the median age was 75.8 years. The baseline characteristics of the study participants are revealed in Table I. Patient outcomes are presented in Table II. The recurrence interval was 18.8 ± 16.5 days for Group B ($P = 0.001$), and neurological

Table III. Univariate analysis for neurological improvement.

Parameters	No improvement	With improvement	P-value
Groups, n (%)	157 (94.6)	9 (5.4)	
Group A, n (%)	148 (89.1)	6 (3.6)	0.002
Group B, n (%)	9 (5.4)	3 (1.8)	
Age, mean $\pm$ SD (years)	75.6 $\pm$ 10	78.6 $\pm$ 11.5	0.207
Sex (male), n (%)	120 (72.2)	6 (3.6)	0.505
Anticoagulant use, n (%)	47 (28.3)	6 (3.6)	0.022
Type of anesthesia, n (%)			
General, n (%)	81 (48.7)	5 (3.0)	0.817
Dexmedetomidine sedation, n (%)	76 (45.7)	4 (2.4)	
History of previous head trauma event, n (%)	139 (83.7)	6 (3.6)	0.055
History of brain stroke event, n (%)	46 (27.7)	6 (3.6)	0.019
Presurgical imaging findings			
Laterality			
Left, n (%)	74 (44.5)	4 (2.4)	0.073
Right, n (%)	57 (34.3)	1 (0.6)	
Bilateral, n (%)	26 (15.6)	4 (2.4)	
Hematoma density			
Hypodense, n (%)	32 (19.2)	4 (2.4)	0.088
Isodense, n (%)	44 (26.5)	2 (1.2)	0.705
Hyperdense, n (%)	10 (6.0)	2 (1.2)	0.074
Mixed density, n (%)	71 (42.7)	1 (0.6)	0.045
Hematoma thickness, mean $\pm$ SD (mm)	16.3 $\pm$ 3.4	18.7 $\pm$ 6.7	0.531
Midline shift, mean $\pm$ SD (mm)	9.5 $\pm$ 1.8	10.5 $\pm$ 3.1	0.465
Neurological findings at admission			
Positive pronator drift test, n (%)	146 (87.9)	8 (4.8)	0.644
Gait disturbances, n (%)	99 (59.6)	8 (4.8)	0.115
Speech disturbances related to chronic subdural hematoma, n (%)	76 (45.7)	4 (2.4)	0.817
Post-surgical (24-h) imaging findings			
Hematoma thickness, mean $\pm$ SD (mm)	9.1 $\pm$ 4.2	7.7 $\pm$ 2.4	0.713
Midline shift, mean $\pm$ SD (mm)	3.1 $\pm$ 1.9	3.0 $\pm$ 0.9	0.701
Post-surgical (2-month) imaging findings			
Hematoma thickness, mean $\pm$ SD (mm)	11.3 $\pm$ 6.6	8.0 $\pm$ 3.3	0.479
Midline Shift, mean $\pm$ SD (mm)	5.1 $\pm$ 3.5	3.3 $\pm$ 1.6	0.242
Diabetes mellitus, n (%)	34 (20.4)	4 (2.4)	0.114
Hypertension, n (%)	41 (24.6)	1 (0.6)	0.314
Dementia, n (%)	26 (15.6)	3 (1.8)	0.197
Recurrence interval, mean $\pm$ SD (days)	1.1 $\pm$ 6.1	5.7 $\pm$ 10	0.002
Mortality, n (%)	0 (0)	4 (2.4)	0.001

SD, standard deviation.

improvement occurred in 148 out of 154 patients (96.1%) for Group A (P=0.002).

Univariate analysis for neurological improvement revealed that there was a statistically significant difference in the following parameters: Anticoagulant use (P=0.022), history of brain stroke event (P=0.019), mixed hematoma density (P=0.045), and recurrence interval (P=0.002) (Table III).

Multivariate analysis (Table IV) revealed that none of the three parameters (anticoagulant use, history of brain stroke

events, and mixed hematoma density) alone could predict hematoma reappearance. Overall, recurrence interval was the only independent factor associated with chSDH recurrence (P=0.023). ROC analysis for neurological improvement and recurrence interval demonstrated that a recurrence interval of 16 days after the first hematoma evacuation has better dispersion (100% sensitivity and 97.5% specificity) as evaluated by an area under the curve standard error [AUC(SE)] of [0.638 (0.110)] and (P=0.163) Table V and Fig. 2.

Table IV. Multivariate analysis for neurological improvement.

Parameter	P-value	Exp (B)	95% CI for Exp (B)	
			Lower	Upper
Anticoagulant use, n (%)	0.921	-0.013	-0.266	0.240
History of brain stroke event, n (%)	0.500	-0.087	-0.341	0.167
Mixed density, n (%)	0.057	0.066	-0.002	0.134
Recurrence interval, mean $\pm$ SD (days)	0.023	-0.006	-0.011	-0.001

CI, confidence interval; SD, standard deviation.

Table V. ROC analysis for Neurological improvement.

Parameters	Area	Standard error	95% CI lower-upper	P-value
Anticoagulant, n (%)	0.684	0.093	0.500-0.867	0.064
History of brain stroke event, n (%)	0.687	0.093	0.504-0.870	0.060
Mixed density, n (%)	0.329	0.078	0.176-0.483	0.086
Recurrence interval, mean $\pm$ SD (days)	0.638	0.110	0.423-0.854	0.163

SD, standard deviation; CI, confidence interval.

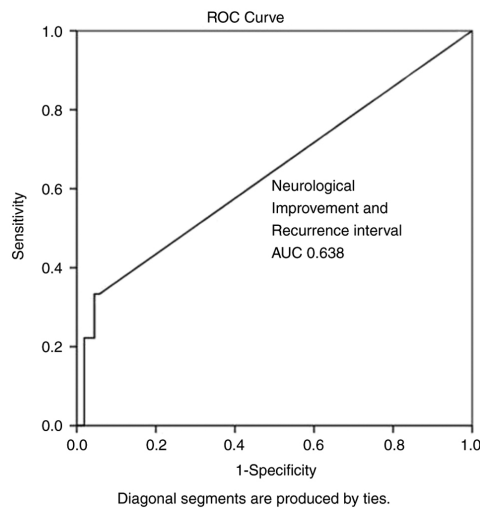


Figure 2. ROC analysis for neurological improvement and recurrence interval, predicting a recurrence interval of 16 days after initial hematoma removal. AUC, 0.638. ROC, receiver operative characteristic; AUC, area under the curve.

Discussion

In the present study, the hematoma recurrence rate using single burr hole surgery for chSDH evacuation was 7.2%, which was relatively small in comparison with other procedures mentioned in the literature (1-3). Overall, the results of the present study suggest that the patients who underwent single burr hole surgery for chSDH evacuation had an increased risk of hematoma recurrence, if they also used anticoagulants, had history of a brain stroke event, and mixed hematoma density observed in CT scans. Notably, when recurrence occurred, the

potential recurrence interval was 16 days after the first hematoma surgical evacuation.

The mechanisms underlying postoperative recurrence of chSDHs are multifaceted. Age-related changes in the brain may contribute to the development of recurrence of chSDH due to the reduced compliance of the brain (decreased elasticity and atrophic characteristics), making it harder for the brain to recover after hematoma removal (14,15). Therefore, damaged postoperative brain expansion impedes the elimination of the subdural space, leading to easier shifting of the brain (14,15). In addition, the main reasons for recurrence after single burr hole surgery for chSDH, include incomplete flushing, operating at the wrong time, and poor selection of cases.

An incidentally noticed hematoma no thicker than the width of the skull, which does not produce symptoms, can generally be managed conservatively initially, however when symptomatic chSDH is detected, it usually requires surgical removal (11,12). With a reported recurrence rate as high as 34% among symptomatic patients with surgically treated chSDH, recurrence was one of the main outcome measures analyzed by the present study.

Along these lines, the rate of recurrence in managing small chSDH with eMMA was found to be 9% in asymptomatic patients (11,12).

However, the frequency of recurrent cases varies based on the designated circumstances. The present definition was based on the association between neurologic and radiologic findings that was effective in determining the need for re-intervention and which yielded a 7.2% result.

There is evidence that chSDH could develop in the presence of potential hemorrhagic diathesis due to receiving anticoagulation therapy (16). In addition, recurrent hematoma

in the subdural space could be caused by hemorrhagic diathesis from the anticoagulant medication (11,17). In the present study, anticoagulant therapy was not demonstrated to be an independent factor for hematoma recurrence, and only when combined with other factors could it lead to a higher likelihood of reoperation.

There are multiple association models investigating risk factors for chSDH recurrence (18-20). Among the numerous factors involved in chSDH recurrence, the density of the hematoma has been reported as an independent predictor of recurrence. More precisely, patients with mixed chSDH density, observed in CT scans, had a higher rate of recurrence (21). However, in the present study, mixed hematoma density did not prove to be an independent factor for chSDH recurrence and was only considered in conjunction with other factors (such as anticoagulant therapy and history of stroke).

With regard to the time between the first surgical evacuation of chSDH and recurrence, there is a wide range of time intervals reported in studies, ranging from 12 to 180 days (21,22). In the present study, if recurrence occurred, the potential recurrence interval was 16 days after the initial surgical removal of the hematoma. It should be noted that the present study had several limitations. The main limitation was that it was a single-center study performed by two neurosurgeons who used the same surgical technique, as well as its retrospective nature, which could lead to inaccuracies in collecting and interpreting data from the medical records of patients. In addition, the neurological outcome of patients after surgical hematoma evacuation depends on the underlying initial pathology, as most of the included patients were elderly.

In conclusion, the present study revealed that the hematoma recurrence rate using single burr hole surgery for chSDH evacuation was markedly low (7.2%) compared with other procedures reported in the literature. Overall, the patients who underwent single burr hole surgery for chSDH evacuation had an increased risk of hematoma recurrence only when this was in combination with anticoagulant use, history of a brain stroke event, and mixed hematoma density observed in CT scans. If recurrence occurred, the potential recurrence interval was 16 days after the first hematoma surgical evacuation. The results of the present study were derived from a single-center study; therefore, multi-center standardized protocols are required to be developed to improve the evaluation of patient outcomes. Furthermore, prospective data collection could provide further insight into the value of the present study's assessment.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

CG and GF conceptualized the study. CG, VEG, PS, NT, DAS, GF and KNF substantially contributed to data interpretation and analysis and wrote and prepared the draft of the manuscript. CG and GF analyzed the data and provided critical revisions. CG and GF confirm the authenticity of all the raw data. All authors contributed to manuscript revision and have read and approved the final version of the manuscript.

Ethics approval and consent to participate

The Institutional Review Board of the School of Medicine and School of Health Sciences of University of Thessaly approved (approval no. 2591/25-02-2022) the present study and the decision was finalized by the 33rd General Assembly on 28/02/2022. The present study was in line with the Declaration of Helsinki (1995; as revised in Edinburgh in 2000). Written informed consent was obtained from all the included patients for participating in the present study.

Patient consent for publication

Written informed consent was obtained from all included patients or their next-of-kin before surgery for the publication of any associated images and data.

Competing interests

DAS is the Editor-in-Chief for the journal, but had no personal involvement in the reviewing process, or any influence in terms of adjudicating on the final decision, for this article. The other authors declare that they have no competing interests.

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