BrainLossNet: A deep-learning based method to assess brain volume loss is more robust and features a higher effect size than Siena

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Introduction and Purpose

- Brain volume loss (BVL) is frequently used as an endpoint in phase II/III trials in MS and is currently being incorporated into patient care as a marker of disease progression.
- BrainLossNet is a novel deep-learning based method [1] to assess BVL based on 3D T1 baseline (BL) and follow-up (FU) images.

Methods

- Robustness with respect to short-term variations was compared in 354 BL/FU pairs from a single healthy male acquired in the same session with 116 scanners, the Frequently Traveling Human Phantom (FTHP) dataset; publicly available at [2].
- A longitudinal cohort of 563 healthy individuals (normals) and a longitudinal cohort of 786 MS patients were analyzed (see Table 1).
- All BVL measurements were calculated with BrainLossNet [1] and Siena and then annualized (BVL/year).
- Quadratic regression was used to model the relationship between age and BVL/year in the normals separately for BrainLossNet and Siena.
- BVL/year measurments were adjusted for age by computing the residuals from the quadratic regression model obtained for the normals.
- Cohen's d was used to characterize the effect size of the difference in the age-adjusted residuals between MS patients and the normals.

	FTHP dataset	normals	MS patients
no. patients	1	563	786
no. of BL and FU pairs	354	563	786
age at BL in years mean [range]	49.6 [48.6,51.2]	61.4 [23.8,88.9]	44.0 [19.2,83.8]
interval between BL and FU mean (std)	<1min	3.1 (1.9)	2.6 (1.3)
number of different scanner	116	2	54

Table 1 Cohorts used for validation. FTHP: Frequently Traveling Human Phantom [2]

Results

- BrainLossNet was significantly more robust. The standard deviation on the FTHP dataset was 0.09% for BrainLossNet and 0.17% for Siena ($p=0.005$), see Fig. 1.
- Quadratic regression models are shown in Fig. 2. Mean annual BVL at age 30/40/50/60/70/80 years was -0.08/-0.16/-0.27/-0.42/-0.60/-0.82% for BrainLossNet and -0.02/-0.11/- 0.22/-0.34/-0.47/-0.63% for Siena (see Fig. 2).
- Cohen's effect size of the difference in the age-adjusted residuals of the BVL/year between patients and normals was significantly larger with BrainLossNet than with Siena (-0.75 versus -0.47, $p<0.0001$) (see Fig. 3).

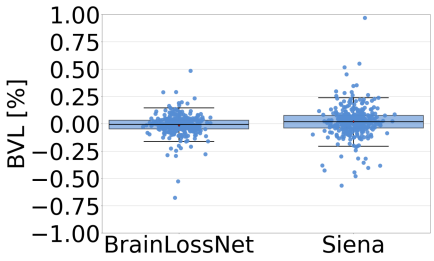

Figure 1 Robustness with respect to short-term repeated scans using the FTHP dataset

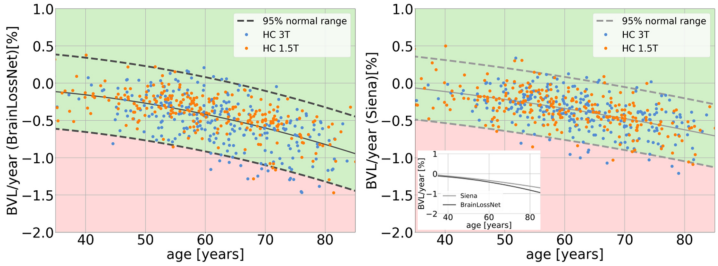

Figure 2 Quadratic regression model for BrainLossNet and Siena. The dashed lines represent the 95% normal range (regression model ±1.96*std)

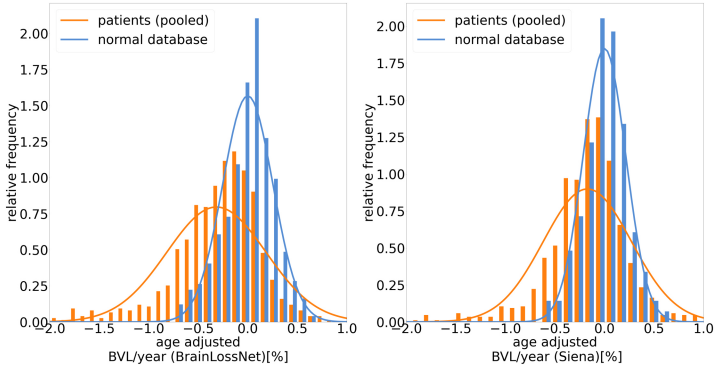

Figure 3 Distribution of the age-adjusted residuals of the BVL/year in the patients versus normals, separately for BrainLossNet (left) and Siena (right).

Conclusion

BrainLossNet provides BVL estimates with a processing time of 2 to 3 minutes, improves robustness by 50%, and has an effect size that is 40% higher than Siena.

Literature

[1] Opfer, R., et al., BrainLossNet: a fast, accurate and robust method to estimate brain volume loss from longitudinal MRI. Int J Comput Assist Radiol Surg, 2024.

[2] https://www.kaggle.com/datasets/ukeppendorf/frequently-traveling-human-phantom-fthp- dataset

Disclosures

RO, JK, LP are employees of jung diagnostics GmbH. MS: Has served on advisory boards for, and received funding for travel or speaker honoraria from Actelion-Janssen, Almirall, Bayer, Biogen, Bristol Myers Squibb, Celgene, Sanofi-Genzyme, Merck, Novartis, Roche, and Teva and received research support from Novartis and Bayer. HHK: Has received travel grants, speaker honoraria, financial research support, and consultancy fees from Bayer, Biogen Idec, Novartis, Siemens, and Teva; served on advisory boards for Biogen, Ixico, and Novartis; received research grants from Novartis.TZ: Has received advisory board fees from Biogen, Bristol Myers Squibb, Merck, Novartis, Roche, Sanofi and Teva; speaker fees from Almirall, Alexion, Biogen, Bristol Myers Squibb, Hexal, Novartis, Roche, Sanofi, Teva, and Viatris and research support from Biogen, Bristol Myers Squibb, Novartis, Roche, Sanofi, and Teva