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Regional Cerebellar Gray Matter Volume and Speech Intelligibility in Elderly Hearing Loss

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Introduction

Understanding the association of regional cerebellar gray matter volume with speech perception and effectiveness of cochlear implantation (CI) surgery in the elderly with hearing loss may aid in the discovery of neuroimaging biomarkers to predict the effectiveness of CI. We sought to investigate the association of regional cerebellar gray matter volume with speech perception and effectiveness of CI in the elderly with hearing loss.

Methods

This retrospective cross-sectional study included data from patients with elderly hearing loss who underwent CI at age 70 years or older between 2010 and 2022 in the CI group. And two types of healthy control groups were also enrolled: (1) sex and age-matched healthy control group and (2) normal hearing group. We investigated voxel-wise cerebellar gray matter volume (1) associated with each score for the four subitems of speech intelligibility tests at each of the two time points (preoperative and ≥ 6 months after CI) and recovery rates between the two time points in the CI group and (2) difference between the CI group and each of the control groups.

Results

The CI, healthy control, and normal hearing groups consisted of 52, 52, and 13 subjects, respectively. Each group had 20 (38.5%), 19 (36.5%), and 6 (46.2%) males, with a mean (standard deviation) age of 75.5 (4.2), 76.1 (3.6), and 76.4 (3.2) years, respectively. Voxel-wise multiple regression analyses showed that the left cerebellar Crus I gray matter volume was associated with preoperative speech perception, and the cerebellar vermis VIIIa with right Crus I gray matter volume was related to the maximum scores ≥ 6 months after CI. The gray matter volume of the right Crus I was also related to the recovery rate of speech perception. Compared with each control group, the CI group showed a widespread decrease in the gray matter volume of the cerebellum.

Table 1. Statistically Significant Regional Distribution of Cerebellar Gray Matter Regions According to SIT Subitems and Comparison Group

	MNI coordinates with peak raw *Z*					Number of significant voxels and composition[a]						
	SUIT Label	Peak *Z*	x	y	z	No. of voxels, n	L Crus I, %	R Crus I, %	Vm VIIb, %	Vm VIIIa, %	L VI, %	R VI, %
Subitem of SIT in the CI group												
MaxSPT	R Crus I	3.6	42	−54	−34	158	–	95.6	–	–	–	–
MaxCAP	Vm VIIIa	3.5	10	−66	−33	206	–	–	10.2	36.9	–	–
MaxMSW	R Crus I	3.2	44	−64	−34	36	–	55.6	–	41.7	–	–
RRSPT	R Crus I	3.6	42	−54	−34	34	–	100.0	–	–	–	–
PreSPT	L Crus I	4.0	−25	−82	−30	184	100.0	–	–	–	–	–
PreMSW	L Crus I	3.3	−26	−82	−30	150	78.7	21.3	–	–	–	–
PreDSW	L Crus I	3.4	−26	−82	−32	189	100.0	–	–	–	–	–
Groups compared with the CI group												
HC	L Crus I	7.9	−34	−60	−30	769	17.0	12.4	–	–	18.5	18.7
NLH	L Crus I	5.7	−32	−60	−32	255	15.7	–	–	–	31.8	–

Abbreviations: CAP, Categories of Auditory Performance; CI, Cochlear Implant; DSW, disyllabic word test; HC, healthy control; L, left; Max, maximum scores ≥ 6 months after cochlear implant; MNI, Montreal Neurological Institute; MSW, monosyllabic word test; NLH, normal hearing; Pre, preoperative; R, right; RR, Recovery rates; SIT, speech intelligibility test; SPT, sentence perception test; SUIT, spatially unbiased atlas template of the human cerebellum; Vm, vermis.

[a] Only compositions that account for or more than 10% of surviving voxels for each subitem are shown.

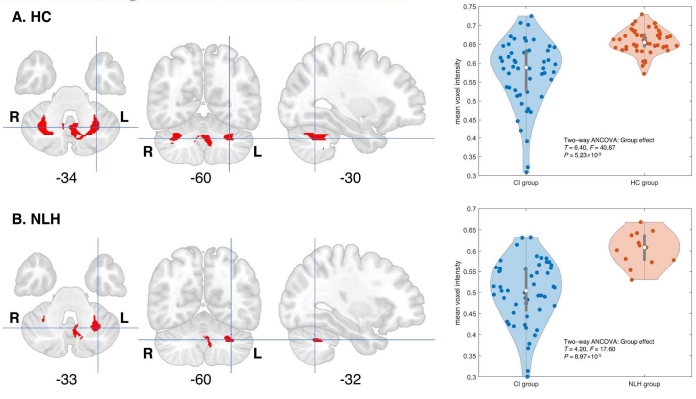

Figure 1. Binary Maps of Statistically Significantly Different Voxel-wise Intensities and MVI Distribution Comparing CI Group to Each Control Group.

Conclusion

Regional cerebellar gray matter volume, especially that of bilateral Crus I, may be a useful biomarker of central speech perception and a predictor of effectiveness of CI in the elderly with hearing loss. Further prospective research is warranted to evaluate whether recovery of the cerebellar gray matter volume is consistent with improvement in speech perception following long-term auditory-language rehabilitation after CI.