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Baseline Headache Phenotype and Early Headache Response After Venous Sinus Stenting for Symptomatic Transverse Sinus Stenosis

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Abstract

Objectives: Headache response after venous sinus stenting (VSS) is variable, and it is unclear whether the presenting headache phenotype is associated with early improvement. We examined the association between clinically recorded baseline headache phenotype and headache status at first follow-up after VSS for symptomatic transverse sinus stenosis.

Materials and Methods: This secondary analysis used a single-center registry comprising 75 VSS procedures. Patients with baseline headache, a recorded headache phenotype, and complete first-follow-up headache status were included. Phenotype was a clinician-assigned registry category ("IIH-like," "migraine," or "tension type"); it was not independently adjudicated against ICHD-3, and the "IIH-like" label did not require a recorded IIH diagnosis. The primary outcome was headache improvement at first follow-up. Phenotype groups were compared with Fisher's exact test; exact binomial confidence intervals and mean bias-reduced logistic regression were used because there were few non-improvement events.

Results: Forty-six patients had baseline headache (median age 32 years; 93.5% female; median BMI 29.1 kg/m^2); only 12/46 (26.1%) had a recorded IIH diagnosis. Recorded phenotypes were IIH-like in 23, migraine in 13, and tension type in 10 patients. Median first follow-up was 64.5 days. Overall, 33/46 patients improved (71.7%; exact 95% CI 56.5%-84.0%). Improvement occurred in 18/23 patients with IIH-like headache (78.3%), 11/13 with migraine (84.6%), and 4/10 with tension-type headache (40.0%; overall Fisher exact $P=0.046$). In mean bias-reduced regression adjusted for recorded IIH diagnosis, the association was attenuated: adjusted odds ratios were 4.63 (95% CI 0.94-22.79) for IIH-like and 6.37 (0.97-42.06) for migraine relative to tension type (global phenotype $P=0.093$). Additional adjustment for variable follow-up duration gave similar results (global $P=0.103$).

Conclusions: Early headache improvement was common after VSS, but the tension-type group had a lower observed response proportion. Because the phenotype categories were non-adjudicated descriptive registry labels, and because the association attenuated after limited adjustment with imprecise estimates, phenotype should be considered hypothesis-generating rather than a validated treatment-selection marker. Prospective studies using adjudicated headache diagnoses and repeated validated headache outcomes are needed.

Keywords: Idiopathic intracranial hypertension, Venous sinus stenting, Transverse sinus stenosis, Headache phenotype, Migraine, Tension-type headache.

Introduction

Transverse sinus stenosis is common in idiopathic intracranial hypertension (IIH), a syndrome defined by raised intracranial pressure without an alternative cause and typically characterized by headache, papilledema, and risk of visual loss (1-4). Venous outflow obstruction and intracranial pressure can interact bidirectionally: elevated cerebrospinal fluid pressure may narrow a compliant transverse sinus, while a functionally important stenosis can increase venous pressure and impair cerebrospinal fluid absorption, creating a positive feedback loop (1,4,5). Venous sinus stenting mechanically supports the stenotic segment and generally produces an immediate reduction in the trans-stenotic pressure gradient.

Most outcome literature for venous sinus stenting (VSS) comes from medically refractory IIH. Prospective series and systematic reviews report frequent improvement in papilledema, pulsatile tinnitus, and headache, although headache response is less uniform than technical or hemodynamic success (6-9). Patient-selection practices remain heterogeneous, and recommendations emphasize clinical context and venous manometry rather than a single universally validated pressure-gradient threshold (10). VSS has also been reported in carefully selected patients with symptomatic venous sinus stenosis outside a formal IIH diagnosis, including patients with isolated pulsatile tinnitus, underscoring that stented populations need not be diagnostically homogeneous (11-13).

Headache itself is particularly heterogeneous. In the Idiopathic Intracranial Hypertension Treatment Trial, migraine was the most common phenotype, and headache disability did not correlate with lumbar puncture opening pressure, BMI, papilledema grade, or visual-field loss (14). Prospective phenotyping has similarly shown that

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headache associated with active IIH may be migraine-like or tension-type-like rather than a unique syndrome (15). The International Classification of Headache Disorders, 3rd edition (ICHD-3), therefore emphasizes the relationship between headache and intracranial hypertension rather than a pathognomonic pain phenotype (16). Headache may also persist after control of intracranial pressure or papilledema and is a major determinant of quality of life (17,18). A small retrospective IIH cohort found no clear association between phenotype and short-term treatment response (19). Against this background, we performed an analysis to test whether the baseline clinical headache phenotype recorded before VSS was associated with early headache improvement. As the registry included symptomatic transverse sinus stenosis regardless of a recorded IIH diagnosis, we treated headache phenotype and recorded IIH diagnosis as separate variables and regarded all inference as exploratory.

Methods

Study Design and Data Source

We conducted a retrospective secondary analysis of a prospectively maintained, single-center registry of adults undergoing VSS for symptomatic transverse sinus stenosis. The source registry contained 75 VSS procedures recorded during the study period; procedure dates in the supplied dataset ranged from November 2022 through November 2024. General procedural and clinical outcomes of the full registry are reported in a related manuscript. The present analysis addressed a distinct primary question—whether baseline headache phenotype was associated with early headache response—and should be disclosed to editors as a secondary analysis of the same source registry. The analysis used de-identified registry records.

Participants

Patients were eligible for this secondary analysis if headache was recorded as present before stenting, a baseline headache phenotype was recorded, and headache status was available at the first clinical follow-up. Patients without baseline headache were excluded. No eligible headache patient had a missing phenotype or primary outcome.

Headache Phenotype and Baseline Variables

The registry recorded baseline headache phenotype clinically as "IIH-like," "migraine," or "tension." These were clinician-assigned descriptive registry categories rather than protocolized diagnoses. In particular, the "IIH-like" label did not require a recorded diagnosis of IIH; in patients without recorded IIH, it denotes only that the headache was clinically recorded as IIH-like and does not confer an IIH diagnosis. The analytic dataset did not retain the symptom-level criteria, the rationale used for assigning the label, or the elements required for independent ICHD-3 adjudication; therefore, the category cannot be reconstructed as a formal diagnosis of headache attributed to intracranial hypertension (16). We consequently treat phenotype and recorded IIH diagnosis as separate variables throughout and use "IIH-like" only as the original registry label. Baseline headache burden was represented by headache days per month and the six-item Headache Impact Test (HIT-6), a validated measure of headache impact (20). Other recorded variables included age, sex, body mass index (BMI), recorded IIH diagnosis, pulsatile tinnitus, visual symptoms, papilledema, stenosis estimate, pre- and post-stent pressure gradients, stent dimensions, balloon angioplasty, and P2Y12 platelet-reactivity units (PRU).

Procedure and Follow-up

All included patients underwent venography, transvenous manometry, and stent placement according to the treating neurointerventional team's clinical protocol. Acute gradient reduction was calculated as the pre-stent minus post-stent gradient. The date of the first outpatient follow-up was used to calculate follow-up duration. The present analysis did not use the registry's follow-up pressure-gradient variable because the method and timing of follow-up manometry could not be established from the analytic file.

Outcomes

The primary outcome was headache status at first follow-up, dichotomized using the registry categories as "improved" versus "unchanged." The follow-up field was a routine clinician-recorded categorical assessment reflecting the patient's reported change during the clinical visit; it was not derived from a structured headache questionnaire, and the analytic file did not contain separate patient-only and clinician-only ratings. No patient was categorized as worsened at first follow-up. The secondary outcome was improvement at discharge, dichotomized as improved versus unchanged or worsened. Discharge-to-follow-up transitions were examined to distinguish net group-level change from within-patient changes.

Statistical Analysis

Continuous variables are presented as median [interquartile range] and categorical variables as count/denominator (percentage). Baseline characteristics were compared across phenotype groups using Kruskal–Wallis tests for continuous variables and Fisher's exact tests for categorical variables. Response proportions are accompanied by exact Clopper–Pearson 95% confidence intervals (CIs).

The primary unadjusted comparison used a three-by-two Fisher exact test. This secondary analysis used a fixed registry cohort, so no a priori sample-size calculation was performed. Only 13 patients did not improve at first follow-up. The primary adjusted model therefore included

only the two coefficients required for the three-level phenotype variable plus recorded IIH diagnosis (three predictor coefficients in total, approximately 4.3 non-improvement events per coefficient). This event count was inadequate for a broad conventional multivariable model, so additional covariate adjustment was deliberately avoided. Mean bias-reduced logistic regression was used to reduce small-sample and separation bias. A sensitivity model additionally included follow-up duration per 30 days and was interpreted as secondary. We did not perform a post-hoc power calculation because the observed confidence intervals directly convey the limited precision of the estimates; accordingly, the analyses were considered exploratory and were not designed to exclude modest phenotype-specific differences. Exploratory univariable bias-reduced models evaluated prespecified clinical, hemodynamic, device, and PRU variables. These exploratory analyses were not adjusted for multiplicity and were interpreted through effect estimates and confidence intervals rather than isolated *P* values. Change in binary improvement status between discharge and first follow-up was evaluated with an exact McNemar test. Analyses were performed in R version 4.3.3 using brglm2 version 1.1.0. All tests were two-sided.

Results

Cohort and Baseline Characteristics

Of 75 registry entries, 46 (61.3%) met eligibility criteria because headache was present at baseline; all 46 had complete phenotype and first-follow-up headache status (Figure 1). The included patients were a median age of 32 [26-38.5] years and a median BMI of 29.05 [26.63-34.13] kg/m^2; 43/46 (93.5%) were women. A recorded diagnosis of IIH was present in 12/46 (26.1%), pulsatile tinnitus in 36/46 (78.3%), visual symptoms in 25/46 (54.3%), and papilledema in 15/46 (32.6%). Headache was classified as IIH-like in 23 patients, migraine in 13, and tension type in 10.

Baseline HIT-6 differed across groups (median 51 for IIH-like, 63 for migraine, and 56.5 for tension type; p=0.007). Age, BMI, headache frequency, recorded IIH diagnosis, papilledema, pre-stent pressure gradient, acute gradient reduction, and follow-up duration showed no clear between-group differences (Table 1).

Headache Outcomes

At discharge, 27/46 patients (58.7%) were categorized as improved, 16/46 (34.8%) as unchanged, and 3/46 (6.5%) as worsened. At first follow-up, performed a median of 64.5 [46.25–96.75] days after stenting, 33/46 patients were improved (71.7%; exact 95% CI 56.5%–84.0%) and 13/46 were unchanged.

First-follow-up improvement occurred in 18/23 patients with IIH-like headache (78.3%; 95% CI 56.3%–92.5%), 11/13 with migraine (84.6%; 54.6%–98.1%), and 4/10 with tension-type headache (40.0%; 12.2%–73.8%) (Table 2; Figure 2). The overall unadjusted association between phenotype and improvement reached the conventional significance threshold (Fisher exact $P=0.046$), although group-specific confidence intervals were wide.

Within-patient status was not monotonic: 15 patients who were not improved at discharge were improved at

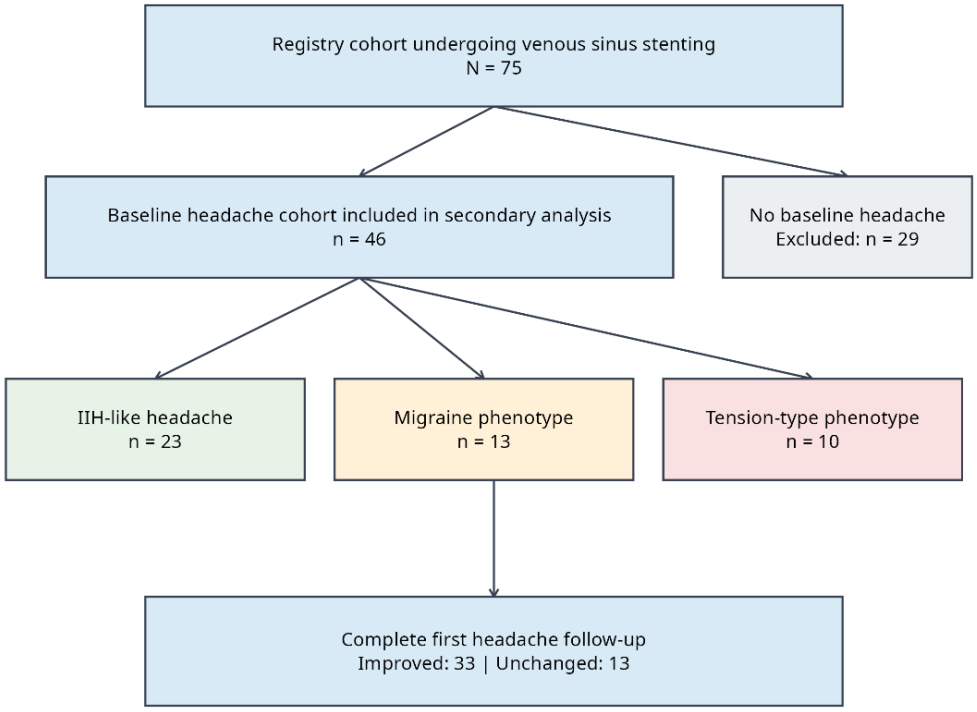

Figure 1. Cohort Selection and Analysis Flow.

Table 1. Baseline Characteristics by Recorded Headache Phenotype

Characteristic	IIH-like (n=23)	Migraine (n=13)	Tension type (n=10)	*P* value
Age, years	32 [26.5–37]	32 [25–43]	32 [22.5–38.5]	0.633
BMI, kg/m²	28.7 [26.7–32.8]	29.6 [26.7–34.5]	28.8 [26.9–34.8]	0.859
Headache days per month	11 [8.5–16.5]	9 [6–15]	12.5 [7.5–15.2]	0.544
Baseline HIT-6 score	51 [47–56.5]	63 [56–67]	56.5 [48.5–59]	0.007
Pre-stent pressure gradient, mm Hg	15 [11–18]	15 [10–17]	16.5 [15–19.8]	0.467
Post-stent pressure gradient, mm Hg	2 [1–4.5]	4 [2–5]	1.5 [0.2–2.8]	0.154
Acute gradient reduction, mm Hg	13 [7.5–16.5]	10 [7–15]	16 [12.2–17.8]	0.168
Stenosis estimate, %	70 [56–84.5]	73 [65–78]	77 [68.5–80.8]	0.525
Stent diameter, mm	7.7 [7.2–8.9]	7.3 [6.7–8.2]	7.3 [6.4–8.5]	0.381
Stent length, mm	60 [30–70]	60 [60–60]	40 [30–75]	0.619
First follow-up, days	59 [43.5–98]	79 [57–96]	69.5 [50.2–93.5]	0.698
Female sex	22/23 (95.7%)	12/13 (92.3%)	9/10 (90.0%)	0.783
Recorded IIH diagnosis	7/23 (30.4%)	3/13 (23.1%)	2/10 (20.0%)	0.827
Pulsatile tinnitus	19/23 (82.6%)	9/13 (69.2%)	8/10 (80.0%)	0.584
Visual symptoms	11/23 (47.8%)	9/13 (69.2%)	5/10 (50.0%)	0.465
Papilledema	10/23 (43.5%)	4/13 (30.8%)	1/10 (10.0%)	0.175
Balloon angioplasty	15/23 (65.2%)	7/13 (53.8%)	5/10 (50.0%)	0.734

IIH, idiopathic intracranial hypertension; HIT-6, six-item Headache Impact Test.
Values are median [interquartile range] or n/N (%). *P* values are unadjusted and are from Kruskal–Wallis or Fisher exact tests. The IIH-like phenotype was a clinician-assigned registry label and did not require a recorded IIH diagnosis.

Table 2. Headache Outcomes at Discharge and First Follow-up

Outcome	Overall	IIH-like	Migraine	Tension type
Discharge: improved	27/46 (58.7%)	13/23 (56.5%)	7/13 (53.8%)	7/10 (70.0%)
Discharge: unchanged	16/46 (34.8%)	9/23 (39.1%)	5/13 (38.5%)	2/10 (20.0%)
Discharge: worsened	3/46 (6.5%)	1/23 (4.3%)	1/13 (7.7%)	1/10 (10.0%)
First follow-up: improved (95% CI)	33/46 (71.7%; 56.5–84.0)	18/23 (78.3%; 56.3–92.5)	11/13 (84.6%; 54.6–98.1)	4/10 (40.0%; 12.2–73.8)
First follow-up: unchanged	13/46 (28.3%)	5/23 (21.7%)	2/13 (15.4%)	6/10 (60.0%)

IIH, idiopathic intracranial hypertension

follow-up, whereas nine who were improved at discharge were categorized as unchanged at follow-up. Four were not improved and 18 were improved at both assessments. Consequently, the net increase in the proportion improved from 58.7% to 71.7% was not statistically reliable in the paired exact analysis ($P=0.307$). An improvement-at-discharge followed by unchanged-at-follow-up indicates loss of the early improvement category, not documented worsening below baseline; no participant was classified as worsened at first follow-up.

Regression Analyses

In the primary bias-reduced model adjusted for recorded IIH diagnosis, the odds of improvement were higher for IIH-like headache (adjusted OR 4.63, 95% CI 0.94–22.79) and migraine (adjusted OR 6.37, 95% CI 0.97–42.06) than for tension-type headache, but the global phenotype test was not statistically significant ($P=0.093$). Recorded IIH diagnosis itself was not associated with improvement (adjusted OR 1.06, 95% CI 0.22–5.02) (Table 3). Adding follow-up duration produced similar estimates, with a global phenotype $P=0.103$; follow-up duration was not associated with improvement (OR 1.14 per 30 days, 95% CI 0.54–2.39).

In exploratory univariable analyses, higher pre-stent gradient and higher post-procedural PRU showed inverse associations with reported improvement. These signals

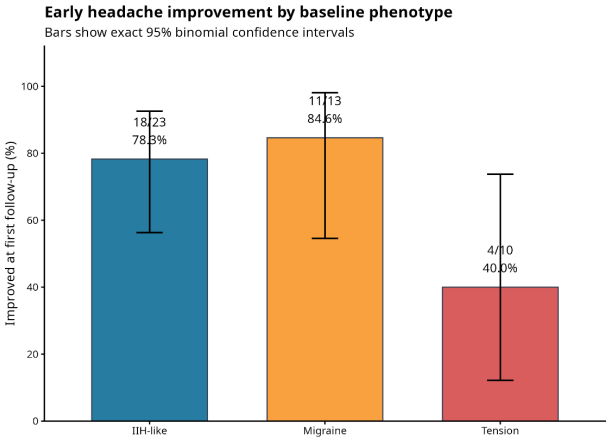

Figure 2. Proportion With Headache Improvement at First Follow-up by Baseline Phenotype. Error bars are exact 95% binomial confidence intervals.

Table 3. Primary Bias-Reduced Logistic Regression Model for Headache Improvement

Predictor	Odds ratio (95% CI)	*P* value
IIH-like vs tension-type phenotype	4.63 (0.94–22.79)	0.059
Migraine vs tension-type phenotype	6.37 (0.97–42.06)	0.054
Recorded IIH diagnosis (yes vs no)	1.06 (0.22–5.02)	0.940

Table 4. Exploratory Univariable Associations With First-Follow-up Headache Improvement

Predictor	Odds ratio (95% CI)	*P*
Headache phenotype: IIH-like vs tension	4.86 (0.99–23.87)	0.052
Headache phenotype: migraine vs tension	6.64 (1.00–44.35)	0.051
Recorded IIH diagnosis: yes vs no	1.16 (0.27–5.07)	0.840
Pulsatile tinnitus: yes vs no	2.00 (0.46–8.68)	0.353
Papilledema: yes vs no	3.03 (0.63–14.63)	0.168
Follow-up duration, per 30 days	1.17 (0.59–2.32)	0.662
Age, per 5 years	1.17 (0.79–1.73)	0.437
BMI, per 5 kg/m²	0.85 (0.45–1.61)	0.626
Headache frequency, per 5 days/month	1.43 (0.68–3.03)	0.349
HIT-6, per 5 points	1.24 (0.86–1.79)	0.246
Pre-stent gradient, per 5 mmHg	0.41 (0.17–0.99)	0.046
Acute gradient reduction, per 5 mmHg	0.48 (0.23–1.02)	0.056
Stent diameter, per 1 mm	1.70 (0.90–3.23)	0.105
Pre-procedural PRU, per 50 units	0.59 (0.33–1.03)	0.065
Post-procedural PRU, per 50 units	0.44 (0.22–0.90)	0.025

arose from multiple small-sample comparisons, were not independently adjusted, and should be considered hypotheses for future study rather than confirmatory findings (Table 4; Figure 3).

Discussion

In this secondary registry analysis, 71.7% of patients with baseline headache were categorized as improved at first follow-up after VSS. Improvement was observed in 78.3% of the IIH-like group, 84.6% of the migraine group, and 40.0% of the tension-type group. Although the unadjusted three-group association reached *P*=0.046, the association attenuated after adjustment for recorded IIH diagnosis and remained imprecise. The most appropriate interpretation is that recorded headache phenotype may be useful for generating hypotheses and framing counseling, not that it is ready to select or exclude patients for VSS.

The overall response proportion is broadly compatible with the IIH VSS literature. Systematic reviews and meta-analyses have generally reported headache improvement in approximately four-fifths of treated patients, but contemporary reviews emphasize substantial heterogeneity in indications, outcome definitions, follow-up intervals, and ascertainment (6,8-10,21). Direct comparison with those studies should be cautious because the present registry was not restricted to patients meeting formal IIH criteria; only 12/46 patients in the headache cohort had a recorded IIH diagnosis. Reports of VSS in symptomatic venous sinus stenosis without formal IIH and in isolated pulsatile tinnitus further illustrate the broader clinical spectrum in which venous interventions are used (11,13). Our results therefore contribute primarily to headache-outcome phenotyping in a symptomatic transverse sinus stenosis cohort rather than providing an IIH-specific estimate of treatment efficacy.

The high observed response in patients labeled as having migraine is clinically plausible. Migraine-like headache is common in IIH, headache phenotype is not specific for active intracranial hypertension, and headache disability may not track intracranial pressure or papilledema closely (14,15). ICHD-3 and contemporary reviews emphasize the

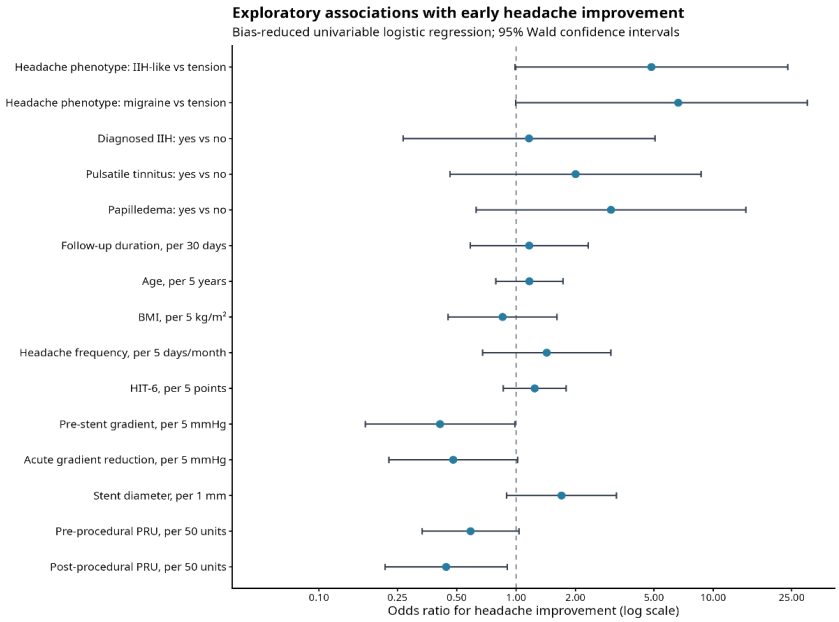

Figure 3. Exploratory Bias-Reduced Univariable Associations With Headache Improvement. Confidence intervals are Wald intervals from mean bias-reduced logistic regression.

temporal relationship between headache and intracranial hypertension, while also recognizing persistent headache after control of the underlying pressure disorder (16,17). Headache is also a major determinant of quality of life in IIH (18). VSS could therefore remove a pressure-related trigger in a patient whose headache appears migrainous, while a coexisting primary migraine disorder, medication overuse, central sensitization, or another pain mechanism could sustain headache in others. The registry did not systematically record post-stenting changes in migraine preventive therapy, acute headache medications or analgesics, acetazolamide, topiramate, or medication-overuse status. Consequently, treatment intensification could have produced apparent improvement independent of stenting, whereas medication tapering, withdrawal, or undertreatment could have reduced an otherwise genuine procedural benefit. The present data cannot separate these effects.

The lower observed response in the tension-type group requires particular caution. Only ten patients were in this category, the exact 95% response interval extended from 12.2% to 73.8%, and the registry labels could not be independently adjudicated against ICHD-3 criteria. A recent retrospective IIH case series likewise found no clear relationship between headache phenotype and short-term treatment response, although that study was small and included heterogeneous treatments (19). The IIH-like category is particularly vulnerable to conceptual misclassification because it was not anchored to a recorded IIH diagnosis or reproducible ICHD-3 symptom criteria. Misclassification could dilute a true phenotype effect, create spurious between-group differences if classification differed by clinical context, or simply amplify sampling variation in this small cohort. The present finding could therefore reflect a true difference in pressure-responsive biology, phenotype misclassification, residual confounding, or chance. Replication in a larger prospective cohort using standardized ICHD-based headache diagnosis is necessary.

The exploratory inverse association between pre-stent gradient and headache improvement should not be interpreted as evidence for an upper treatment threshold. Manometric gradients are widely used in VSS evaluation, and selection recommendations support venous manometry while acknowledging limited comparative evidence (22). However, a higher gradient need not translate monotonically to a better headache outcome: headache is a heterogeneous symptom, and a low-gradient IIH cohort has also reported clinical benefit after VSS across commonly used gradient strata (23). Moreover, the present analysis is restricted to a clinically selected, already-stented cohort, which narrows the gradient range and can alter associations observed within treated patients. The inverse estimate was univariable, based on only 46 patients with 13 non-improvement events, and arose among 15 reported exploratory coefficient tests; its nominal $P = 0.046$ would not survive a conservative multiplicity correction. Other studies have linked outcomes to variables beyond the baseline gradient, including pressure characteristics, post-stenting intracranial pressure, and the extent of transverse-sinus reinforcement (24-26). We therefore regard the inverse gradient estimate as an unstable hypothesis-generating signal rather than evidence of a mechanistic inverse dose-response relationship or a basis for defining a treatment cutoff. The post-procedural PRU signal is similarly exploratory and was not linked to a prespecified biological mechanism for headache improvement.

A further observation was the substantial switching of categorical response status between discharge and first follow-up: 15 patients moved from not improved to improved, while nine moved from improved at discharge to unchanged at follow-up. Those nine patients represented 19.6% of the cohort and were not documented as worsened below baseline. Several non-mutually exclusive explanations are plausible: discharge status may reflect acute post-procedural hemodynamic effects or short-term analgesic exposure; chronic migraine or tension-type biology can fluctuate; unrecorded medication changes can alter symptoms; and a coarse binary category is susceptible to regression to the mean and assessment variability. Longer-term VSS studies show that sustained improvement, recurrent symptoms, persistent symptoms, and stent-adjacent stenosis are clinically distinct trajectories (21,27). Because medication exposure and repeated quantitative headache measures were unavailable, we cannot determine which mechanism accounted for the reversions in this cohort. Future studies should therefore collect monthly headache days, headache intensity, HIT-6, acute and preventive medication use, and a patient global impression of change at standardized repeated time points.

Strengths and Limitations

Strengths include use of a structured registry, complete primary outcome data among eligible patients, exact confidence intervals, deliberately restricted adjusted modeling, bias-reduced logistic estimation, and transparent separation of primary and exploratory analyses. The analysis plan and executable code accompany the manuscript draft. The study also has important limitations. It was retrospective, single-center, uncontrolled, and based on a fixed cohort of 46 headache patients with only 13 non-improvement events; it was therefore not designed to detect subtle phenotype-specific differences or to support broad multivariable adjustment, and it cannot estimate the causal effect of stenting compared with medical treatment or natural history. The cohort was diagnostically heterogeneous: only 26.1% had a recorded IIH diagnosis, and that registry variable was not independently adjudicated in this secondary analysis. The IIH-like, migraine, and tension

labels were clinician-assigned registry categories rather than adjudicated ICHD-3 diagnoses; specifically, IIH-like did not require a recorded IIH diagnosis, and the criteria used to assign it could not be reconstructed. This creates a meaningful risk of phenotype misclassification. The primary outcome was a routine clinician-recorded categorical assessment reflecting patient-reported change, not a structured questionnaire, and it had no defined minimum clinically important difference. The analytic file did not contain separate patient-only and clinician-only ratings. No post-treatment HIT-6, headache-frequency, headache-intensity, or systematic medication data were available, including changes in migraine preventives, acute analgesics, acetazolamide, or topiramate, so medical-therapy changes could have masked or simulated procedural response. Follow-up ranged from 32 to 120 days, although adjustment for follow-up duration did not materially change the phenotype estimates. Wide confidence intervals indicate substantial uncertainty, and exploratory analyses were not corrected for multiplicity. Finally, the present work reuses the source registry of a related general-outcomes manuscript and therefore requires explicit cross-disclosure and citation if either paper is submitted or published.

Conclusions

Early headache improvement was recorded in 71.7% of patients with baseline headache after VSS. Improvement was observed less often in the small tension-type group than in the IIH-like and migraine groups, but the association attenuated after limited adjustment and remains exploratory. Given the small sample, non-adjudicated clinician-assigned phenotype labels, diagnostic heterogeneity of the cohort, and unmeasured post-procedural headache treatment, baseline headache phenotype should not currently determine VSS candidacy. Larger prospective studies should use adjudicated IIH and ICHD headache diagnoses, repeated validated headache outcomes, medication tracking, and standardized longer-term follow-up.

Authors' Contribution

Conceptualization: Soheil Naderi.
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Funding acquisition: Soheil Naderi.
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Methodology: All authors.
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Visualization: Shayan Khalilollah.
Writing–original draft: All authors.
Writing–review & editing: All authors.

Conflict of Interests

Authors have no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT in order to improve the readability and language of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Ethical Issues

The study was approved by the Ethics Committee of Iran University of Medical Sciences (IR.IUMS.FMD.REC.1405.179), with a waiver of individual consent for this de-identified registry analysis. Patient information was kept confidential and analyzed anonymously. No additional financial burden was imposed on participants as part of the study. The study procedures were conducted in accordance with the principles of the Declaration of Helsinki.

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