

Volbrain vs. Freesurfer For CSF Volume And Ratio Measurements in Idiopathic Normal Pressure Hydrocephalus



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Ezgi Yetim Arsava¹, Ibrahim Melih Ozturkmen², Melike Cakan¹, Gul Yalcin-Cakmakli¹, Ilkay Isikay³, Rahsan Gocmen⁴, Bulent Elibol¹.

¹Department of Neurology, Hacettepe University Faculty of Medicine, Ankara, Turkey, ²Hacettepe University Faculty of Medicine, Ankara, Turkey, ³Department of Neurosurgery, Hacettepe University Faculty of Medicine, Ankara, Turkey, ⁴Department of Radiology, Hacettepe University Faculty of Medicine, Ankara, Turkey.

VolBrain and FreeSurfer agree well on lateral ventricle volumes, but not on external CSF or derived ratios. These pipelines are not interchangeable for eCSF/lvCSF-based analyses in iNPH without method-specific validation.

INTRODUCTION

Idiopathic normal pressure hydrocephalus (iNPH) is a potentially reversible cause of gait disturbance, cognitive decline, and urinary incontinence in older adults. Its radiological hallmark - disproportionately enlarged subarachnoid-space hydrocephalus (DESH) - reflects a pathological redistribution of CSF from the vertex sulci into the ventricular system, which can be targeted by shunt surgery. In this study, we aimed to compare CSF volumetric measurements obtained from volBrain and FreeSurfer in patients with iNPH to evaluate the level of agreement and potential clinical interchangeability between pipelines.

METHODS

In this retrospective, single-center study, 90 patients with probable iNPH evaluated between 2021-2024 and diagnosed based on 2022 ISHCSF guidelines. Only preoperative 3D T1-weighted MRI scans included. Figure 1 shows the included CSF compartments.

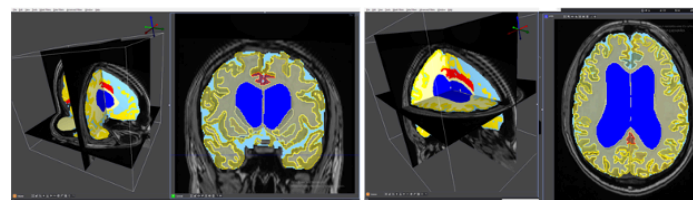
Table 1. Agreement Between volBrain and FreeSurfer — Summary of Results

Measure	Spearman ρ	Mean Difference (VB - FS)	95% CI of Mean Diff	Bland-Altman LoA (cm ³)	ICC	95% CI of ICC
Total CSF Volume	0.72	-79.8 cm ³	[-90.6, -68.9]	-177.6 to 18.1	~0.46	[-0.09, 0.77]
External CSF	0.47	-69.7 cm ³	[-80.5, -58.9]	-169.1 to 30.3	0.20	[-0.09, 0.47]
Lateral Ventricles	0.96	-6.2 cm ³	[-9.6, -2.8]	-37.5 to 25.1	0.976	[0.913, 0.989]
eCSF/lvCSF Ratio	0.90	-0.40	[-0.52, -0.35]	-1.17 to 0.31	0.762	[0.10, 0.912]

RESULTS

90 iNPH patients were processed through both pipelines (mean age 70.9 ± 7.5 years; 41.9% female). Lateral ventricle volume: The only metric that showed consistent concordance across pipelines. volBrain values were minimally lower than FreeSurfer (mean difference, -6.2 cm³), with narrow limits of agreement and an ICC of 0.976 (95% CI: 0.913-0.989). Total CSF volume: volBrain systematically underestimated total CSF compared to FreeSurfer by a mean of 79.8 cm³. Despite a moderate rank correlation ($\rho = 0.72$), individual-level agreement was poor (ICC ~0.46; LoA: -177.6 to 18.1 cm³). External CSF volume: volBrain values were consistently lower than FreeSurfer by a mean of 69.7 cm³, with very wide limits of agreement and an ICC and the modest rank correlation ($\rho = 0.47$). eCSF/lvCSF: The ratio showed a strong rank correlation ($\rho = 0.90$). However, individual-level agreement was only moderate (ICC = 0.762; 95% CI: 0.10-0.91), with a systematic bias of -0.40 and limits of agreement spanning nearly 1.5 units (-1.17 to 0.31) (Table 1).

Figure 1. The visualization of External CSF volume / Lateral ventricle volume ratio



External CSF volume (eCSF)

Lateral ventricle CSF volume (lvCSF)



eCSF / lvCSF

CONCLUSION

These findings indicate that volBrain and FreeSurfer CSF outputs should not be used interchangeably, particularly for external CSF quantification and derived ratios without prior harmonization or pipeline-specific validation in iNPH.

CONTACT

ezgiyetim@hacettepe.edu.tr