Bilateral use of Active Middle Ear Implants: Speech Discrimination Results in Noise

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Background: Binaural sound reception has advantages over unilateral perception, including better localization and sound quality as well as speech and tone reception in both quiet and noisy environments. Up to now, most active middle ear implant (AMEI) users have been unilaterally implanted, but patient demand for an implant on the other side is increasing. However, minimal data exists for the active middle ear implant (AMEI) Vibrant Soundbridge (VSB), which is used for patients with sensorineural, conductive and mixed hearing loss who are unable to use a conventional hearing aid due to audiological or medical reasons. Up to now, most AMEI patients have been implanted unilaterally. The aim in our study was to present an analysis of speech discrimination in bilaterally VSB-aided subjects as measured by signal-to-noise ratios for 50% correct understanding of words in sentences.

Patient #	Gender	Age at first VSB surgery	Side of first VSB surgery	First VSB surgery			Second VSB surgery		
				Type of HL	Pathology	Time between VSB surgeries (months)	Type of HL	Pathology	
1	m	78	right	MHL	COM	4	SNHL	Presbycusis	
2	m	44	right	CHL	Cholesteatoma	7	CHL	COM	
3	f	71	right	SNHL	Sudden HL	5	SNHL	Sudden HL	
4	m	38	left	SNHL	Unknown+COE	4	SNHL	Unknown+COE	
5	m	52	right	SNHL	Sudden HL	4	SNHL	Sudden HL	
6	f	70	right	MHL	COE	14	SNHL	COE	
7	f	60	left	MHL	Cholesteatoma	3	MHL	Cholesteatoma	
8	m	84	right	SNHL	Barotrauma	5	SNHL	Barotrauma	
9	m	64	right	SNHL	COE	8	SNHL	COE	
10	m	66	right	SNHL	Presbycusis	7	SNHL	Presbycusis	
				m=7	mean	r=8	MHL=3	mean	MHL=1
				w=3	62,7	l=2	CHL=1	6	CHL=1
							SNHL=6		SNHL=8

Table 1: Subjects' demographic overview (COM: chronic otitis media; COE: chronic otitis externa; MHL: mixed hearing loss; CHL: conductive hearing loss; Presbycusis: no satisfactory amplification with conventional hearing aid)

Material & Methods: Ten bilaterally-AMEI implanted native German-speaking adults were included in the study. The Oldenburg sentence test was used to measure speech reception thresholds in noise. The subject's signal-to-noise ratio (SNR) at a speech reception score of 50% was calculated for different noise conditions. SRT was measured as a function of noise condition (nc) and listening condition (lc) - for example, SRT (lc,nc), with nc from SON0, SON-90, or SON90 and lc from left, right or both. For each noise condition, the squelch effect and the binaural summation effect was calculated.

	Frequency (kHz)									
Mean difference pre-op vs. post-op, both sides	0.25	0.5	1	1.5	2	3	4	6	8	Mean all frequencies
BC n=17 mean SD	0.88 ± 10.34	1.18 ± 8.39	5.00 ± 11.86	3.53 ± 8.25	0.88 ± 6.18	0.29 ± 7.39	0.94 ± 9.35	NR	NR	1.96 ± 8.82
AC n=14 mean SD	2.50 ± 9.15	5.00 ± 9.41	5.71* ± 6.75	3.21 ± 9.53	1.43 ± 9.89	6.07 ± 10.59	7.14* ± 11.88	5.71 ± 11.91	0.38 ± 8.53	4.13 ± 9.74
BC=bone conduction, AC=air conduction, NR = not recorded, VSB=Vibrant Soundbridge, -op=operatively, SD=standard deviation										

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Table 2: Mean differences in bone-, and air-conduction thresholds before and after VSB surgeries. * $p \leq 0.05$.

Figure 2

Figure 4

Figure 3

Figure 5

Results: Patients in this study demonstrated improvement with bilateral AMEIs compared to right or left AMEI only in all three tested listening conditions. Statistical significance was found in the SON0 condition to favor usage of bilateral AMI versus either the right or left side only.

Discussion: The benefits of binaural hearing are well known, also in normal-hearing individuals. In the future every bilateral implantation should be a part of the clinical routine. Bilateral implantation can help to reduce problems in background noise and restore directional hearing. AMEIs such as the VSB help patients with high-frequency hearing loss, occlusion or distortion problems, as well as other medical problems preventing permanent hearing aid usage. Bilateral VSBs can help to reduce problems in background noise and restore directional hearing.

Figure 1: Mean free field post-op warble tone threshold for both implanted ears; error bars reflect $\pm$ standard deviation.

Figure 2: Mean SNR in listening condition SON0. Error bars reflect standard deviation.
Figure 3: Mean summation effect for the left and the right side (SNR left/right – SNR both in listening condition SON0). Error bars reflect standard deviation
Figure 4: Mean SNR with noise from the right side (SON90) and noise from the left side (SON-90). Error bars reflect standard deviation.
Figure 5: Mean Squelch effect with noise from the right side (SON90) and noise from the left side (SON-90). Error bars reflect standard deviation