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Balance Function In Cochlear Implant Patients Examined With Computerized Dynamic Posturography With Implant(s) On And Off

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Introduction

Cochlear implantation is widely acknowledged as the standard hearing rehabilitation for patients suffering from bilateral profound hearing loss when conventional hearing aid treatment does not adequately provide enough sound amplification to aid any residual hearing to satisfactory levels. Even thought the implantation is performed using minimally invasive surgery, patients with cochlear implant (CI) commonly suffer from permanent or transient dizziness postoperatively. This can be due to various iatrogenic complications or due to electrical stimulation from the CI causing mismatch between the sensory inputs from the two vestibular organs and the visual impressions. The aim is to examine whether CIs immediately alter balance function when turned on or off. Secondary endpoints include determination of the incidence of damage to any of the six semicircular canals and detection of any subjective feelings of vertigo.

Methods

Patients with uni- or bilateral CI were examined using Computerized Dynamic Posturography (CDP) (figure 1). The balance function was assessed by the sensory organization test, the motor control test, and the adaptation test with the CI turned on and off. Order of testing with the CI turned on/off was random and all data were compared to a healthy control group. Video Head Impulse Testing (vHIT) of all six semicircular canals succeeded CDP testing. Finally, all patients filled out the 25-item Dizziness Handicap Inventory (DHI) questionnaire to quantify any subjective symptoms of vertigo**.** The background characteristics of the study population can be seen in table 1.

Inclusion criteria:

- Age at or above 18
- Uni- or bilateral cochlear implant

Exclusion criteria:

- Failure to comply with planned examinations
- Inability to stand up straight for 20 minutes without support.

Results

11 patients were included. Four of these were excluded from statistical analyses due to incomplete evaluation by CDP evaluation. As seen in tables 2, 3 and 4, no significant p-values were found between examinations with the CI-on and -off. Eight significant p-values were found between condition with CI-on and control group. Five patients completed vHIT examinations (table 5). 46.8% of SCCs ipsilateral to the CI had hypofunction and 14.3% of SCCs contralaterally had hypofunction. 10 out of 11 patients (90.9%) were categorized as having a mild dizziness handicap according to the total DHI-score, with the physical aspect being affected in 9 of 11 (81.8%) questionnaires.

Discussion

With a mean age of 73.4, many of the older patients complained of fatigue during the second examination, which was mirrored in their performance during the second examination with the patient performing worse regardless of randomization. In a few cases, this lead to the patient's data being excluded from statistical analyses. Additionally, in the ATP the software program assigned a failed attempt a value of 200. However, patients with great anterior-posterior sway, who did not fall during the examination, also received a value of 200, hence datasets of patients performing examinations without falling were incorrectly excluded from statistical analyses as "incompletion of examination". Lastly, all results are preliminary due to ongoing inclusion of patients in the study, and the few significant p-values currently presented must be considered in the context of only 7 included datasets.

Figure 1: Computerized Dynamic Posturography.
During the examinations, the patient firmly stands on the platform with the lateral malleoli placed parallel to the horizontal line visualized on the platform. The patient wears a safety harness to prevent injury in case of falls during the examinations. The patient is instructed to look straight ahead on the screen during all examinations. During the various CDP examinations, the platform will move forward, backwards, up or down, and the white rings seen on the platform will remain fixed or move according to the sway of the patient.

Conclusion

According to the preliminary results of the present study, the condition with a CI does not immediately alter the balance function when turned on or off. Compared to a healthy control group, condition with CI turned on worsen the overall balance function during CDP examinations. Video head impulse test results revealed hypofunction in 46.8% of SCCs on the implanted side and total DHI-scores revealed a mild to moderate dizziness handicap.

PATIENT	AGE AT CI	IMPLANTED EAR	YEARS SINCE IMPLANTATION	SEX	CI MANUFACTURER	ETIOLOGY
1	70.9	Left	2.4	F	Cochlear	Other
2	29.0	Bilateral	R: 7.6 L: 7.6	M	Advanced bionics	Congenital
3	43.3	Left	5.6	M	Cochlear	Meningitis
4	65.4	Right	9.0	F	MedEL	Ototoxic
5	51.3	Right	2.7	F	Cochlear	Maternal rubella
6	R: 71.0 L: 69.7	Bilateral	R: 2.6 L: 4.0	M	R: Oticon Medical L: Cochlear	Other
7	18.0	Left	8.0	F	Cochlear	CHARGE-syndrome
8	64.5	Left	14.4	M	Unknown	Maternal rubella
9	R: 40.2 L: 44.3	Bilateral	R: 9.0 L: 5.0	F	R: MedEL L: MedEL	Head trauma
10	63.2	Left	7.8	M	Cochlear	Congenital
11	28.4	Right	4.9	M	Cochlear	Meningitis

Table 1: Background Characteristics. R = right, L = left, M = male, F = female

SOT CONDITION	P-VALUE CI ON/OFF	CONFIDENCE INTERVAL 95% ON/OFF	P-VALUE CI-ON/CONTROL	P-VALUE CI-OFF/CONTROL
CONDITION 1	0.341	[-2.53 , 6.25]	**0.0001***	**0.025***
CONDITION 2	0.133	[-0.52 , 3.1]	**0.003***	0.202
CONDITION 3	0.327	[-1.17 , 2.98]	**0.022***	**0.027***
CONDITION 4	0.788	[-17.59 , 13.97]	0.216	0.722
CONDITION 5	0.344	[-7.94 , 19.41]	**0.013***	0.279
CONDITION 6	0.270	[-8.94 , 26.56]	**0.031***	0.359
EQUILIBRIUM COMPOSITE	0.872	[-20.04 , 17.47]	**0.023***	0.224
SOMATOSENSORY RATIO	0.333	[-50.31 , 20.02]	**0.049***	0.531
VISUAL RATIO	0.438	[-24.81 , 12.24]	0.532	0.312
VESTIBULAR RATIO	0.699	[-15.06 , 21.06]	**0.043***	0.079
VISUAL PREFERENCE	0.545	[-46.07 , 26.93]	0.934	0.616

*Table 2: Sensory Organization Test Results. The first column shows the subtest performed with the SOT. The second column shows the p-value calculated with the paired t-test between condition with CI-on and CI-off. Significant results ($p \leq 0.05$) are marked with a * and highlighted in bold. The third column shows the confidence interval set at 95% between condition with CI-on and CI-off. The fourth and fifth columns shows the p-value calculated between the CI-on and the control group and the p-value calculated between the CI-off and control group, respectively.*

		P-VALUE CI ON/OFF	CONFIDENCE INTERVAL ON/OFF 95%	P-VALUE CI ON/CONTROL	P-VALUE CI OFF/CONTROL
BACKWARD TRANSLATION	Latencies medium	0.908	[-10.65 , 9.65]	**0.038***	0.270
	Latencies large	0.673	[-4.2 , 6.05]	0.055	**0.045***
	Amplitude scaling small	0.924	[-1.69 , 1.83]	0.694	0.664
	Amplitude scaling medium	0.489	[-2.47 , 1.32]	0.664	0308
	Amplitude scaling large	0.230	[-2.83 , 0.83]	0.733	0.271
FORWARD TRANSLATION	Latencies medium	0.068	[-0.72 , 14.72]	0.519	**0.016***
	Latencies large	0.778	[-6.25 , 7.96]	0.117	0.203
	Amplitude scaling small	0.182	[-1.87 , 0.45]	0.481	0.663
	Amplitude scaling medium	0.509	[-3.2 , 1.77]	0.934	0.796
	Amplitude scaling large	0.245	[-2.07 , 0.64]	0.558	0.955
	Latencies composite	0.358	[-3.33 , 7.9]	0.094	0.072

*Table 3: Motor Control Test. Significant results ($p \leq 0.05$) are marked with a * and highlighted in bold. The third column shows the p-value of CI-on and CI-off. The fourth column shows the confidence interval between condition with CI-on and CI-off, the fifth column shows the p-value between CI-on and the control group, and finally, the sixth column shows the p-value between CI-off and the control group.*

SEMICIRCULAR CANAL	CI-EARS EXAMINED	VHIT RESULTS Normal	Grey zone	Pathological	NON-CI EARS EXAMINED	VHIT RESULTS Normal	Grey zone	Pathological
LEFT HORIZONTAL	4	2	0	2	1	1	0	0
RIGHT HORIZONTAL	3	2	1	0	2	1	0	1
LEFT ANTERIOR	2	1	1	0	1	1	0	0
RIGHT ANTERIOR	2	1	1	0	1	1	0	0
LEFT POSTERIOR	2	1	1	0	1	1	0	0
RIGHT POSTERIOR	2	1	0	1	1	1	0	0
		TOTAL HYPOFUNCTIONAL SCCs CI: 7/15 = 46.7%				TOTAL HYPOFUNCTIONAL SCCs NON-CI: 1/7 = 14.3%		

Table 5: Video Head Impulse Results. Results were categorized as normal when the mean gain value calculated by computer software was above 0.80 for the horizontal SCCs and above 0.70 for the vertical SCCs and no pathological saccades were registered. Results were categorized as grey zone when the mean gain value was below 0.80 or 0.70 for horizontal and vertical SCCs, respectively and no pathological saccades were found, or mean gain value was normal but pathological saccades were found. Results were categorized as pathological saccades if mean gain values were below the stated reference value and pathological saccades were found. Note that 46.7 % of the implanted ears have hypofunction of SCCs.

CONDITION	CI ON/OFF	CONFIDENCE INTERVAL 95% ON/OFF	CI ON/CONTROL	CI OFF/CONTROL
TOES UP	0.666	[-30.01 , 43.67]	0.069	0.136
TOES DOWN	0.813	[-39.17 , 31.97]	**0.030***	0.214

*Table 4: Adaptation Test. The first column defines the subtest of the ADT. The second column represents the p-value of the comparison between condition with CI-on and CI-off. The third column shows the 95% confidence interval between condition with CI-on and CI-off. The fourth and fifth columns shows the p-values with CI-on and the control group and the CI-off and the control group, respectively. The significant result ($p \leq 0.05$) is marked with a * and highlighted in bold.*

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