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Novel Analyses Showing how Hearing Perception Changes Over Time After Auditory Brainstem Implantation for Sensorineural Hearing Loss with Vestibular Schwannoma: A Systematic Review

Jeffrey Alexander Zuccato BHSc MD; Shervin Taslimi; Alireza Mansouri MD; Laureen D Hachem MD; Jetan H. Badhiwala MD; Johannes Kuchta; Joseph M Chen; Farhad Pirouzmand MD, MSc
Sunnybrook Health Science Centre, Toronto, Ontario, Canada

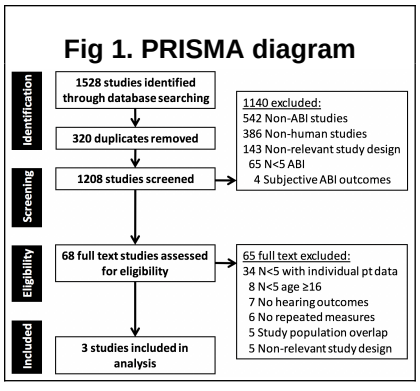
UNIVERSITY OF TORONTO
Sunnybrook HEALTH SCIENCES CENTRE

Introduction

- Neurofibromatosis type 2 (NF2) incidence – 1/33,000 [1]
- 90% develop bilateral vestibular schwannomas (VS) with progressive hearing loss [2]
- Auditory brainstem implants (ABIs) improve their hearing by stimulating proximal to the damaged vestibulocochlear nerve [3]
- The are small cohorts with variability in outcomes reported
- We reanalyze available individual patient data to describe ABIs impact in NF2

Methods

Fig 1. PRISMA diagram



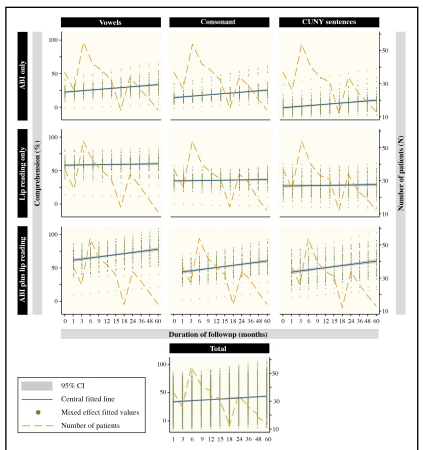
- Abstracted data included hearing ability with different complexities of sound (sounds to speech) and with different aids (ABI +/- lip reading(LR)) plus demographics (age/gender)
- Random effect multi-level mixed linear modelling was used separately for each study due to methodology differences to analyze how hearing changes over time and interactions between

Results

Table 1. Included studies

	Kuchta et al.	Matthies et al.	Lenarz et al.
Publication year	2007	2013	2001
Start date	1992	2001	1996
End date	2000	2009	2000
No. of patients	65	27	13
Country	USA	Germany	Germany
Gender	–	16 male, 11 female	–
Age (avg yrs, range)	–	37.6, 19-66	–

Kuchta et al. study [3]



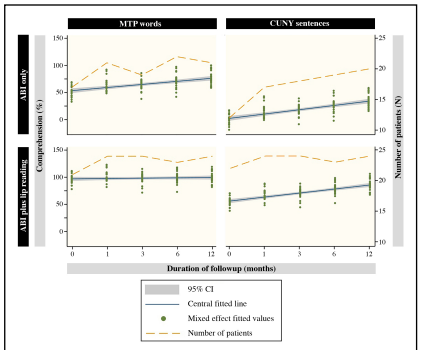
	Numerator df	Denominator df	F	P value
Intercept	*1*	*67.183*	*581.5*	*<0.0001*
(A) Hearing ability category	2	207.287	345.81	<0.0001
(B) Hearing complexity category	2	259.557	186.09	<0.0001
(C) Duration of follow-up	1	59.054	45.53	<0.0001
A x B interaction	4	959.89	14.73	<0.0001
A x C interaction	2	163.55	24.81	<0.0001
B x C interaction	2	139.65	0.093	0.911
A x B x C interaction	4	2465.301	3.795	0.004

Pairwise comparisons based on the model

Hearing ability category	Mean	SE	df	95% confidence interval		Pairwise comparison (p value)
(1) ABI	16.552	1.65	124.16	13.28	19.81	2 <0.0001 3 <0.0001
(2) Lip reading	40.850	1.65	124.81	37.58	44.12	1 <0.0001 3 <0.0001
(3) ABI plus lip reading	56.566	1.65	124.16	53.30	59.83	1 <0.0001 2 <0.0001
Hearing complexity category	**Mean**	**SE**	**df**	**95% confidence interval**		**Pairwise comparison (p value)**
(1) Vowel	51.47	1.57	106.5	48.3	54.6	2 <0.0001 3 <0.0001
(2) Consonant	35.07	1.57	106.52	31.9	38.1	1 <0.0001 3 <0.0001
(3) CUNY sentence test	27.42	1.58	107.45	24.2	30.5	1 <0.0001 2 <0.0001

- Comprehension improved over time (p<0.001)
- Comprehension improved with ABI or ABI+LR but not lip reading alone
- ABI+LR comprehension > ABI or LR (p<0.001)
- Vowel comprehension > consonant

Matthies et al. study [4]



	Numerator df	Denominator df	F	P value
Intercept	*1*	*23.34*	*48.76*	*<0.0001*
(A) Hearing ability category	1	23.51	177.606	<0.0001
(B) Hearing complexity category	1	24.32	163.41	<0.0001
(C) Duration of followup	4	87.491	25.94	<0.0001
(D) Age (binary at 40 yrs)	1	23.36	1.307	0.265
(E) Gender	1	23.52	0.203	0.656
A x B interaction	1	247.69	71.77	<0.0001
A x C interaction	4	240.76	5.53	<0.0001
B x C interaction	4	261.17	3.86	0.005
A x B x C interaction	4	234.81	1.78	0.132

Pairwise comparisons and estimations based on the model

Hearing ability category	Mean	SE	df	95% confidence interval		Pairwise comparison (P value)
(1) ABI	42.02	3.53	32.70	34.8	49.2	2 <0.0001
(2) ABI plus lip reading	80.99	3.51	31.79	73.8	88.1	1 <0.0001
Hearing complexity category	**Mean**	**SE**	**df**	**95% confidence interval**		**Pairwise comparison (P value)**
(1) MTS words	83.69	3.59	33.49	76.3	91.0	2 <0.0001
(2) CUNY sentences	39.32	3.69	36.23	31.8	46.8	1 <0.0001
Duration of followup	**Mean**	**SE**	**df**	**95% confidence interval**		
Preop	46.68	3.65	38.61	39.29		54.08
1 month	59.53	3.55	34.73	52.31		66.75
3 months	62.60	3.56	35.03	55.37		69.84
6 months	66.61	3.54	34.39	59.40		73.82
12 months	72.10	3.53	34.00	64.91		79.28

- Comprehension improved over time (p<0.001)
- ABI+LR comprehension > ABI alone (p<0.001)
- Word comprehension > sentence
- Age and gender did not affect comprehension

Lenarz et al. study [5]

Fig 4. Lenarz study hearing comprehension

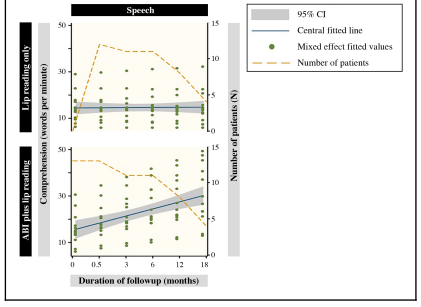


Table 4. Lenarz study hearing comprehension

	Numerator df	Denominator df	F	P value
Intercept	*1*	*12.91*	*70.55*	*<0.0001*
(A) Hearing ability category	1	15.56	20.48	<0.0001
(C) Duration of follow-up	5	74.64	6.28	<0.0001
A x C interaction	4	76.45	2.18	0.078

Pairwise comparisons and estimations based on the model

Hearing ability category	Mean	SE	df	95% confidence interval		Pairwise comparison (P value)
(1) Lip reading	14.69	2.44	19.31	9.59	19.79	2 <0.0001
(2) ABI plus Lip reading	22.56	2.38	17.64	17.56	27.57	1 <0.0001
Duration of followup	**Mean**	**SE**	**df**	**95% confidence interval**		
Preop	14.89	2.71	29.21	9.33		20.44
2 weeks	16.51	2.36	17.82	11.52		21.49
3 months	17.83	2.43	19.42	12.75		22.91
6 months	20.40	2.43	19.42	15.32		25.48
12 months	21.24	2.57	23.71	15.94		26.55
18 months	20.99	3.00	39.25	14.91		27.07

- Comprehension improved over time (p<0.001)
- Comprehension improved with ABI plus lip reading but not lip reading alone
- ABI + lip reading comprehension > ABI alone (p<0.001)

Conclusions

- ABI use in NF2 improves hearing beyond a lip reading alone and these continue over time from ABI, suggesting they can improve hearing beyond patient function without ABI
- Improvements occur with all complexities of sound, but vowels are better comprehended than consonants and word better than sentences, likely related to sound complexity
- Comprehension rates were over 50% overall after one year of ABI use, with some sound subgroups having over 75 or near 100% comprehension
- Speech comprehension was 15 words per minute with lip reading alone but improved to 30 words per minute with ABI after 18 months
- Age and gender do not significantly affect hearing

Impact & Future Directions

- This knowledge will aid in resource allocation for ABI, including rehabilitation programs
- This data may inform patient counseling and discussion about treatment options
- Further work is required to standardize hearing outcomes, further elucidate patient impact, identify prognostic factors, and determine cost-effectiveness

References

[1]. Evans DG, Howard E, Giblin C, et al. Birth incidence and prevalence of tumor-prone syndromes: estimates from a UK family genetic register service. Am J Med Genet A. 2010; 152A(2):327-32. **[2].** Kanowitz SJ, Shapiro WH, Golfinos JG, et al. Auditory brainstem implantation in patients with neurofibromatosis type 2. Laryngo-scope. 2004; 114(12):2135-46. **[3].** Kuchta J, Otto SR, Shannon RV, et al. The multichannel auditory brainstem implant: how many electrodes make sense? J Neurosurg. 2004; 100(1):16-23. **[4].** Matthies C, Brill S, Kaga K, et al. Auditory brainstem implantation improves speech recognition in neuro-fibromatosis type II patients. ORL J Otorhinolaryngol Relat Spec. 2013; 75(5):282-95. **[5].** Lenarz T, Moshrefi M, Matthies C, et al. Auditory brainstem implant: part I. Auditory performance and its evolution over time. Otol Neurotol. 2001; 22(6):823-33.