ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neuroendoscopy

Editor
J. André Grotenhuis, MD
Radboud University Medical Center; Nijmegen, The Netherlands

SNI® Open Access

Original Article

Where to make burr hole for endoscopic hematoma removal against intracerebral hemorrhage at the basal ganglia to increase the hematoma removal rate – Comparison between trans-forehead and along-the-long-axis approaches

Masahito Katsuki[1], Norio Narita[1], Kanako Sato[1], Ryuzaburo Kochi[1], Taketo Nishizawa[1], Kokoro Kawamura[1], Naoya Ishida[1], Ohmi Watanabe[1], Siqi Cai[1], Shinya Shimabukuro[1], Teiji Tominaga[2]

[1]Department of Neurosurgery, Kesennuma City Hospital, Kesennuma, [2]Department of Neurosurgery, Tohoku University Graduate School of Medicine, Sendai, Miyagi, Japan.

E-mail: Masahito Katsuki - ktk1122nigt@gmail.com; *Norio Narita - nnarita@mbr.nifty.com; Kanako Sato - knkst.1128@gmail.com; Ryuzaburo Kochi - ryuzaburo0618@hotmail.co.jp; Taketo Nishizawa - shunchan99@icloud.com; Kokoro Kawamura - kokorokawamura32@gmail.com; Naoya Ishida - naoya0618utss@gmail.com; Ohmi Watanabe - domybest.1507@gmail.com; Siqi Cai - saisiki2006@yahoo.co.jp; Shinya Shimabukuro - urtwnttntl@gmail.com; Teiji Tominaga - tomi@nsg.med.tohoku.ac.jp

***Corresponding author:**
Norio Narita,
Department of Neurosurgery,
Kesennuma City Hospital,
Kesennuma, Miyagi, Japan.

nnarita@mbr.nifty.com

Received : 08 December 2020
Accepted : 13 January 2021
Published : 03 February 2021

DOI
10.25259/SNI_887_2020

Quick Response Code:

ABSTRACT

Background: Endoscopic hematoma removal is performed to treat intracerebral hemorrhage (ICH) at the basal ganglia. In our hospital, young neurosurgical trainees perform it for the only 1st to the 3rd time. We perform a "trans-forehead approach" and hypothesized that our technique would contribute to higher hematoma removal rate and easiness despite their inexperience. We compared our dataset with an open dataset with along-the-long-axis approaches using pre- and intraoperative neuronavigation by well-trained neurosurgeons and tested the utility of our trans-forehead approach.

Methods: We retrospectively investigated our 17 consecutive patients with hypertensive ICH who underwent endoscopic hematoma removal using the trans-forehead approach. We obtained the open dataset and compared our data with the 12 patients from the open dataset using the inverse probability weighting method. Operative time, hematoma removal rate, postoperative hematoma volume, Glasgow Coma Scale (GCS) on day 7, and modified Rankin Scale (mRS) at 6 months were assessed as outcomes.

Results: The median age was 68 (interquartile range; 58–78) years. Median postoperative hematoma volume, removal rate, operative time, GCS on day 7, and mRS at 6 months were 9 (2–24) mL, 90 (79–98)%, 53 (41–80) min, 13 (12–13), and 4 (2–5), respectively. The weighted generalized estimating equations revealed that operative time was shorter in the along-the-long-axis group, but other items were not significantly different between the two approaches.

Conclusion: The hematoma removal rate of endoscopic hematoma removal with the trans-forehead approach by young trainees was not different from that of the along-the-long-axis approach by well-trained neurosurgeons using neuronavigation.

Keywords: Endoscopic hematoma removal, Hematoma removal rate, Intracerebral hemorrhage, Less invasive surgery, Training of residents

INTRODUCTION

Intracerebral hemorrhages (ICHs) comprise 10–30% of all strokes and are strongly related to high mortality and morbidity.[6,12] Hypertensive ICH accounts for about 70% of all ICH types. After onset, the median 30-day mortality rate is 15–50%,[1,19] and only 20% regain functional independence 3 months after ICH.[20] Surgical hematoma removal and conservative therapy are the main treatments for ICH, but the meaning of surgery for most ICH patients remains under discussion. The effectiveness of surgery has been repeatedly evaluated,[14,15] and the surgical treatment for ICH (STICH) and STICH II trials did not exhibit comprehensive benefits for the functional outcome over medical therapy.[13] However, almost all of the patients underwent craniotomy in these previous studies; therefore, the benefit and efficacy of endoscopic hematoma removal remain unknown.

In 2016, Phase II of the Minimally Invasive Surgery with Thrombolysis for ICH Evacuation (MISTIE) trial showed favorable preliminary results for the stereotactic aspiration and catheter drainage with a tissue plasminogen activator.[3,16] Furthermore, an endoscopic evacuation arm of MISTIE II, called the intraoperative stereotactic computed tomography-guided endoscopic surgery (ICES), showed the safety and effectiveness of the chronic neurological outcome.[23] Recently, the MISTIE trial Phase III demonstrated no functional benefit for the MISTIE procedure in selected patients; however, a subgroup analysis demonstrated improvement of the 1-year outcomes in patients with an increased hematoma removal rate (≤15 mL residual hematoma after the surgery).[4] These minimally invasive surgeries are becoming popular, and endoscopic hematoma removal has been widely practiced and reduces operative time and invasiveness compared to traditional craniotomy.[11]

Considering these previous studies on minimally invasive surgery, although the effect of endoscopic surgery for intracerebral hematoma remains unclear, a higher removal rate of hematoma would be important for outcome improvement.[4] However, Hayashi *et al.* reported that surgeons who experienced less than 10 cases of endoscopic hematoma removal achieved poor hematoma removal rates.[5] Therefore, we should invent a superior endoscopic hematoma removal procedure to achieve a high removal rate of the hematoma that even less experienced surgeons can do well.

In our hospital, young neurosurgical trainees of 3–7 years perform endoscopic hematoma removal under a mentor's supervision over 60 years old, who were not skill qualified by the Japanese Society for Neuroendoscopy.[8] The trainees experienced endoscopic hematoma removal for the only 1st to the 3rd time. We perform a "trans-forehead approach" for the ICH at the basal ganglia and hypothesized that our trans-forehead approach would contribute to higher hematoma removal rate and easiness despite their inexperience. In this study, we compared our database with the open dataset of endoscopic hematoma removal for ICH at the basal ganglia with along-the-long-axis using pre- and intraoperative neuronavigation by well-trained neurosurgeons[10] and tested the utility of our trans-forehead approach.

MATERIALS AND METHODS

Study population

From the medical records between 2013 and 2020, we retrospectively investigated 17 consecutive patients with hypertensive ICH who underwent endoscopic hematoma removal. The ICH diagnosis was based on the clinical history and the presence of ICH on computed tomography (CT). The inclusion criteria for the study were as follows: (1) patients with ICH at the basal ganglia, (2) patients indicated for surgical treatment according to the Japanese Guidelines for the Management of Stroke 2009[21] and 2015[22] (described in detail in the next section) and treated endoscopically, and (3) interval between onset and hematoma removal less than 24 h. Exclusion criteria were as follows: (1) ICHs due to tumor, trauma, aneurysm, arteriovenous malformation, and hemorrhage after infarction and (2) patients who had the thalamic or caudate head hemorrhage with intraventricular hemorrhage treated by neuroendoscope for removing intraventricular hematoma only. The hospital's research ethics committee approved this study, and we gained the written informed consent for this study from all of the patients or patients' families. This retrospective study was performed following the Declaration of Helsinki.

General management

All patients received standard management according to the Japanese Guidelines for the Management of Stroke 2009[21] and 2015.[22] They were first treated with nicardipine and kept with normal blood pressure. In patients under anticoagulation therapy, their prothrombin time was normalized by administering Vitamin K and/or fresh frozen plasma. A surgical indication was also made according to the guidelines (same described in both versions).[21,22] Patients with hematoma at the basal ganglia, which was more than 30 mL and who were deteriorating neurologically were surgically indicated. Rehabilitation and nutritional support were started as soon as possible after the operation, and the prevention and treatment of complications were also performed. Patients with antithrombotic drugs were postoperatively discontinued for several days, depending on their condition and comorbidities.

Neuroendoscopic procedure

We have performed trans-forehead endoscopic procedures regardless of age, comorbidities, and presence of antithrombotic drugs. Endoscopic hematoma removal was performed under local anesthesia. We also prepared for conversion to craniotomy under general anesthesia simultaneously just in case the brain expanded rapidly or hemostasis was difficult endoscopically. The patient's head was placed on the horseshoe headrest. We first confirmed the orbitomeatal line (OM line). We then checked the CT images slice in which the hematoma was described most vigorously and write its line parallel to the OM line. As the mark, the electrocardiogram electrode was fixed [Figure 1a]. A 3 cm skin incision along the wrinkling and burr hole 3–4 cm outside the midline was made parallel to the cross-sectional line of the CT slice [Figure 1b]. After a cruciate dural incision and corticotomy, we prepared a transparent sheath with a diameter of 10 mm (Neuroport regular type; Olympus, Tokyo, Japan). The stopper was clamped so that the sheath's tip reached 1/3 of the length from the hematoma's deepest part. We made the cut out and the clamp orientation the same direction as a mark [Figure 1c]. A neurosurgeon introduced the sheath with the observation by the rigid endoscope (A70960, 2.7 mm, 0° angle; Olympus Corporation, Tokyo, Japan) through the sheath. The ECG electrode helps determine the inserting orientation, and we just considered the lateral angle [Figure 1d]. First, we saw the white matter [Figure 1e], and then, we saw the red hematoma cavity and confirmed the reach into the hematoma [Figure 1f]. The sheath was inserted to the stopper's pre-clamped position, and we removed the hematoma by the suction cannula. We did not aggressively change the sheath's direction but just rotated the sheath and removed the hematoma that came out naturally from the cut out into the sheath [Figure 1g]. The hematoma was removed by gradually pulling out and rotating the sheath. When the bleeding arteries were observed, we coagulated it by monopolar electrocautery through the suction cannula. We conserved white matter by refraining from aggressively changing the sheath's direction. We also refrained from aggressive hematoma removal near the internal capsule to save the pyramidal tract, which was not destroyed by hemorrhage, and left some part of the hematoma [Figure 1h]. After hematoma removal, we reinsert the sheath and left the drainage tube [Figure 1i]. We filled the

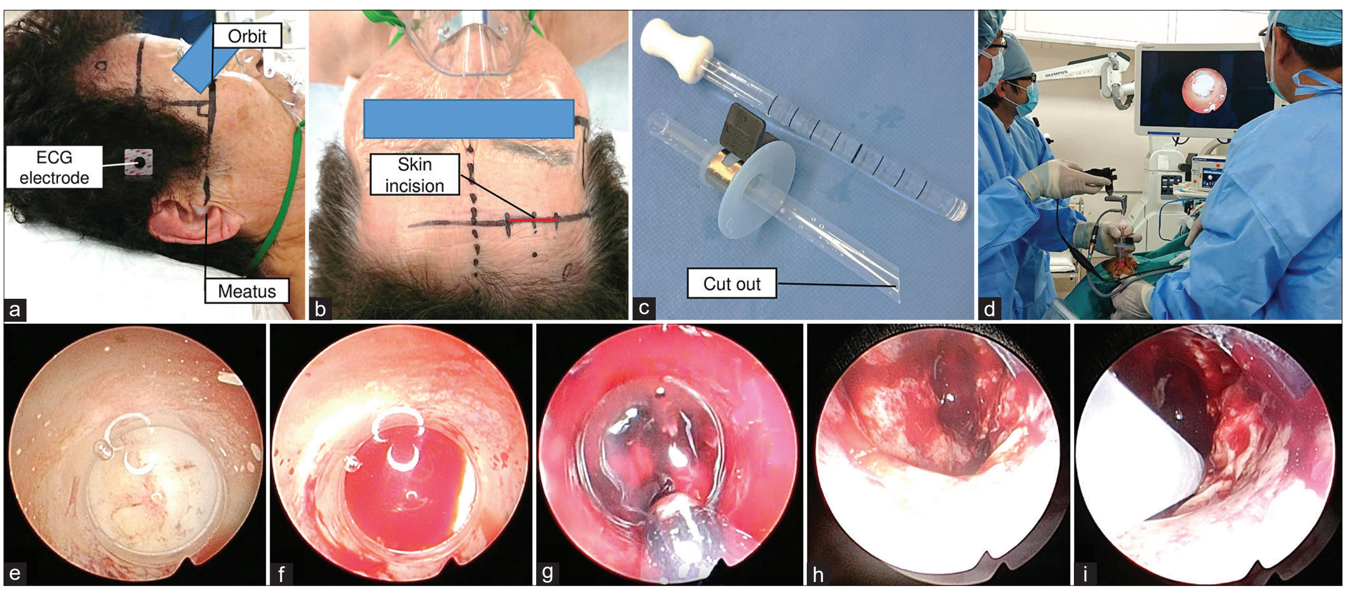

Figure 1: Intraoperative findings. We first confirmed the orbitomeatal line (OM line). We then checked the computed tomography images slice in which the hematoma was described most vigorously and write its line parallel to the OM line. As the mark, the electrocardiogram electrode was fixed (a). A 3 cm skin incision along the wrinkling and burr hole 3–4 cm outside the midline were made parallel to the cross-sectional line of the CT slice (b). After a cruciate dural incision and corticotomy, we prepared a transparent sheath. The stopper was clamped so that the sheath's tip reached 1/3 of the length from the hematoma's deepest part. We made the cut out and the clamp orientation the same direction as a mark (c). A neurosurgeon introduced the sheath with the observation by the rigid endoscope through the sheath. The ECG electrode helps to determine the inserting orientation, and we just considered the lateral angle (d). First, we saw the white matter (e), and then, we saw the red hematoma cavity and confirmed the reach into the hematoma (f). The sheath was inserted to the stopper's preclamped position, and we removed the hematoma by the suction cannula. We did not aggressively change the sheath's direction but just rotated the sheath and removed the hematoma that came out naturally into the sheath (g). We refrained from aggressive hematoma removal near the internal capsule to save the pyramidal tract, which was not destroyed by hemorrhage and left some part of the hematoma (h). After hematoma removal, we reinsert the sheath and left the drainage tube (i). The burr hole was covered with the burr hole cover, and the skin was sutured.

hematoma cavity with the artificial cerebrospinal fluid. The burr hole was covered with the burr hole cover, and the skin was sutured. The drainage tube was removed on the next day.

Clinical variables and outcomes

We collected data regarding physiological symptoms and medical history on admission; age, sex, hematoma location, Glasgow Coma Scale (GCS) score, systolic blood pressure on admission, presence of smoking, heavy drinking, comorbidities, use of antithrombotic drugs, and operative time. We also measured the hematoma volume and the hematoma removal rate from the head CT on admission and just after the operation. The hematoma volume was calculated by the ABC/2 method.[2] To evaluate the outcomes, operative time, postoperative hematoma volume, hematoma removal rate, GCS on day seven, and modified Rankin Scale (mRS) 6 months after the operation were investigated from the medical records or by telephonic or personal interview.

Comparative data

We gained the comparative data from the open dataset of Suwa Red Cross Hospital.[10] Twelve patients who had ICH at the basal ganglia underwent along-the-long-axis approaches using pre- and intraoperative neuronavigation. The data were acquired on their age, sex, GCS score on admission and day 7, systolic blood pressure on admission, presence of smoking, heavy drinking, comorbidities, use of antithrombotic drugs, pre- and postoperative hematoma volume, operative time, and mRS 6 months after the operation. We asked the corresponding author and confirmed that all the 12 patients were treated by the well-trained (over 11 years) neurosurgeons who were skill qualified by the Japanese Society for Neuroendoscopy.[8] The detail of the surgical procedures was described in their previous reports.[9,11]

Statistical analysis

Results were presented as median (interquartile range). We investigated all the 29 ICH patients focusing on the clinical variables described above, using the Mann–Whitney U-test and Fisher's exact test as univariate analysis. We performed the inverse probability weighting (IPW) method to address confounding by observed covariates, a type of propensity score analysis. The propensity score was calculated by a logistic regression model predicting treatment (trans-forehead or along-the-long-axis approaches) and adjusting the baseline characteristics of age, sex, past history, systolic blood pressure on admission, GCS score on admission, and preoperative hematoma volume as independent variables. The calculated probability of receiving the treatment was evaluated by the Hosmer–Lemeshow test and *c*-statistic. The weights for each patient were calculated as the inverse of the probability of receiving the treatment. After balancing with the IPW method, we made generalized estimating equations to assess the association between the surgical procedure and each outcome. We conducted these analyses using version 21.0.0 of SPSS software (IBM, NY, USA). A two-tailed $P < 0.05$ was considered as statistically significant.

RESULTS

General characteristics

[Tbale 1] shows the characteristics of 29 patients (17 trans-forehead approach and 12 along-the-long-axis approach) with ICH at the basal ganglia. Thirteen women and 16 men were included. The median age was 68 (58–78) years. Median postoperative hematoma volume, removal rate, operative time, GCS on day 7, and mRS at 6 months were 9 (2–24) mL, 90 (79–98)%, and 53 (41–80) min, 13 (12-13), and 4 (2–5), respectively. Only the preoperative GCS E score was significantly worse in the along-the-long-axis group ($P = 0.011$). Other variables were not significantly different between the two datasets. In all 29 patients, no one had chronic renal failure treated with hemodialysis or liver cirrhosis, reported as related to the hematoma removal rate.[5]

Among both patients who underwent trans-forehead approach and along-the-long-axis approach, no one needed conversion to craniotomy during endoscopic hematoma removal. All the patients could undergo endoscopic surgery under local anesthesia without the patient's body movement, change of the vital signs, or worsening respiratory conditions.

Comparison of the trans-forehead approach and along-the-long-axis approach using IPW method

Regarding the probability of receiving the treatment, *P*-value was 0.821 according to the Hosmer–Lemeshow test, and the c-statistic was 0.873 (95% confident interval 0.745–1.000). The weighted generalized estimating equations revealed that operative time was shorter in the along-the-long-axis group ($P < 0.001$). However, postoperative hematoma volume, removal rate, GCS score on day 7, and mRS at 6 months were not significantly different between the two approaches [Table 2].

Representative case

A 79 woman presented with the left hemiplegia and her GCS score was 7 (E2V1M4) on admission. CT showed 75 mL of the right putaminal hemorrhage [Figure 2a]. Endoscopic hematoma removal with a trans-forehead approach was performed. Postoperative CT showed 3 mL of the rest, and the hematoma removal rate was 96% [Figure 2b]. Her GCS score was 14 on postoperative day 7, and mRS at 6 months was 4 due to severe left hemiparesis.

Table 1: Characteristics of the patients and dataset.

Variables	Total (*n*=29)	Trans-forehead (*n*=17)	along-the-long-axis (*n*=12)	*P*-value
Age (years)	68 (58–78)	65.5 (60–72)	63 (43–79)	0.556
36–65	14 (48%)	8 (47%)	6 (50%)	
66–75	6 (21%)	4 (24%)	2 (17%)	
76–85	8 (28%)	5 (29%)	3 (25%)	
86–90	1 (3%)	0	1 (8%)	
Women:men (%women)	13:16 (45%)	7:10 (41%)	6:6 (50%)	0.716
History				
History of smoking	11 (38%)	6 (35%)	5 (42%)	0.999
History of drinking	6 (21%)	4 (21%)	2 (17%)	0.999
Hypertension	21 (72%)	12 (71%)	9 (75%)	0.999
Dyslipidemia	12 (41%)	6 (35%)	6 (50%)	0.471
Diabetes mellitus	6 (21%)	5 (29%)	1 85%)	0.354
Antiplatelet drugs	21 (9%)	4 (24%)	2 (17%)	0.999
Anticoagulant drugs	3 (10%)	1 (6%)	2 (17%)	0.553
Systolic blood pressure on admission (mmHg)	181 (155–204)	175 (155–192)	186 (161–207)	0.711
GCS score preoperative				
E	3 (1–4)	3 (2–4)	1.5 (1–3)	0.011*
V	1 (1–3)	1 (1–3)	1 (1–2)	0.777
M	5 (4–6)	5 (4–6)	4.5 (2–6)	0.499
Total	9 (7–11)	10 (7–11)	7.5 (4–10)	0.152
Hematoma volume preoperative (mL)	97 (60–161)	97 (69–158)	98 (59–163)	0.983
Presence of intraventricular hematoma	15 (52%)	7 (41%)	8 (67%)	0.264
Hematoma volume postoperative (mL)	9 (2–24)	10 (4–24)	4 (1–20)	0.245
Hematoma volume postoperative > 15 mL	12 (41%)	7 (41%)	5 (42%)	0.999
Hematoma removal rate (%)	90 (79–98)	90 (79–95)	93 (77–99)	0.303
Operative time (min)	53 (41–80)	60 (46–88)	48 (40–61)	0.107
GCS score POD 7				
E	4 (3–4)	4 (4–4)	4 (3–4)	0.251
V	3 (2–4)	3 (2–3)	3 (2–5)	0.610
M	6 (5–6)	6 (6–6)	6 (4–6)	0.294
Total	13 (11–14)	13 (12–13)	12 (9–15)	0.746
mRS 6-mo postoperative	4 (2–5)	4 (3–5)	4 (2–5)	0.811
mRS 0–3	10 (34%)	5 (29%)	5 (42%)	
mRS 4	8 (28%)	6 (35%)	2 (17%)	
mRS 5	5 (17%)	3 (17%)	2 (17%)	
mRS 6	6 (21%)	3 (17%)	3 (24%)	

The results are shown with the number (%) or the median (interquartile range). *P*-value was calculated by Fisher's exact test or Mann–Whitney U-test. GCS: Glasgow Coma Scale, mRS 6-mo postoperative: Modified Rankin Scale 6 months after the operation, POD: Postoperative day, *P<0.05

DISCUSSION

The concept of our surgical strategy is as follows: (1) easiness for young trainees by inserting sheath parallel to the CT slice to understand the orientation, (2) conserve white matter by refraining from aggressively changing the sheath's direction but just rotating the sheath and removed the hematoma that came out naturally into the sheath, and (3) not requiring specialized tools for endoscopic hematoma removal,[17] the neuronavigation,[9,11,24,25] nor echo sonography.[26] Of course, when a surgeon is to perform the endoscopic procedure for the 1st time, he or she should be supervised by a skilled surgeon.[5,18] However, our results suggested that the hematoma removal rate of endoscopic hematoma removal with the trans-forehead approach for ICH at the basal ganglia by young trainees was not different from that with the along-the-long-axis approach by well-trained neurosurgeons using neuronavigation.

Where to make burr hole

Burr hole for endoscopic hematoma removal at the basal ganglia is often made at the frontal region for trans-forehead or along-the-long-axis (frontal approaches), near the Kocher's point, or on the point which was shortest to the hematoma (temporal approach). Hsieh *et al.* investigated the

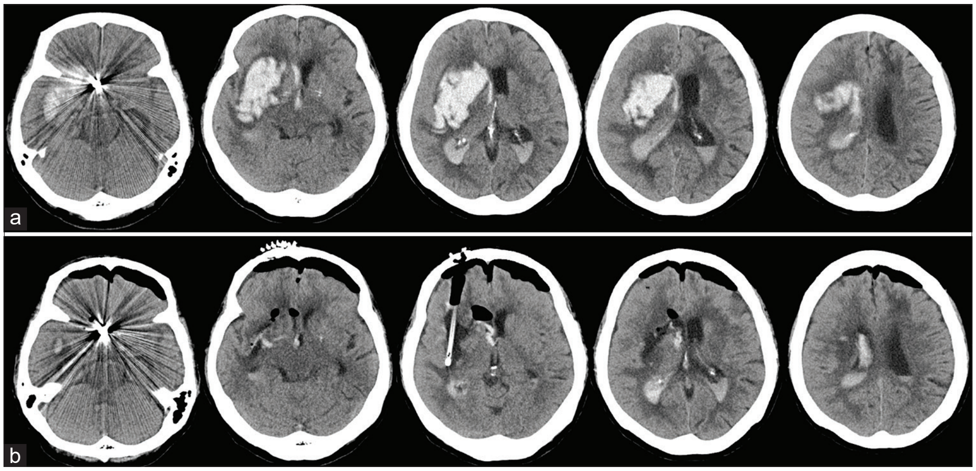

Figure 2: Representative case: a 79 woman presented with the left hemiplegia, and her GCS score was 7 (E2V1M4) on admission. The preoperative CT showed 75 mL of the right putaminal hemorrhage (a). Endoscopic hematoma removal with a trans-forehead approach was performed. Postoperative CT showed 3 mL of the rest, and the hematoma removal rate was 96% (b).

Table 2: Effect of trans-forehead approach for outcome tested by inverse probability of where to make burr hole weighting methods.

Outcome	B	Standard error	*P*-value	Beta	95% confidence interval for beta
Operative time	20.787	5.8840	<0.001*	1×10^{9}	1.039×10^{5}–1.081×10^{14}
Hematoma volume postoperative	–1.188	5.2937	0.822	0.305	0.9507×10^{-6}–9772
Hematoma volume postoperative >15 mL	–0.071	0.5582	0.899	0.932	0.312–2.782
Removal rate	–0.032	0.0388	0.415	0.969	0.898–1.045
Total GCS score POD 7	1.103	0.6841	0.107	3.013	0.788–11.514
mRS 6-mo postoperative	0.506	0.3379	0.134	1.659	0.855–3.217
mRS 4–6	0.717	0.5728	0.211	2.048	0.667–6.294

Weights are based on results from a selection model for where to make burr hole, estimated using logistic regression with trans-forehead or along the long-axis approach as the dependent variables and the baseline characteristics of age, sex, history, systolic blood pressure on admission, GCS score on admission, and preoperative hematoma volume. The weights for each patient were calculated as the inverse of the probability of approaches. We made a generalized estimating equation to assess the association between the approaches and each outcome after weighting. As to the probability of receiving the treatment, p value was 0.821 by the Hosmer–Lemeshow test, and the c-statistic was 0.873 (95% confident interval 0.745–1.000). GCS: Glasgow Coma Scale, mRS 6-mo postoperative: Modified Rankin Scale 6 months after the operation, POD: Postoperative day, *$P<0.05$ by weighted generalized estimating equations

efficacy of the two entry sites (frontal or temporal approach), and they concluded that the frontal approach could facilitate the optimal evacuation of putaminal hemorrhage. The frontal approach is through the noneloquent area, and the hematoma evacuation rate can be better than the temporal approach because the visualization of the frontal part of the hematoma might be blocked due to the limited inclination of the tube through a small burr hole in the temporal approach.[7] Their concepts of the surgical procedure are similar to ours.

Yokosuka *et al.* reported a freehand technique with making a burr hole near the Kocher's point, which is used for the cerebral ventricular drainage[26] and its utility for simplicity and safety. Their technique contributes to understanding the orientation during the puncture and hematoma removal, but their technique sometimes requires a change of the sheath's direction to remove the hematoma. The damages of sheath insertion and inclination during this technique are unknown, so we should further discuss whether to make a burr hole near the Kocher's point or along-the-long-axis (frontal) approaches. As described above, various points for making a burr hole were reported, and each point has advantages and disadvantages. Although the endoscopic hematoma removal procedure still varies from surgeon to surgeon, our results suggest that our technique contributes to the removal rate even for inexperienced young trainees.

Disadvantages of our technique

Sometimes, we could not take the sheath into the hematoma by one trial and injured the white matter. Neuronavigation enables us to precisely reach into the hematoma by one trial and avoid injuring the eloquent area and vessels while making the entry tract.[9,11,24,25] Intraoperative echo sonography is also helpful.[26] Furthermore, we did not use specialized tools for endoscopic hematoma removal like the combined irrigation-coagulation suction cannula (Fujita Medical Instrument, Tokyo, Japan), which can also be simultaneously used for irrigation and monopolar coagulation at its tip.[17] We could have performed wet and dry field techniques by irrigation[27,28] to removed more hematoma under clear visualization if we could use this. Although preparation and familiarity with those devices are required, they should be used depending on the situation and the surgeon's skill level.

Limitation

Our study's sample size was small, and quantification of the hematoma volume by ABC/2 methods is not so exact. Thus, a prospective, multicenter study with a large number of patients is needed to evaluate the difference of where to make a burr hole. However, every surgical procedure has its advantages and disadvantages. It is impossible to say which method is superior for endoscopic hematoma removal. We hope that the trans-forehead approach would help us when there is no navigation or when a young neurosurgeon is unfamiliar with the endoscopic hematoma removal for ICH at basal ganglia.

CONCLUSION

The hematoma removal rate of endoscopic hematoma removal with the trans-forehead approach for ICH at the basal ganglia by young trainees was not different from that of the along-the-long-axis approach well-trained neurosurgeons using neuronavigation.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Bernardo F, Rebordão L, Machado S, Salgado V, Pinto AN. In-hospital and long-term prognosis after spontaneous intracerebral hemorrhage among young adults aged 18-65 years. J Stroke Cerebrovasc Dis 2019;28:104350.
2. Gebel JM, Sila CA, Sloan MA, Granger CB, Weisenberger JP, Green CL, *et al*. Comparison of the ABC/2 estimation technique to computer-assisted volumetric analysis of intraparenchymal and subdural hematomas complicating the GUSTO-1 trial. Stroke 1998;29:1799-801.
3. Hanley DF, Thompson RE, Muschelli J, Rosenblum M, McBee N, Lane K, *et al*. Safety and efficacy of minimally invasive surgery plus alteplase in intracerebral haemorrhage evacuation (MISTIE): A randomised, controlled, open-label, phase 2 trial. Lancet Neurol 2016;15:1228-37.
4. Hanley DF, Thompson RE, Rosenblum M, Yenokyan G, Lane K, McBee N, *et al*. Efficacy and safety of minimally invasive surgery with thrombolysis in intracerebral haemorrhage evacuation (MISTIE III): A randomised, controlled, open-label, blinded endpoint phase 3 trial. Lancet 2019;393:1021-32.
5. Hayashi T, Karibe H, Akamatsu Y, Narisawa A, Shoji T, Sasaki T, *et al*. Endoscopic hematoma evacuation for intracerebral hemorrhage under local anesthesia: Factors that affect the hematoma removal rate. World Neurosurg 2019;126:e1330-6.
6. Hemphill JC, Greenberg SM, Anderson CS, Becker K, Bendok BR, Cushman M, *et al*. Guidelines for the management of spontaneous intracerebral hemorrhage: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2015;46:2032-60.
7. Hsieh PC, Cho DY, Lee WY, Chen JT. Endoscopic evacuation of putaminal hemorrhage: How to improve the efficiency of hematoma evacuation. Surg Neurol 2005;64:147-53.
8. Japanese Society for Neuroendoscopy. Skill Qualified Doctors by Japanese Societiy for Neuroendoscopy. Japanese Society for Neuroendoscopy; 2020; Available from: http://www.square.umin.ac.jp/jsne/qualifications.html. [Last accessed on 2020 Sep 04].
9. Katsuki M, Kakizawa Y, Nishikawa A, Yamamoto Y, Uchiyama T. Lower total protein and absence of neuronavigation are novel poor prognostic factors of endoscopic hematoma removal for intracerebral hemorrhage. J Stroke Cerebrovasc Dis 2020;29:105050.
10. Katsuki M, Kakizawa Y, Nishikawa A, Yamamoto Y, Uchiyama T. The dataset on the characteristics of the intracerebral hemorrhage patients treated by endoscopic hematoma removal or craniotomy. Data Br 2020;33:106387.
11. Katsuki M, Kakizawa Y, Nishikawa A, Yasunaga Y, Uchiyama T. Endoscopic hematoma removal of supratentorial intracerebral hemorrhage under local anesthesia reduces operative time compared to craniotomy. Sci Rep 2020;10:10389.
12. Keep RF, Hua Y, Xi G. Intracerebral haemorrhage: Mechanisms of injury and therapeutic targets. Lancet Neurol 2012;11:720-31.
13. Kellner CP, Song R, Pan J, Nistal D, Scaggiante J, Chartrain AG, *et al*. Long-term functional outcome following minimally invasive endoscopic intracerebral hemorrhage evacuation. J Neuro Intervent Surg 2020;12:489-94.
14. Mendelow AD, Gregson BA, Fernandes HM, Murray GD, Teasdale GM, Hope DT, *et al*. Early surgery versus initial conservative treatment in patients with spontaneous supratentorial intracerebral haematomas in the international surgical trial in intracerebral haemorrhage (STICH): A randomised trial. Lancet 2005;365:387-97.
15. Mendelow AD, Gregson BA, Rowan EN, Murray GD, Gholkar A, Mitchell PM, *et al*. Early surgery versus initial conservative treatment in patients with spontaneous supratentorial lobar intracerebral haematomas (STICH II): A randomised trial. Lancet 2013;382:397-408.
16. Mould WA, Carhuapoma JR, Muschelli J, Lane K, Morgan TC,

McBee NA, *et al*. Minimally invasive surgery plus recombinant tissuetype plasminogen activator for intracerebral hemorrhage evacuation decreases perihematomal edema. Stroke 2013;44:627-34.
17. Nagasaka T, Tsugeno M, Ikeda H, Okamoto T, Inao S, Wakabayashi T. Early recovery and better evacuation rate in neuroendoscopic surgery for spontaneous intracerebral hemorrhage using a multifunctional cannula: Preliminary study in comparison with craniotomy. J Stroke Cerebrovasc Dis 2011;20:208-13.
18. Nishihara T, Nagata K, Tanaka S, Suzuki Y, Izumi M, Mochizuki Y, *et al*. Newly developed endoscopic instruments for the removal of intracerebral hematoma. Neurocrit Care 2005;2:67-74.
19. Sacco S, Marini C, Toni D, Olivieri L, Carolei A. Incidence and 10-year survival of intracerebral hemorrhage in a population-based registry. Stroke 2009;40:394-9.
20. Safatli DA, Günther A, Schlattmann P, Schwarz F, Kalff R, Ewald C. Predictors of 30-day mortality in patients with spontaneous primary intracerebral hemorrhage. Surg Neurol Int 2016;7:S510-7.
21. The Japan Stroke Society. Japanese Guidelines for the Management of Stroke 2009. Tokyo: Kyowa Kikaku; 2009.
22. The Japan Stroke Society. Japanese Guidelines for the Management of Stroke 2015. Tokyo: Kyowa Kikaku; 2015.
23. Vespa P, Hanley D, Betz J, Hoffer A, Engh J, Carter R, *et al*. ICES (Intraoperative Stereotactic Computed Tomography-Guided Endoscopic Surgery) for brain hemorrhage: A multicenter randomized controlled trial. Stroke 2016;47:2749-55.
24. Wang Q, Guo W, Liu Y, Shao W, Li M, Li Z, *et al*. Application of a 3D-printed navigation mold in puncture drainage for brainstem hemorrhage. J Surg Res 2020;245:99-106.
25. Wu R, Qin H, Cai Z, Shi J, Cao J, Mao Y, *et al*. The clinical efficacy of electromagnetic navigation-guided hematoma puncture drainage in patients with hypertensive basal ganglia hemorrhage. World Neurosurg 2018;118:e115-22.
26. Yokosuka K, Uno M, Hirano K, Toi H, Matsuzaki K, Matsubara S. Freehand technique for putaminal hemorrhage. Neurol Med Chir (Tokyo) 2011;51:543-6.

How to cite this article: Katsuki M, Narita N, Sato K, Kochi R, Nishizawa T, Kawamura K, *et al*. Where to make burr hole for endoscopic hematoma removal against intracerebral hemorrhage at the basal ganglia to increase the hematoma removal rate – Comparison between trans-forehead and along-the-long-axis approaches. Surg Neurol Int 2021;12:41.