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High-Fidelity Venous Sinus Manometry in Idiopathic Intracranial Hypertension: Standardized Assessment Reveals Systematic Underestimation by Conventional Techniques

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Abstract

Purpose

The optimal pressure gradient threshold for venous sinus stenting (VSS) in idiopathic intracranial hypertension (IIH) remains controversial, partly due to non-standardized measurement techniques. This study evaluated the feasibility and safety of high-fidelity microcatheter manometry guided venous sinus stenting, and explored its early clinical outcomes compared with ventriculoperitoneal (VP) shunting.

Methods

Between 2016 and 2025, 105 patients with IIH were evaluated, of whom 35 were refractory to pharmacological therapy. Thirteen patients underwent VP shunting. Fifteen underwent VSS guided by a predefined trans-stenotic pressure gradient threshold of ≥ 8 mmHg. In five of these patients, parallel pressure measurements were obtained using microcatheter-based and fluid-based techniques. Clinical and safety outcomes were assessed at 90 days.

Results

High-fidelity microcatheter manometry was feasible in all cases. Pre-stenting sinus gradients had a median of 20 mmHg (range 8–31) with a median reduction of 14 mmHg after stenting. In paired testing (n = 5), the high-fidelity system consistently measured higher gradients than the fluid-filled technique (2–25 vs 4–30 mmHg; $p < 0.05$). Bland–Altman analysis demonstrated systematic underestimation by the fluid-filled method, with increasing discrepancy at higher gradients. At 90 days, stable or improved visual acuity occurred in 93.3% of stented patients and 61.6% of shunted patients ($p = 0.069$). Complications were less frequent after VSS (6.7% vs 46.2%; $p = 0.0286$).

Conclusions

High-fidelity microcatheter manometry is feasible and reveals systematic underestimation of pressure gradients by conventional techniques. In this exploratory analysis, VSS demonstrated early outcomes comparable to VP shunting with fewer complications. Standardized physiological assessment may refine treatment selection in IIH.

Introduction

Idiopathic intracranial hypertension (IIH) is characterized by elevated intracranial pressure (ICP) in the absence of an identifiable structural or infectious cause and predominantly affects obese women of childbearing age. Annual incidence averages 0.5–3.2/100,000 in general populations, surging to 22.0/100,000 among obese females of childbearing age(1, 2). Patients commonly present with

headache, pulsatile tinnitus, and visual disturbances related to papilledema, which may progress to permanent visual impairment (3). While medical therapy and weight reduction remain first-line treatments, a subset of patients develops refractory symptoms or progressive visual decline requiring procedural intervention (4).

The pathophysiology of IIH is multifactorial, with increasing evidence implicating abnormalities of cerebral venous outflow (5). Although most patients respond to weight reduction and acetazolamide, approximately 15–20% develop medically refractory disease or progressive visual decline requiring procedural intervention(6). Traditionally, cerebrospinal fluid diversion—most commonly ventriculoperitoneal (VP) shunting—has been the primary surgical management strategy. However, long-term shunt dependency is associated with substantial complication and revision rates, with large series reporting reintervention in approximately 20–30% of patients and infection rates of 5–10% (7). Transverse venous sinus stenosis is frequently observed and may participate in a feedback loop in which elevated ICP compresses compliant venous sinuses, impairing venous drainage and perpetuating intracranial hypertension (8, 9). This relationship provides the physiological rationale for venous sinus stenting (VSS), which has emerged over the past decade as a minimally invasive treatment option in carefully selected patients(10).

Central to patient selection for venous sinus stenting (VSS) is the assessment of trans-stenotic venous pressure gradients (11). Although symptomatic improvement after stenting has been widely reported, the gradient threshold required to justify intervention remains controversial, with proposed cut-offs ranging from as low as 4 mm Hg to more than 20 mmHg (7, 11). Few studies have included patients with borderline gradients, and definitions of hemodynamic significance vary substantially(7, 12). These discrepancies are compounded by the absence of standardized measurement techniques. In routine practice, venous sinus manometry is typically performed using fluid-filled microcatheters connected to external transducers, systems susceptible to damping, hydrostatic levelling errors, catheter position effects, and limited temporal resolution. In low-pressure venous systems, even small measurement differences may influence treatment decisions near proposed intervention thresholds(13, 14).

High-fidelity pressure measurement microcatheters developed for cardiology applications allow direct intraluminal pressure sensing with high temporal resolution and minimal signal distortion (15) (Fig. 1.). While validated in arterial circulation, their use within the intracranial venous system has not been systematically evaluated. It is unknown whether such systems produce systematically different trans-stenotic gradients compared with conventional fluid-filled microcatheter techniques, and whether potential differences may affect treatment decisions near proposed intervention thresholds(7, 15). We aimed to assess the feasibility and measurement characteristics of a high-fidelity pressure microcatheter system through paired comparisons with standard microcatheter measurements and we report the early clinical outcomes of patients undergoing stenting guided by high-fidelity microcatheter manometry, compared with a contemporaneous surgically treated cohort.

Methods

Study population

This retrospective study included consecutive patients with idiopathic intracranial hypertension (IIH) evaluated at the __ between 2016 and 2025. IIH was diagnosed according to established criteria, including symptoms of intracranial hypertension, absence of structural or infectious cause on neuroimaging, and elevated cerebrospinal fluid opening pressure confirmed by lumbar puncture.

Treatment allocation was determined by a multidisciplinary team consisting of neuro-ophthalmologists, neurosurgeons, and neurointerventional specialists. In the earlier years of the study period, only medical management and ventriculoperitoneal (VP) shunting were available procedural options. With the later introduction of venous sinus stenting, endovascular treatment became the predominant strategy for suitable candidates.

Venous gradient measurement:

All patients underwent invasive venous sinus evaluation in a dedicated neuroangiography suite under standardized procedural conditions. Arterial access was obtained preferentially via the distal radial artery. The right carotid artery was selectively catheterized using a 5-French Simmons diagnostic catheter (Terumo Corporation, Tokyo, Japan) to perform cerebral angiography and assess venous sinus morphology, including the presence, location, and extent of transverse or sigmoid sinus stenosis.

Venous access was obtained via puncture of the right common femoral vein. The internal jugular vein was cannulated using an Infinity Plus long sheath (Stryker Neurovascular, Fremont, California, USA). Under fluoroscopic guidance, a 0.014-inch Traxcess guidewire (MicroVention, Tustin, California, USA) was advanced through the venous system into the superior sagittal sinus. This wire served as the rail for advancement of the high-fidelity intraluminal pressure measurement catheter.

The TruPhysio pressure measurement system (Insight Lifetech Co., Ltd., Shenzhen, People's Republic of China) enabled continuous acquisition of venous pressure signals during controlled catheter pull-back from the superior sagittal sinus to the internal jugular vein. Pressure recordings were obtained during a standardized pull-back manoeuvre performed over approximately 30 seconds, allowing continuous assessment of pressure changes throughout the venous sinus system and across stenotic segments.

During routine measurements, the system simultaneously recorded arterial pressure signals obtained from the diagnostic arterial catheter as a reference channel. For paired measurement analyses, the arterial pressure input was replaced by a conventional XT-27 microcatheter connected to the pressure measurement outlet, enabling simultaneous recording of pressures from the high-fidelity catheter and the fluid-filled microcatheter during the same pull-back manoeuvre.

All pressure transduction systems were prepared according to standard protocols prior to measurement. The system was levelled to a standardized external reference point, zeroed, and equalized in accordance with manufacturer recommendations. Adequate flushing was performed to eliminate air, and waveform

quality and signal stability were confirmed before recording. Pressure measurements were obtained under stable hemodynamic conditions and prior to any therapeutic intervention. Trans-stenotic pressure gradients were calculated as the difference between pressures measured proximal and distal to the stenotic segment.

Venous Stenting procedure

Venous sinus stenting was performed following completion of invasive venous sinus manometry. Pressure measurements were obtained with the patient awake under conscious sedation, whereas stent implantation was performed under general anaesthesia. Patients were pre-treated with dual antiplatelet therapy (aspirin and clopidogrel), and treatment efficacy was confirmed using multiplate aggregometry. During the procedure, systemic anticoagulation was achieved with intravenous sodium heparin, with activated clotting time maintained at approximately twice the baseline value.

The TruPhysio rapid-exchange pressure microcatheter permits catheter removal while maintaining the 0.014-inch guidewire position across the stenotic segment, allowing direct transition from diagnostic manometry to therapeutic intervention without wire exchange. Self-expanding stents were advanced over the in-situ guidewire and deployed across the stenosis under fluoroscopic guidance. Stent selection was based on venous sinus anatomy and operator discretion and included Wallstent devices (Boston Scientific, Marlborough, Massachusetts, USA) or Precise stents (Cordis, Miami Lakes, Florida, USA). Following deployment, repeat angiography and post-stenting pressure measurements were performed to confirm stent position, restoration of venous outflow, and resolution of the trans-stenotic gradient.

Ventriculoperitoneal shunt implantation

Cerebrospinal fluid diversion was performed using standard ventriculoperitoneal (VP) shunt placement under general anaesthesia. Sophysa shunt systems (Sophysa, Besançon, France) were used in all cases. A ventricular catheter was inserted into the lateral ventricle using anatomical landmarks without neuronavigation. The catheter was connected to a subcutaneous valve and tunnelled to the peritoneal cavity for distal cerebrospinal fluid drainage. Valve type and opening pressure were selected at the discretion of the operating neurosurgeon. Perioperative and postoperative management followed standard institutional protocols.

Clinical outcomes and follow-up

Clinical outcomes were assessed at 3 months after intervention, a predefined time point selected to evaluate early clinical and visual response and to ensure uniform follow-up across cohorts by our certified neuro-ophthalmologist (__).

Symptoms evaluated at baseline and 3 months included headache, pulsatile tinnitus, diplopia, and transient visual obscuration. Symptom status was determined from standardized clinical documentation at follow-up visits.

Visual outcomes were assessed using best-corrected visual acuity in each eye at baseline and 3 months. Papilledema was evaluated by ophthalmologic examination according to routine clinical practice. Improvement was defined as resolution or reduction of papilledema and/or stabilization or improvement of visual acuity.

Procedure-related complications, including neurological events, access-site complications, and reinterventions, were recorded for both treatment groups. Time from diagnostic confirmation to intervention was documented and analysed as a potential factor influencing clinical outcomes. All patients completed the 3-month follow-up, and they were ass included in outcome analyses, clinical data was retrospectively extracted from the medical records.

Statistical analysis

Statistical analyses were performed with an exploratory intent consistent with the feasibility design of the study. Continuous variables are reported as mean ± standard deviation or median with interquartile range, as appropriate. Categorical variables are reported as counts and percentages.

For the pressure measurement comparison, paired t-tests were used to compare trans-stenotic pressure gradients obtained with the high-fidelity pressure measurement system and the conventional microcatheter-based system. Given the small sample size, Wilcoxon signed-rank tests were performed as sensitivity analyses. Agreement between measurement techniques was assessed using Bland–Altman analysis, with calculation of mean bias and limits of agreement.

Clinical outcome analyses were descriptive and exploratory. Comparisons between venous sinus stenting and surgically managed patients at 3-month follow-up were performed using Fisher's exact test for categorical variables and Mann–Whitney U tests for continuous variables, as appropriate. Time from diagnostic confirmation to intervention was compared between groups using non-parametric methods.

No adjustments were made for multiple comparisons. Statistical significance was defined as a two-sided p value < 0.05. All analyses were performed using GraphPad Prism 10 (GraphPad Software, San Diego, California, USA).

Ethics approval

The study was approved by the Regional and Institutional Scientific and Research Ethics Committee (__).

Use of artificial intelligence

Artificial intelligence tool (ChatGPT-5.1, Open AI) was used to support language editing of the manuscript, it did not contribute to the scientific content, or the generation of any original results. All study design, data handling, statistical analyses, and scientific conclusions were conducted and verified by the authors. The authors take full responsibility for the accuracy, integrity, and originality of all content presented in this manuscript.

Results

Study population:

A total of 105 patients were identified having IIH, of whom 61 were successfully managed conservatively. Thirty-four patients were classified as having therapy resistant IIH due to persistent or progressive symptoms despite optimized medical therapy, including acetazolamide. Invasive evaluation in these patients included repeat lumbar pressure assessment and neuroimaging.

Thirteen patients underwent VP shunt placement. Twenty-one patients were evaluated for venous sinus stenting; six previously treated with XT-27–guided stenting and two with a trans-stenotic gradient < 8 mmHg were excluded from the high-fidelity cohort. Fifteen patients underwent TruePhysio-guided venous sinus stenting using a predefined pressure gradient threshold of ≥ 8 mmHg. Five patients were included in the parallel pressure measurement sub-study, of whom four underwent sinus stenting. (Supplementary Table S1.)

Baseline characteristics of the therapy resistant IIH patients included in the study:

A total of 28 patients with therapy-resistant IIH were included in the exploratory comparative analysis, comprising 15 patients treated with venous sinus stenting and 13 patients treated with ventriculoperitoneal (VP) shunting. Median age was 30 years (range 11–56) in the stenting group and 29 years (range 12–50) in the VP shunt group (p = 0.8827). Female sex predominated in both cohorts (80% vs 100%, p = 0.2262). Median body mass index was 34.4 kg/m² (range 27.7–46.9) in the stenting group and 36.6 kg/m² (range 29.3–68.0) in the shunt group (p = 0.2586). In the stenting cohort, the median trans-stenotic sinus gradient was 20 mmHg (range 8–31).

The median time from diagnosis to intervention was 61 days (range 1–1565) in the stenting cohort and 141 days (range 14–1073) in the shunt cohort (p = 0.4063). At baseline, headache was present in 73.3% of stented patients and 76.9% of shunted patients (p = 0.9999), impaired vision in 86.7% and 100%, respectively (p = 0.4841), diplopia in 33.3% and 16.7% (p = 0.1727), and tinnitus in 20.0% and 23.1% (p = 0.9999). Papilledema was documented in 86.7% of stented patients and 76.9% of shunted patients (p = 0.6389). Baseline median visual acuity was 0.9 (range 0.1–1.0) in the right eye in both groups (p = 0.9518) and 0.9 (range 0.3–1.0) versus 0.8 (range 0.15–1.0) in the left eye in the stent and shunt groups, respectively (p = 0.1093). No statistically significant baseline differences were observed between treatment groups. (Table 1.)

Table 1
Baseline characteristics and clinical evolution of medical therapy resistant idiopathic intracranial hypertension patients

Demographics			
	Sinus stent n = 15	**VP. shunt n = 13**	**P Value**
Age *Median (min; max)*	30 (11; 56)	29 (12; 50)	0.8827
Female sex	80% n = 12/15	100% n = 13/13	0.2262
Body Mass index *Median (min; max)*	34.4 (27.7;4.9)	36,6 (29.3;68.0)	0.2586
Days to treatment *Median (min; max)*	61 (1;1565)	141 (14;1073)	0.4063
Lumbal opening pressure cmH_2O *Median (min; max)*	39 (20; 54)	30 (23; 45)	0.3231
Baseline symptoms			
Tinnitus	20.0% n = 3	23.1% n = 3	0,9999
Double vision	33.3% n = 5	16.7% n = 2	0.1727
Headache	73.3% n = 11	76.9% n = 10	0.9999
Impaired vision	86.7% n = 12	100.0% n = 13	0.4841
Visual acuity (Right eye) *Median (min; max)*	0.9 (0,1;1,0)	0.9 (0,1 ;1,0)	0.9518
Visual acuity (Left Eye) *Median (min, max)*	0.9 (0,3; 1,0)	0.8 (0,15; 1,0)	0.1093
Papilla oedema	86.7% n = 13	76.9% n = 10	0.6389
Pre-operative sinus gradient (mmHg) *Median (min, max)*	20 (8; 31)	n. a.	n. a.
Change in sinus gradient (mmHg) *Median (min, max)*	-14 (-31; -6)	n. a.	n. a.
90-day follow up			
Tinnitus	0% n = 0	0% n = 0	n. a.

Demographics			
	Sinus stent n = 15	**VP. shunt n = 13**	**P Value**
Double vision	0% n = 0	7.7% n = 1	0.4643
Headache	0% n = 0	23.1% n = 3	0.0873
Progression of visual loss	6.7% n = 1	38.5% n = 5	0.0691
Stable or improved visual acuity	93.3% n = 14	61.6% n = 8	0.0691
Improved visual acuity	50% n = 7	41% n = 5	0.7127
Papilla oedema at 3 months	6.7% n = 1	15.4% n = 2	0.5833
Procedure related adverse events	**6.7% n = 1***	**46.2% n = 6****	**0.0286**
**Transient hypotension*	***Shunt infection, epidural haematoma, intra-ventricular haemorrhage, meningitis, epidural haematoma, pulmonary embolism*		

Feasibility of high-fidelity venous sinus pressure measurement

High-fidelity venous sinus pressure measurement was successfully performed in all intended cases. The TruePhysio pressure catheter was navigated across the stenotic venous sinus segment in all patients without technical failure. Continuous pressure recordings during pull-back from the superior sagittal sinus to the internal jugular vein were obtained in each case, and transition from diagnostic manometry to therapeutic stenting was achieved without the need for guidewire exchange. No device-related technical complications occurred, and no procedure was aborted due to catheter malfunction or inability to obtain reliable measurements.

Comparative analysis of fluid transmitted and high-fidelity sinus manometry

Parallel venous sinus pressure measurements using a conventional microcatheter and a high-fidelity pressure catheter were successfully obtained in five patients. Measurements were performed during a simultaneous pullback under fluoroscopic control ensuring the registration of pressure values at the exact identical anatomical locations throughout the healthy and stenotic segments. (Fig. 2.)

Trans-stenotic gradients were consistently higher with the high-fidelity system in all five cases. Gradients measured with the XT-27 ranged from 2–25 mmHg, compared with 4–30 mmHg using the high-fidelity catheter. The paired mean difference demonstrated a systematic positive bias toward higher gradients with the high-fidelity system. This difference was statistically significant on paired analysis. Bland–

Altman analysis showed consistent directional bias, with no case in which the microcatheter-based measurement exceeded the high-fidelity measurement. (Fig. 2.)

Exploratory analysis on the clinical efficacy and safety of high-fidelity pressure-catheter based sinus stenting compared to the gold standard surgical approach

At 90 days, early clinical outcomes were comparable between patients undergoing high-fidelity pressure catheter–guided venous sinus stenting (n = 15) and ventriculoperitoneal (VP) shunting (n = 13). Tinnitus resolved in all patients in both groups. Diplopia was absent after stenting and present in 1 shunted patient (7.7%; p = 0.4643). Headache persisted in 0% of stented patients and 23.1% of shunted patients (p = 0.0873).

Progression of visual loss occurred in 6.7% versus 38.5%, respectively (p = 0.0691). Stable or improved visual acuity was observed in 93.3% of stented patients compared with 61.6% of shunted patients (p = 0.0691), with visual improvement alone documented in 50% and 41%, respectively (p = 0.7127). (Fig. 3.)

Papilledema at 3 months was present in 6.7% of the stenting cohort and 15.4% of the shunt cohort (p = 0.5833). Procedure-related adverse events occurred in 6.7% of stented patients (transient hypotension) and 46.2% of shunted patients, including shunt infection, epidural hematoma, intraventricular haemorrhage, meningitis, and pulmonary embolism (p = 0.0286). (Table 1.)

Discussion

In this feasibility study, we demonstrated for the first time, that the microcatheter based high-fidelity venous sinus pressure measurement in patients with idiopathic intracranial hypertension (IIH) is technically feasible and safe. The pressure microcatheter was successfully navigated, and measurements were obtained in 100% of intended cases without device-related complications. These findings establish proof-of-concept for direct intraluminal pressure sensing within the intracranial venous system.

Our paired measurement analysis demonstrates that conventional fluid-filled microcatheters systematically underestimate trans-stenotic venous pressure gradients compared with high-fidelity sensors. Although both systems were simultaneously zeroed at heart level prior to measurement, the fluid-filled microcatheter consistently recorded lower peak sinus pressures and, consequently, lower calculated gradients than the high-fidelity catheter equipped with an integrated, calibrated pressure sensor. Bland–Altman analysis confirmed a consistent bias toward lower gradient values with the fluid-transmitted technique, with increasing discrepancy at higher pressures. Fluid-filled systems are inherently susceptible to damping, hydrostatic levelling errors, incomplete sealing, and catheter kinking—sources of error particularly relevant in low-pressure venous systems. In contrast, a direct pressure sensor positioned at the point of measurement is not subject to transmission-related distortion. These findings are clinically meaningful in the context of ongoing controversy regarding optimal gradient

thresholds for venous sinus stenting, where proposed cut-offs vary widely, and small absolute differences may influence treatment decisions. (Fig. 4.)

The importance of physiology-guided intervention has precedent in coronary artery disease. In FAME 1, fractional flow reserve (FFR)–guided percutaneous coronary intervention reduced the composite endpoint of death, myocardial infarction, and repeat revascularization compared with angiography-guided treatment, while also reducing stent use (16). FAME 2 further demonstrated that PCI in lesions with abnormal FFR improved outcomes compared with medical therapy alone, particularly by reducing urgent revascularization(17). These trials shifted clinical practice from morphology-based to physiology-guided decision-making. A similar paradigm may be applicable in IIH, where trans-stenotic gradients serve as a functional surrogate of venous outflow limitation and may benefit from accurate and standardized measurement.

Fractional flow reserve (FFR) technologies, particularly pressure wires, are widely used in coronary circulation. However, pressure wires provide limited support and may present challenges in trackability, especially in tortuous or complex anatomy. These practical limitations led to the development of pressure-sensing microcatheters, which allow physiological assessment over a standard 0.014-inch guidewire while preserving wire support and facilitating device delivery. In coronary intervention, pressure microcatheters have expanded the applicability of physiology-guided decision-making by improving deliverability without compromising measurement accuracy. A similar rationale applies in the intracranial venous system, where anatomical complexity and the need for secure wire position during stent delivery favours a microcatheter-based high-fidelity sensor over standalone pressure wires or conventional microcatheters (18).

Intracranial venous sinuses differ substantially from coronary arteries, frequently containing intraluminal septations, trabeculations, and parallel venous channels rather than a single uniform lumen. A recent comparative study of microcatheter and pressure wire venous sinus manometry in idiopathic intracranial hypertension demonstrated systematically lower pressures and trans-stenotic gradients when measured with the pressure wire, possibly related to diversion of the wire into smaller parallel venous channels. In this complex anatomical environment, a high-fidelity microcatheter-based sensor may offer practical and hemodynamic advantages over pressure wires. The device can be advanced over dedicated 0.014-inch neurointerventional guidewires designed for safe sinus navigation while maintaining stable positioning within the dominant lumen and sufficient support for subsequent stent delivery. The monorail design permits the guidewire to remain in place throughout the procedure, allowing seamless transition from diagnostic manometry to therapeutic stenting without wire exchange.

In our exploratory clinical analysis, high-fidelity–guided venous sinus stenting demonstrated early outcomes comparable to ventriculoperitoneal (VP) shunting, consistent with published literature (19). Although the study was not powered for definitive comparative conclusions, stented patients showed favourable short-term symptom and visual outcomes. The substantially higher complication rate observed in the shunt cohort underscores the well-recognized morbidity associated with cerebrospinal

fluid diversion. These findings suggest that physiology-guided venous sinus stenting may represent a viable alternative in appropriately selected patients.

Looking forward, management of IIH is likely to evolve toward a patient-specific therapeutic armamentarium. Pharmacologic advances, including glucagon-like peptide-1 (GLP-1) receptor agonists, have demonstrated intracranial pressure–lowering effects and may provide disease-modifying benefit in selected patients (20). At the same time, minimally invasive cerebrospinal fluid diversion technologies, such as endovascular eShunt systems designed to replicate arachnoid granulation function, are emerging as potential alternatives to conventional VP shunting. (21) While still investigational, these approaches may complement physiology-guided venous interventions in the future. Together, accurate hemodynamic assessment, targeted endovascular therapy, modern pharmacologic agents, and minimally invasive CSF diversion could allow individualized treatment strategies based on anatomy, physiology, and visual risk.

Several limitations must be acknowledged. This was a single-centre, retrospective study with a limited sample size. The comparison between stenting and shunting was exploratory and non-randomized, and treatment allocation reflected temporal evolution of available therapies. Follow-up was limited to early (90-day) outcomes. Larger, prospective, and ideally randomized studies are required to determine whether standardized high-fidelity pressure assessment translates into improved long-term clinical outcomes.

Conclusion

In conclusion, high-fidelity microcatheter manometry in the venous sinuses is feasible, safe, and reveals systematic underestimation of pressure gradients by conventional fluid-filled techniques. Standardized physiological assessment may refine patient selection and represents a critical step toward precision-based endovascular management of IIH.

Declarations

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Competing interests: None

Author Contribution

F.Sz. and S.N. contributed to conception and study design. P.O.; Z.K.; I.Sz; G.N.; D.N. B.S.; K.A. and S.N. contributed to data acquisition and analysis. L.E.; O.P.; F. Sz. and S.N. contributed to drafting a significant portion of the manuscript or figures. Allauthors contributed with critical comments during manuscript revision. All authorsapproved the submitted manuscript.

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Figures

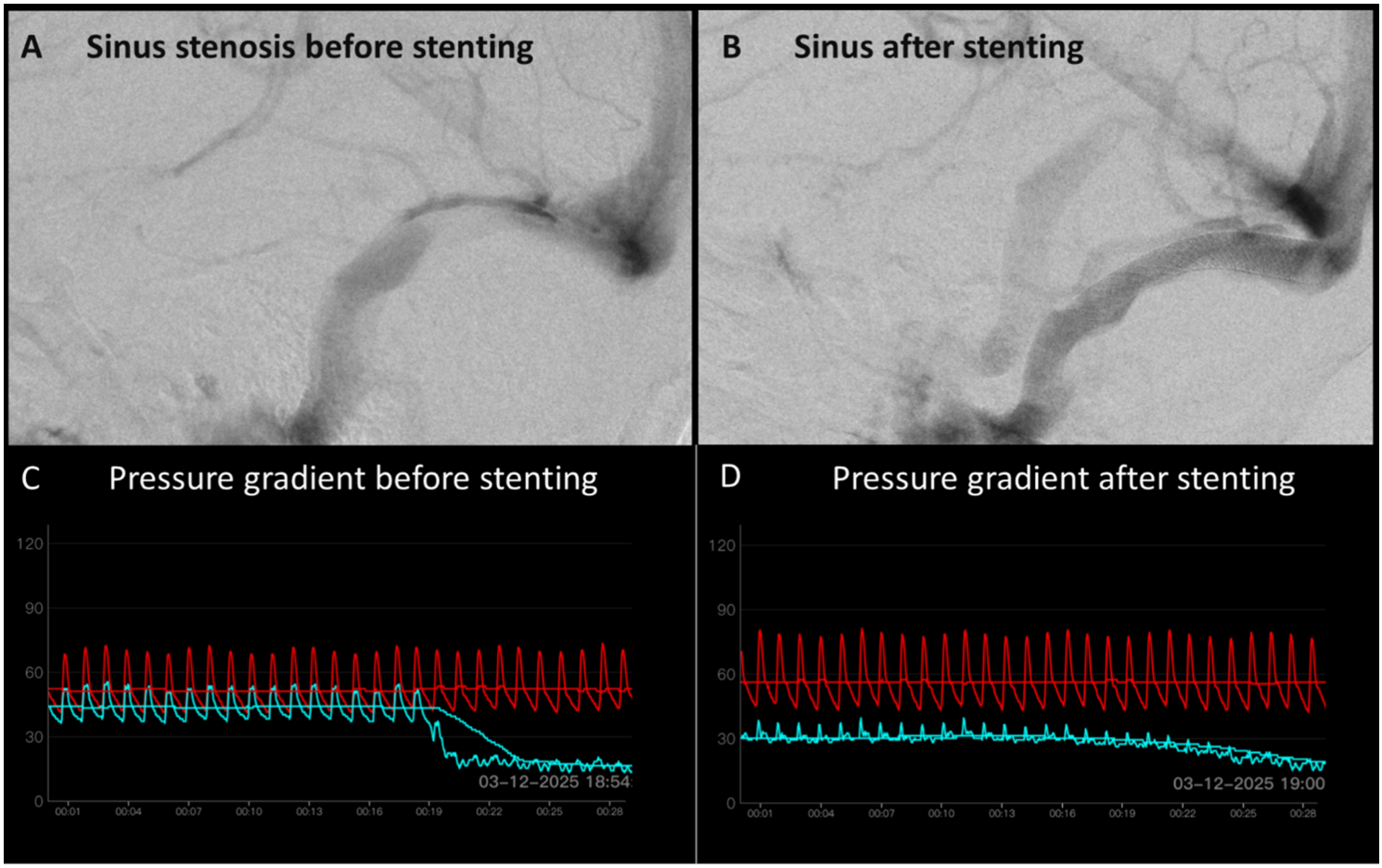


Figure 1

Endovascular treatment and high-fidelity venous sinus manometry in idiopathic intracranial hypertension. (A) Digital subtraction angiography (DSA) demonstrating focal stenosis at the transverse–sigmoid sinus junction. (B) Post-deployment DSA confirming restoration of venous sinus calibre following stent implantation. (C) Simultaneous high-fidelity intraluminal venous (light blue) and arterial (red) pressure recordings obtained during controlled pull-back from the superior sagittal sinus to the internal jugular vein prior to stenting. Cranial to the stenosis, the venous tracing demonstrates arterialized pulsatile morphology with amplification of the pressure waveform and a measurable trans-stenotic gradient. (D) Post-stenting pull-back recording showing abolition of the trans-stenotic pressure gradient and normalization of venous waveform morphology with loss of arterialized features.

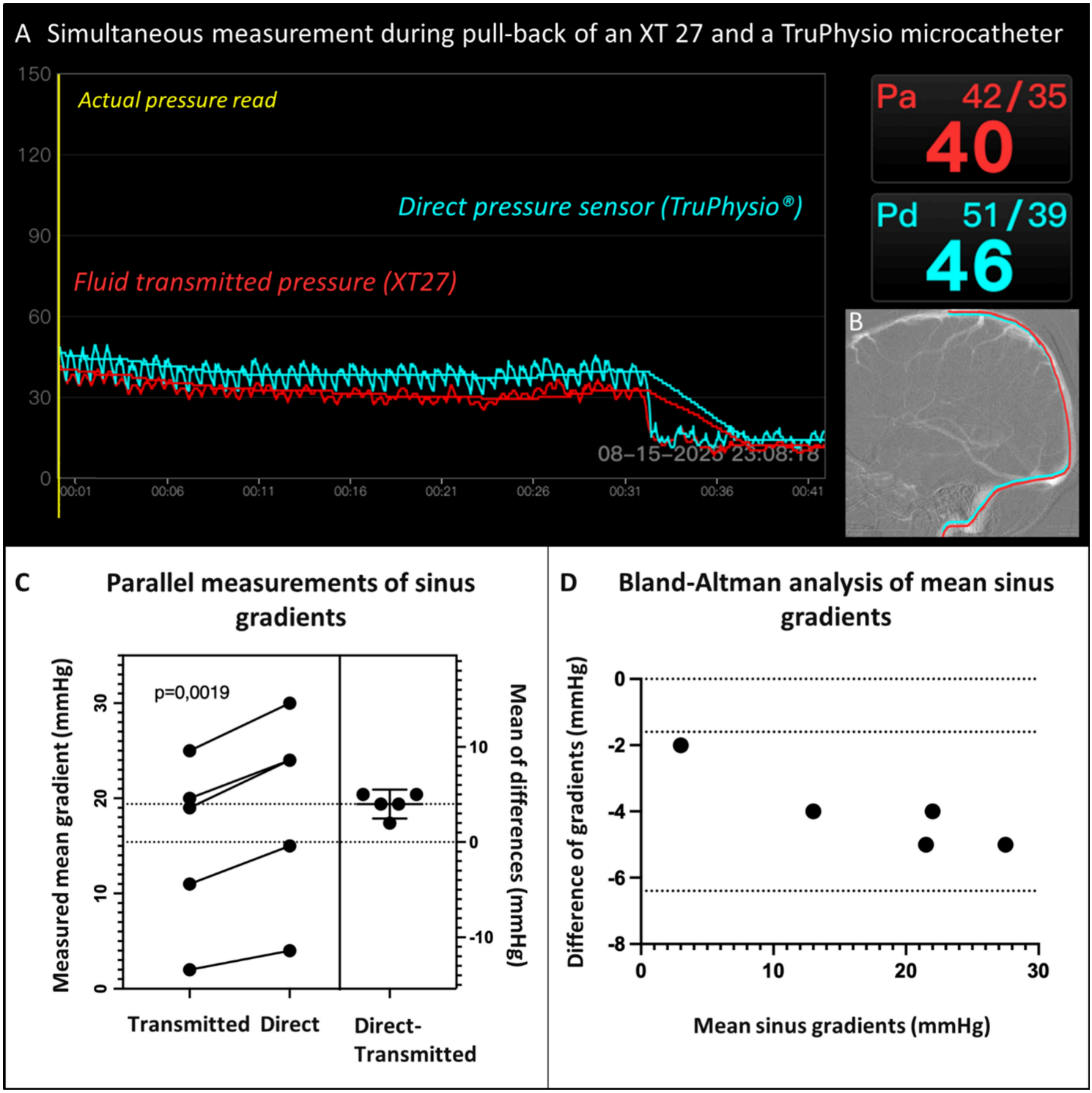


Figure 2

Comparative venous sinus manometry using fluid-filled and high-fidelity systems. (A) Simultaneous pull-back recordings across the transverse–sigmoid sinus stenosis obtained with a conventional fluid-filled microcatheter and a direct high-fidelity pressure sensor. Cranial to the stenosis, the fluid-filled system records lower pressures, underestimating the trans-stenotic gradient; discrepancies are smaller caudally. (B) Fluoroscopic roadmap showing catheter pull-back across the stenotic segment. (C) Paired

comparison of trans-stenotic gradients demonstrating higher values with the high-fidelity system. (D) Bland–Altman analysis demonstrating systematic bias, increasing with higher gradient values.

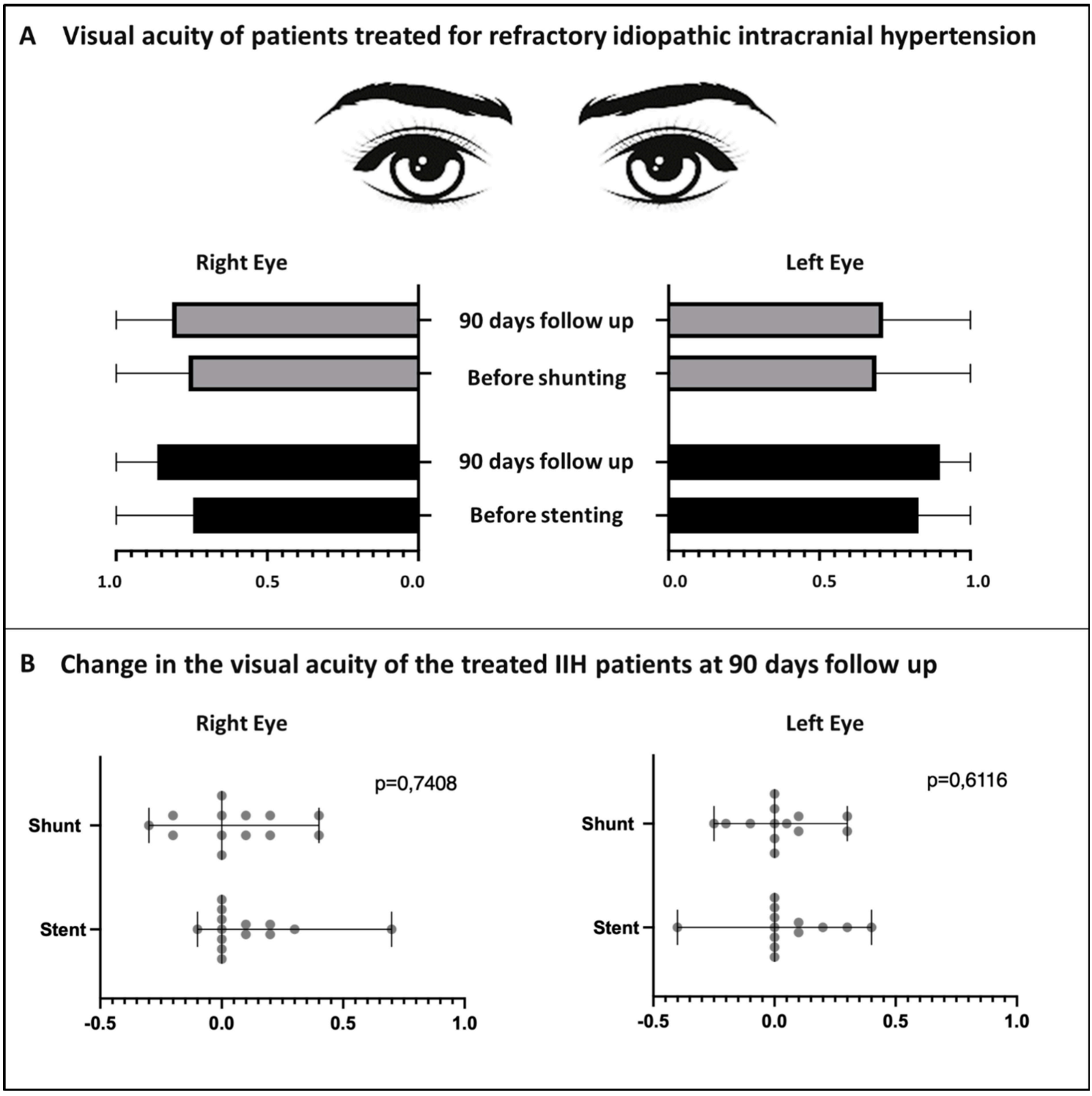


Figure 3

Best-corrected visual acuity at baseline and 90-day follow-up and corresponding change after treatment. (A) Horizontal column plots of best-corrected visual acuity (BCVA) in right and left eyes of patients treated for refractory idiopathic intracranial hypertension with ventriculoperitoneal shunting (gray) or venous sinus stenting (black). Columns represent mean BCVA and whiskers indicate range at

baseline and 90 days. (B) Change in BCVA from baseline to 90 days (ΔBCVA), demonstrating improvement in both cohorts without significant between-group difference.

Supplementary Files

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- Supplementarymaterial.docx