Original research

Stenting versus medical treatment for idiopathic intracranial hypertension: a matched-control study

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ABSTRACT

Background This prospective cohort study compared the outcomes of stenting and medical treatment for patients with idiopathic intracranial hypertension (IIH) and venous sinus stenosis (VSS).

Methods In this single-center cohort study, patients with IIH and VSS were evaluated between January 2014 and December 2019 with follow-up periods of 1, 3, and 6 months. The patients received either stenting or medical treatment. The two groups underwent 1:1 matching using propensity score analysis, and the clinical outcomes were compared.

Results Following 1:1 matching, 36 patients who underwent stenting and 36 who underwent medical treatment were matched. The median improvements in the papilledema Frisén grade were greater in the stenting group at 1 month (−2 vs 0), 3 months (−3 vs −1), and 6 months (−3 vs −1) than in the medical treatment group. Patients who received stenting treatment had a significantly higher prevalence of complete resolution of their respective symptoms (headache, tinnitus, or visual disturbances) at 3 months (58.3% vs 13.9%, OR 8.68, 95% CI 2.74 to 27.52) and 6 months (80.6% vs 22.2%, OR 14.50, 95% CI 4.64 to 45.32) than those receiving medical treatment.

Conclusions This matched-control study shows that stenting has a greater efficacy rate and rapid resolution of papilledema and its respective symptoms compared with medical treatment.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There is clinical evidence supporting the benefits of venous sinus stenting for patients with idiopathic intracranial hypertension (IIH) and venous sinus stenosis (VSS). However, there is a lack of studies comparing stenting with medical treatment.

WHAT THIS STUDY ADDS

⇒ The current study based on a single-center prospective database in China suggested that stenting has a higher efficacy rate and a faster resolution of papilledema and its associated symptoms compared with medical treatment.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study confirms that venous stenting has a significantly greater response rate for treating IIH with VSS than medical treatment. Stenting might be considered as a practical treatment approach that can be generalized for patients with IIH in the future. However, further large randomized controlled trials are warranted.

INTRODUCTION

Idiopathic intracranial hypertension (IIH) is a syndrome of increased intracranial pressure (ICP) of unknown etiology.[1–3] Several factors may contribute to the development of IIH. Recent advances in brain venography imaging have shown that most patients with IIH may have structural abnormalities of the cerebral venous sinus system.[4] Several studies have evaluated stenosis of the transverse venous sinus, since IIH is often associated with venous sinus stenosis (VSS).[2 4 5] Since the disease is often refractory, multimodal treatments are often employed, including weight loss programs, carbonic anhydrase treatments, or therapeutic lumbar punctures. Despite these strategies, 38–45% of patients with IIH experience eventual symptom worsening or recurrence within 6–10 years.[6 7] Although permanent cerebrospinal fluid (CSF) diversion and optic nerve sheath fenestration have been investigated as treatment options, these approaches have certain limitations.[8]

In recent years, venous sinus stenting has been shown to be a promising treatment for patients with IIH with associated VSS. Clinical evidence indicates that venous sinus stenting is beneficial for these patients.[9] Moreover, the safety profile of this procedure is favorable.[5 10] The effectiveness of venous sinus stenting has been assessed through systematic reviews and meta-analyses[9–15]; however, despite overwhelmingly positive results, studies comparing stenting with medical treatment are lacking.

In this study we present a propensity score-matched cohort study designed to determine whether stenting is more beneficial than standard medical treatment for patients with IIH and VSS. The use of propensity scores in this observational study minimizes the effect of confounding factors that arise from differences in the distribution of baseline characteristics, and it allows for replication of findings commonly found in randomized clinical trials. As a secondary outcome parameter, the Frisén scale classification of papilledema was used to increase the objective of the assessment.

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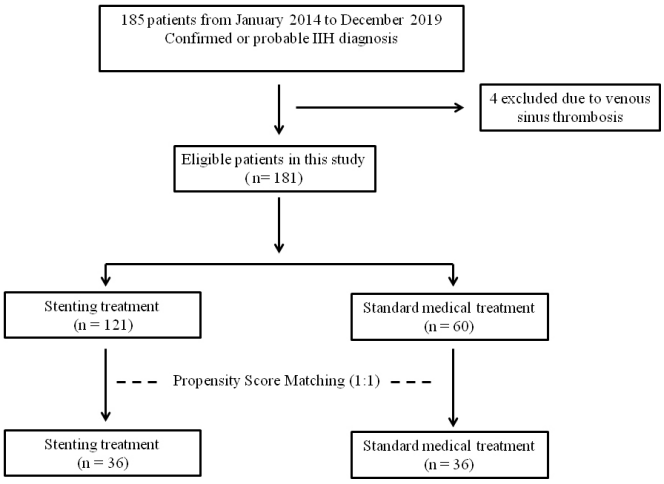

Figure 1 Flow chart of patient selection.

METHODS

Patient population

This retrospective analysis was conducted on prospectively collected data of consecutive IIH patient databases at our institution between January 1, 2014 and December 31, 2019. A flowchart of the patient selection is shown in figure 1. All patients fulfilled the following criteria: (1) papilledema; (2) a normal neurological examination except for cranial nerve abnormalities; (3) neuroimaging showing normal brain parenchyma without hydrocephalus, mass, or any structural lesion and no evidence of meningeal enhancement on MRI or CT; (4) normal CSF composition; (5) elevated CSF opening pressure (>250 mmH_2O in an adequately performed lumbar puncture); and (6) pressure gradient across the stenotic segment of >8 mmHg.

A diagnosis of IIH can be made in the absence of papilledema if criteria 2 and 3 are satisfied with unilateral or bilateral abducens nerve palsy. In addition, a diagnosis of IIH can be made if the following neuroimaging findings are present: (1) an empty sella; (2) flattening of the posterior aspect of the globe; (3) dilation of the perioptic subarachnoid space with or without a tortuous optic nerve; or (4) transverse VSS. The study exclusion criteria were (1) concomitant venous sinus thrombosis and (2) change in treatment modalities within 6 months. Informed consent was obtained from all the patients or their relatives prior to the study.

Treatment strategies, venography, manometry, and medical treatment regimen

The treatment allocation was not randomized and treatment decisions were reached using a consensus between the physicians and patients or their legal representatives. All patients had surgical indications. Some patients chose medical treatment due to a fear of surgical risks or because they declined taking long-term antiplatelet medications following the stenting procedure.

Venography and manometry were performed under conscious sedation via right femoral vein puncture. For each patient, the pressure was measured at seven points: the posterior third of the superior sagittal sinus, the torcular sinus, transverse sinus distal to the stenosis, stenotic segment of the transverse sinus, transverse sinus proximal to the stenosis, jugular bulb, and internal jugular vein. The pressure gradient was defined as the difference in the pressure between the distal and proximal stenosis segments of the transverse sinus. For microcatheter manometry, an 8F MACH 1 guiding catheter (Boston Scientific, Marlborough, Massachusetts, USA) was placed near the skull base and a Rebar-027 ev3 microcatheter (Neurovascular, Irvine, California, USA) was navigated through it over a Command ES guidewire (Abbott Vascular, Santa Clara, California, USA) to the superior sagittal sinus and other points to measure the pressure. The hub of the Rebar-027 microcatheter was connected to the pressure monitoring kit Deltran II, with a flow rate of 3 mL/hour (Utah Medical Products, Midvale, Utah, USA).

If the pressure gradient stenosis was >8 mmHg, stent placement was considered after agreement with the patient. All patients who underwent stent placement received pretreatment oral antiplatelets. Aspirin (100 mg) and clopidogrel (75 mg) were administered 3–5 days before endovascular treatment. The endovascular procedure was performed under general anesthesia. Intraoperatively, anticoagulation therapy was administered at a dose of 4000–6000 units. Intravenous heparin was administered during the stent procedure to increase the activated clotting time to >250 s.[16] An 8F MACH 1 guiding catheter was delivered to the internal jugular vein near the skull base. A 6F Navien intermediate guide catheter (ev3/Covidien, Irvine, California, USA) was then placed into the distal transverse sinus near the torcula through the 8F MACH 1 guiding catheter. A microguidewire was navigated across the stenosis using a microcatheter, followed by the deployment of a self-expanding stent (Precise, Cordis, Florida, USA) adjusted to the normal sinus venous diameter adjacent to the stenosis. Venography and manometry were performed after the procedure. Postoperatively, all patients received dual antiplatelet medications for 3 months and then received a single antiplatelet (either aspirin or clopidogrel). Patients were monitored for 3–7 days. Repeated general, neurological, and imaging examinations were performed to rule out any adverse effects after stent treatment. The patients were followed up at 1, 3, and at least 6 months.

Patients who did not receive stenting underwent a weight loss program and medical treatment. The weight loss program included a low-calorie diet (≤425 kcal/day) with a target weight loss of approximately 5–10%. During hospitalization, the medical treatment consisted of acetazolamide (0.5–4 g/day) and short-term mannitol (bolus of 0.25–1 g/kg body weight) for a duration of about 1 week or repeated lumbar punctures to reduce intracranial pressure (20 mL each), as well as analgesics for headaches.[2] The initial dosage of acetazolamide was 0.5 g daily in two divided doses, followed by dosage increases of one tablet every week up to a maximum dosage of 4 g/day. The dosage escalation was stopped if the participant had papilledema grade <1 in both eyes, unless the presence of other symptoms such as headache or tinnitus suggested that the dosage escalation should continue.[17] The dosage for the participants who were unable to tolerate the study drug was decreased gradually to a minimum of one half tablet daily. Patients were then followed up at 1, 3, and at least 6 months. Patients who were intolerant to medical treatment were considered for stenting, optic nerve sheath fenestration, or diversion of the CSF with a shunt.

Data collection and evaluation

The preoperative demographic and clinical data collected from the patients included age, sex, body mass index (BMI), onset to treatment time, CSF opening pressure, symptoms and signs at admission, past medical history, medication, blood serum immunity, and inflammatory markers, and ophthalmologic examinations. Two trained and qualified neurointerventionists interpreted the MRI or DSA images of the neurovascular system. A third neurointerventionist was introduced to resolve any disagreements and reach a consensus. The characteristics of the lesions were recorded, including the site of dominance (right

or left unilateral dominance or co-dominance) and the location of the stenosis (transverse sinus (TS), sigmoid sinus (SS), or TS to SS). To measure the stenosis rate, the smallest diameter of the affected venous sinus in the lateral projection was compared with the normal diameter of the corresponding venous sinus in the anteroposterior projection. The length of the stenosis was determined by measuring the proximal and distal boundaries of the affected venous sinus from a lateral or anterior-posterior projection.[18]

Improvement in the presenting signs was defined as an improvement in the papilledema Frisén grade at the 1-, 3-, and 6-month follow-ups from the baseline. Two ophthalmologists with at least 10 years of experience blinded to the imaging and clinical results evaluated the degree of papilledema (Frisén grade) in the most severe eye.[19] If there were any disagreements, a third ophthalmologist was consulted to reach a consensus. The Frisén grade of papilledema is graded from 0 to 5: at grade 0 the disc is normal; at grade 1 a subtle grey halo appears with a temporal gap; at grade 2 the halo becomes circumferential; at grade 3 the optic nerve head becomes enlarged and obstructs at least one major vessel; at grade 4 the optic nerve head becomes elevated; and at grade 5 there is complete or partial obscuration of all vessels of the disc, with protrusion of the optic nerve head as a dome.

The other efficacy measures were the improvement status of symptoms at the 1-, 3-, and 6-month follow-ups. Trained and qualified investigators, who were blinded to the baseline and imaging data, evaluated the patients' clinical outcome. The symptom outcome variable was the clinical outcome following the 1-, 3-, and 6-month follow-up periods. An experienced neurologist evaluated the improvement status based on the presenting clinical symptoms including headache, visual symptoms, and tinnitus. Visual symptoms include transient visual obscuration, blurry vision, visual field deficits, and reduced visual acuity. Visual field deficits were measured using a Humphrey visual field analyzer (Carl Zeiss Meditec) using the SITA Faster 24–2 test protocol. Best-corrected visual acuity was measured using the Snellen chart. Visual examinations were performed before and after treatment. These visual examination results were transformed into categorized outcomes—that is, asymptomatic, and improved or unchanged or worsened—to facilitate statistical analysis.

Asymptomatic outcomes indicated the complete resolution of symptoms or other focal objective neurological symptoms. Improved outcomes were defined as residual symptoms or other focal objective neurological symptoms that did not require further intervention, and unchanged (or worsened) outcomes referred to no change or worsening of the aforementioned symptoms. If there was discordance between the resolution of headaches, visual disturbances, and tinnitus, the outcome was considered improved but not asymptomatic.[20] Additionally, permanent but stable visual field deficits were considered improved or asymptomatic, depending on the status of the headache symptoms.[13]

Statistical analysis

The data were presented as mean±SD or median (IQR) for continuous variables and ordinal variables and as numbers (percent) for categorical variables. The baseline and procedural characteristics between the two groups were compared using the Wilcoxon rank-sum test for continuous and ordinal variables and the Pearson χ^2 test or Fisher's exact test for categorical variables.

Propensity score matching was performed to improve comparability between the two groups. The covariates used to generate the propensity scores included patient variables that were significantly associated with the treatment method (medical therapy vs stenting), including age, systolic blood pressure, visual disturbances, papilledema CSF pressure, stenosis rate, preoperative pressure gradient, and preoperative papilledema Frisén grade (online supplemental figures 1–3). The data were matched 1:1 without replacement (greedy matching algorithm) using a caliper width ≤0.2 of the SD of the logit of the propensity scores.

To compare the symptom outcome variable between the groups, the ORs with 95% CIs were analyzed using a binary logistic regression model. The Wilcoxon rank-sum test was used to analyze papilledema improvement. Statistical significance was set at $p<0.05$. The type I error rate was controlled using the Bonferroni correction procedure ($p<0.017$) for multiple comparisons. SPSS version 25.0 (IBM, Armonk, New York, USA) was used to analyze the data.

RESULTS

Patient baseline and lesion characteristics

Of the 181 patients, 121 (66.9%) received stenting while 60 (33.1%) received medical treatment. As shown in table 1, patients in the stenting group were older (37.8 vs 34.1 years, $p=0.033$) and had higher systolic blood pressure (131.8 vs 125.2 mmHg, $p=0.018$) than those receiving medical treatment. Compared with the medical treatment group, patients in the stenting group had a higher prevalence of visual disturbances (86.8% vs 70%, $p=0.007$) and papilledema (89.3% vs 63.3%, $p<0.001$). The CSF pressure was significantly higher in the stenting group than in the medical treatment group (311.7 mmH_2O vs 282.3 mmH_2O, $p=0.001$). In the stenting group the stenosis rate (75.5% vs 70.9%, $p=0.010$) as well as the pressure gradient (15.0 mmHg vs 11.0 mmHg, $p=0.001$) was significantly higher than in those receiving medical treatment. There was no significant difference between the groups regarding onset to treatment time, obesity, metabolic disorder (BMI, hypertension, diabetes mellitus, hyperlipidemia, thyroid disorder), female-related comorbidities (menstrual disorder, uterine myoma, abortion history, contraceptive medication), immune system and related inflammatory comorbidities (allergic history, rheumatic history, and recent common cold), the use of diuretics, anticoagulation therapy, or steroid therapy ($p>0.05$ for each). Similarly, no significant differences between the groups were identified for stenosis length, location, or pattern of venous drainage ($p>0.05$ for each)

Propensity score matching and score-adjusted analysis

Patients in the medical treatment and stenting treatment groups were matched 1:1 according to their baseline characteristics (table 1). Following matching, all covariates were statistically similar between the two groups. The median improvements in papilledema Frisén grade were greater in the stenting group at 1 month (–2 vs 0), 3 months (–3 vs −1), and 6 months (–3 vs −1) compared with the medical treatment group (table 2). The stenting treatment group had a greater proportion of patients with complete resolution of symptoms at 1 month than the medical treatment group (22.2% vs 5.6%, $p=0.057$). At 3 months (58.3% vs 13.9%, $p<0.001$) and 6 months (80.6% vs 22.2%, $p<0.001$), complete resolution of symptoms was significantly greater among patients in the stenting treatment group than in the medical treatment group. In addition, there was a significant association between stenting treatment and complete resolution of symptoms at the 3-month follow-up (OR 8.68,

Table 1 Baseline and procedural characteristics of patients with idiopathic intracranial hypertension and venous sinus stenosis treated with stenting and medical treatment

	Prematched population (n=181)			Postmatched population (n=72)		
Baseline and lesion variables	Medical treatment (n=60)	Stenting (n=121)	P value	Medical treatment (n=36)	Stenting (n=36)	P value
Age, mean±SD	34.1±10.4	37.8±9.8	0.033	34.2±10.5	36.5±9.5	0.332
Women, n (%)	44 (73.3)	93 (76.9)	0.603	27 (75.0)	25 (69.4)	0.599
SBP, mean±SD	125.2±15.6	131.8±18.5	0.018	124.7±17.7	129.6±14.3	0.196
Onset to treatment time, months, median (IQR)	4.5 (1.5–12.0)	3.0 (1.2–8.0)	0.322	4.5 (1.7–12.0)	4.5 (1.5–8.0)	0.615
Symptoms and signs						
Headache, n (%)	51 (85.0)	92 (76.0)	0.163	30 (83.3)	27 (75.0)	0.384
Tinnitus, n (%)	12 (20.0)	23 (19.0)	0.874	7 (19.4)	6 (16.7)	0.759
Visual disturbances, n (%)	42 (70.0)	105 (86.8)	0.007	28 (77.8)	27 (75.0)	0.781
Papilledema, n (%)	38 (63.3)	108 (89.3)	<0.001	28 (77.8)	28 (77.8)	1.0
Obesity and metabolism disorder						
BMI, mean±SD	26.4±5.7	27.5±4.5	0.168	26.6±6.8	27.2±4.3	0.684
Hypertension, n (%)	14 (23.3)	37 (30.6)	0.308	10 (27.8)	12 (33.3)	0.779
Diabetes mellitus, n (%)	2 (3.3)	3 (2.5)	1.0	2 (5.6)	2 (5.6)	1.0
Hyperlipidemia, n (%)	3 (5.0)	13 (10.7)	0.200	3 (8.3)	5 (13.9)	0.71
Thyroid disorder, n (%)	0	3 (2.5)	–	0	2 (5.6)	–
Female-related factors						
Anemia, n (%)	5 (8.3)	5 (4.1)	0.303	3 (8.3)	0	–
Menstrual disorder, n (%)	5 (8.3)	3 (2.5)	0.118	3 (8.3)	1 (2.8)	0.614
Uterine myoma, n (%)	1 (1.7)	5 (4.1)	0.665	0	0	–
Abortion history, n (%)	3 (5.0)	5 (4.1)	1.0	1 (2.8)	0	–
Contraceptive drug, n (%)	1 (1.7)	6 (5.0)	0.428	0	1 (2.8)	–
Immunity and inflammatory related factors						
Allergic history, n (%)	8 (13.3)	9 (7.4)	0.201	4 (11.1)	4 (11.1)	1.0
Rheumatic history, n (%)	1 (1.7)	5 (4.1)	0.665	1 (2.8)	5 (13.9)	0.199
Common cold, n (%)	13 (21.7)	20 (16.5)	0.399	7 (19.4)	5 (13.9)	0.527
Other history						
Diuretic use, n (%)	37 (61.7)	71 (58.7)	0.700	20 (55.6)	13 (36.1)	0.098
Steroid therapy, n (%)	11 (18.3)	26 (21.5)	0.620	7 (19.4)	5 (13.9)	0.527
Anticoagulation therapy, n (%)	14 (23.3)	34 (28.1)	0.494	8 (22.2)	9 (25.0)	0.781
Lesion and procedural characteristics						
CSF pressure, mmH_2O	282.3±70.8	311.7±41.9	0.001	298.6±35.9	303.8±35.7	0.545
Transverse sinus dominance, n (%)						
Uni-dominance	47 (78.3)	94 (77.7)	0.921	28 (77.8)	26 (72.2)	0.586
Co-dominance	13 (21.7)	27 (22.3)		8 (22.2)	10 (27.8)	
Stenosis location, n (%)						
Transverse sinus	21 (35.0)	37 (30.6)	0.283	13 (36.1)	11 (30.6)	0.280
Sigmoid sinus	4 (6.7)	3 (2.5)		4 (11.1)	1 (2.8)	
Transverse sigmoid sinus	35 (58.3)	81 (66.9)		19 (52.8)	24 (66.7)	
Stenosis length, median (IQR)	25.1 (15.7–35.2)	21.1 (15.4–30.0)	0.128	25.1 (17.9–40.0)	20.6 (15.6–29.4)	0.126
Stenosis rate, mean±SD	70.9±12.0	75.5±10.8	0.010	71.7±11.6	73.8±12.1	0.450
Preoperative pressure gradient, median (IQR)	11.0 (9.5, 16.5)	15.0 (11.0, 20.5)	0.001	11.0 (9.0, 16.0)	11.5 (9.5,16.5)	0.986
Pretreatment papilledema Frisén grade, n (%)			0.001			0.577
0	14 (23.3)	8 (6.6)		5 (13.9)	5 (13.9)	
1	4 (6.7)	3 (2.5)		1 (2.8)	2 (5.6)	
2	13 (21.7)	24 (19.8)		9 (25.0)	8 (22.2)	
3	17 (28.3)	53 (43.8)		11 (30.6)	16 (44.4)	

Continued

Table 1 Continued

Baseline and lesion variables	Prematched population (n=181)			Postmatched population (n=72)		
	Medical treatment (n=60)	Stenting (n=121)	P value	Medical treatment (n=36)	Stenting (n=36)	P value
4	12 (20.0)	27 (22.3)		10 (27.8)	5 (13.9)	
5	0	6 (5.0)		0	0	

BMI, body mass index; CSF, cerebrospinal fluid; SBP, systolic blood pressure.

95% CI 2.74 to 27.52, p<0.001) and at the 6-month follow-up (OR 14.50, 95% CI 4.64 to 45.32, p<0.001).

Postoperative complications and second stent placements

After the stenting treatment, 24 patients had gastrointestinal discomfort, 11 patients had menorrhagia, three patients had gingival bleeding, and one patient had fundus hemorrhage. Pulmonary infection occurred in one patient. A pseudoaneurysm at the femoral puncture site was found in one patient. Of all the patients who received stenting treatment, three received a second stent placement. One patient had bilateral papilledema and a second stent was placed at the contralateral venous sinus. Another patient showed improved symptoms after stent placement, with the symptoms worsening later. One year after stenting significant re-stenosis was observed and further stent placement was performed. In another patient, symptoms improved after the first stent placement; however, there was no resolution of the papilledema and occasional headache and blurred vision remained. Three months later, a second stent placement was performed and no worsening of blurred vision was observed.

DISCUSSION

In this 1:1 matched-control study, patients treated with venous stenting had significantly greater response rates than those given medical treatment. One key factor for improving symptoms may be the rapid resolution of the venous pressure gradient across the stenosis and a significant decrease in ICP,[21–23] leading to improvement of the respective symptoms at follow-up. Accordingly, a substantial improvement in the papilledema grade was

Table 2 Outcome measures of patients undergoing medical treatment and stenting

Outcome variables	Prematched population (n=181)				Postmatched population (n=72)			
	Medical treatment (n=60)	Stenting (n=121)	OR (95% CI)	P value	Medical treatment (n=36)	Stenting (n=36)	OR (95% CI)	P value
Papilledema Frisén grade*								
Baseline to month 1 (median)	2 to 1	3 to 1	–		3 to 2	3 to 1	–	
Change (median)	–1	–2	–	<0.001†	0	–2	–	<0.001†
Baseline to month 3 (median)	2 to 1	3 to 0	–		3 to 1	3 to 0	–	
Change (median)	–1	–3	–	<0.001†	–1	–3	–	<0.001†
Baseline to month 6 (median)	2 to 0	3 to 0	–		3 to 1	3 to 0	–	
Change (median)	–2	–3	–	<0.001†	–1	–3	–	<0.001†
Total symptoms								
1 month after treatment, n (%)			2.87 (1.04 to 7.91)	0.036‡			4.86 (0.95 to 24.75)	0.057‡
Asymptomatic	5 (8.3)	25 (20.7)			2 (5.6)	8 (22.2)		
Symptoms improved or unchanged or worse	55 (91.7)	96 (79.3)			34 (94.4)	28 (77.8)		
3 months after treatment, n (%)			8.92 (3.90 to 20.40)	<0.001‡			8.68 (2.74 to 27.52)	<0.001‡
Asymptomatic	8 (13.3)	70 (57.9)			5 (13.9)	21 (58.3)		
Symptoms improved or unchanged or worse	52 (86.7)	51 (42.1)			31 (86.1)	15 (41.7)		
6 months after treatment, n (%)			7.68 (3.79 to 15.56)	<0.001‡			14.50 (4.64 to 45.32)	<0.001‡
Asymptomatic	15 (25.0)	87 (71.9)			8 (22.2)	29 (80.6)		
Symptoms improved or unchanged or worse	45 (75.0)	34 (28.1)			28 (77.8)	7 (19.4)		

*Values are median changes from baseline to months 1, 3 and 6 in papilledema in the study eye, adjusted for center, baseline papilledema Frisén grade in the study eye.
†Assessed using Wilcoxon rank sum test.
‡Assessed using logistic regression.

evident in the stenting group compared with that in the medical treatment group.

This finding is consistent with a previous study which showed that papilledema, the most distinguishing symptom associated with intracranial hypertension, has long been associated with increased ICP.[24] Compared with the medical treatment group, patients undergoing stenting had rapid signs of improvement in both their symptoms and for papilledema. It is essential to resolve the increased ICP as early as possible because prolonged high ICP may interfere with lymphatic drainage and result in the accumulation of metabolic products that can cause long-term or permanent neuronal damage, both metabolically and hydrostatically.[25 26]

Similarly, stented patients had better clinical outcomes than medically treated patients. Improvement in symptoms following venous sinus stenting has been evaluated in systematic reviews and meta-analyses.[9–15] These studies showed satisfactory improvement in the presenting symptoms (headaches, papilledema, visual symptoms, and pulsatile tinnitus) ranging from 70% to >90%. However, most of these studies used a single-arm design so the value of stenting compared with medical treatment could not be determined.

Propensity score matching was performed in this observational study for the final analysis to reduce the effect of confounding factors that may result from differences in the distribution of baseline characteristics, and to replicate the effects commonly reported in randomized clinical trials. In addition, our results were based on real-world experience, and provide additional and updated information regarding the efficacy of stenting treatment in patients with IIH with VSS. Given these prospective study results, stenting may be considered as a practical treatment approach that can be generalized for patients with IIH. Additionally, venous sinus stenting could be considered safe, since serious complications are rare.[27]

Limitations of the study

Despite these promising results, the study should be interpreted cautiously. First, this study had a non-randomized single-center design. Even though we performed propensity score matching during our final analysis, some unmeasured confounding factors that might affect the treatment outcomes were not evaluated in the present study, which may have caused a confounding bias. Second, there might have been a selection bias after the propensity score matching, so the results might not represent the entire study population. Third, the present observational cohort was enrolled from a Chinese population set. There may be genetic, social, cultural, and economic factors or regional management preferences that might make the results of this study difficult to apply to another population. Consequently, further randomized controlled trials with larger sample sizes and a mature study design are necessary to confirm our findings.

CONCLUSION

This 1:1 matched-control study showed that stenting had a higher efficacy rate and faster resolution of papilledema and its respective symptoms compared with medical treatment. Although propensity score matching was used to eliminate baseline differences between the two groups, ideally, a randomized clinical trial should be performed to provide a more definitive conclusion.

Contributors DM, R, HY, and XT: conceptualization, data collection, analysis, drafting original manuscript. XL, LL, and SW: data collection. BS, HQ, KD, YW, and ZM: oversight, revising original manuscript. DM is the guarantor for this work and accepts responsibility for the data presented.

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Competing interests None declared.

Patient consent for publication Not applicable.

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Data availability statement Data are available upon reasonable request.

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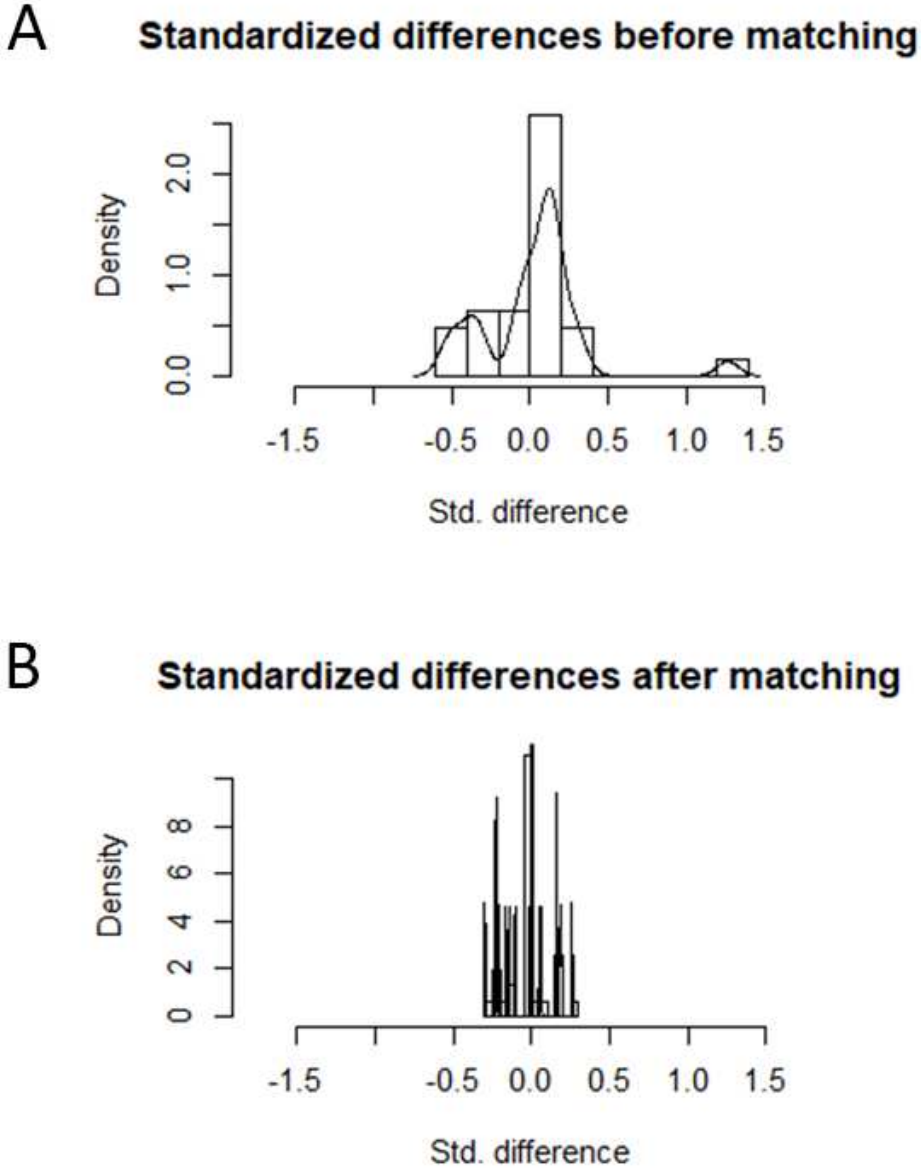
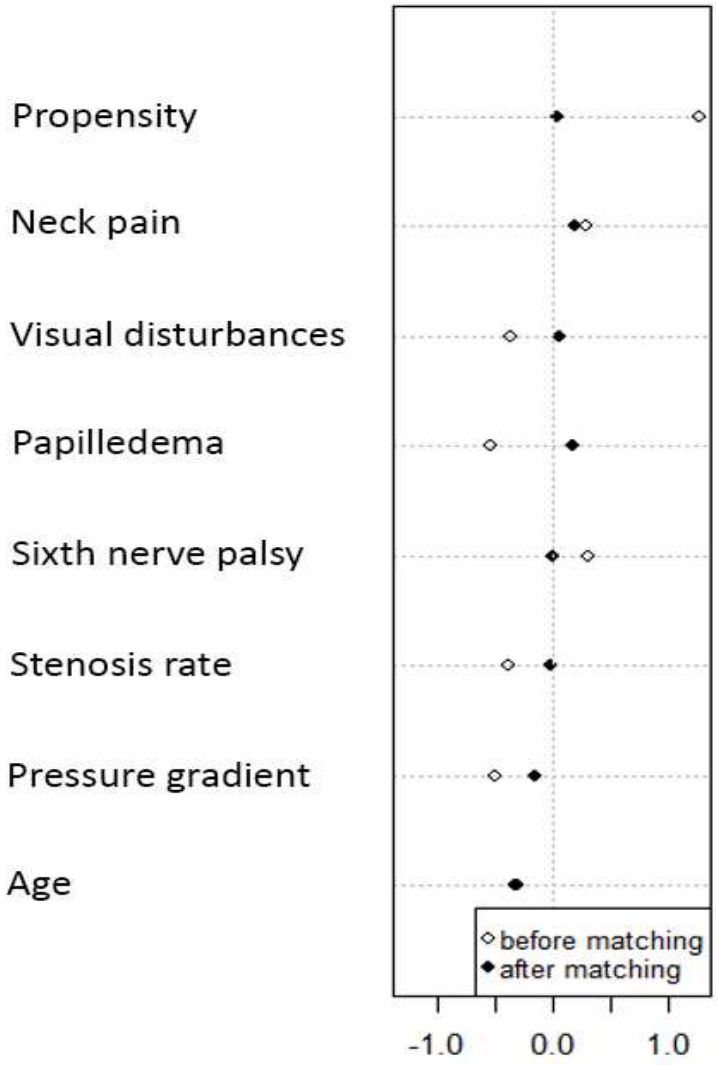
Supplementary figure 1. The histogram of standardized differences. The standard difference after matching is concentrated around 0, which can suggest that the matching has achieved better results.



Supplementary figure 2. The dot-plot of standardized mean difference. Univariate standardized differences scatter chart shows that the standard difference after matching is basically concentrated around 0, suggesting that the variables are balanced and the matching effect is good.



Supplementary figure 3. The line plot of individual differences. Standardized difference change chart shows that the standard differences of most covariables (the gray lines) are significantly reduced after matching except for few covariables (the black lines).