The effect of stimulation waveform on electrically elicited Stapedius Response Threshold (eSRT) in Neuro Cochlear Implants

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Abstract

Standard clinical field reports indicate that the detection rate of eSRT is lower in Oticon Medical (OM) Neuro CI system than in the competitors' systems. In Neuro system the loudness is coded by pulse-width modulation of electrical stimulations, whereas other manufacturers use amplitude modulation to encode the loudness.

We did a pilot study to investigate if the stimulation waveform may influence the eSRT and its detection rate. We compared the eSRT responses when the stimulations were being exerted in single electrode and in a consecutive group of 3 and 5 electrodes.

Our study showed that the stimulation waveshape is an important factor in the modification of eSRT.

Background

The stapedius muscle located in the middle ear has a protective function against loud sounds. Activation of this muscle in response to strong electrical stimulations in cochlear implant (CI) patients may be used to objectively determine the most comfortable level (so-called C-level or MCL) in CI users. The **eSRT (electrically elicited Stapedius Reflex Threshold)** is defined as the minimum amount of electrical stimulation that elicits a measurable contraction of the stapedius muscle.

State of the art

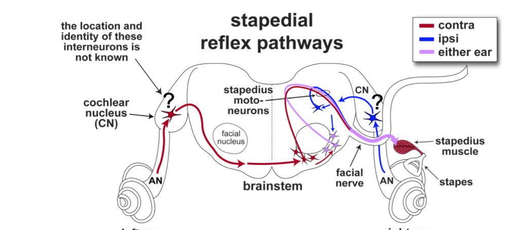
Researchers have reported different values for the detection rate of eSRT ranging from 16% to 87%.

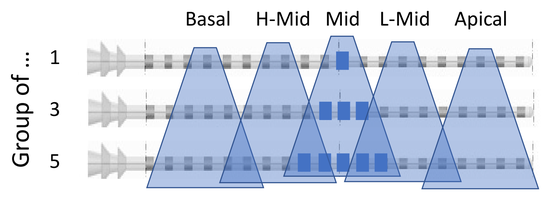
It seems that the setup and its corresponding recording and acquisition parameters (e.g., employed CI device, ipsi versus contra, basal versus apical, probe tone frequency, …) may change the detection rate of eSRT to a big extent.

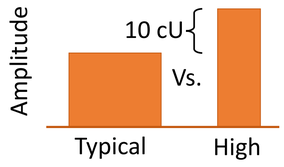
- About 30% to 40% of patients do not show eSRT on any electrodes [1],[2]
- eSRT thresholds are well correlated (r=0.75 to 0.9) with Most comfortable level (M-Levels) over time [2].
- eSRT thresholds exhibit higher mean values than their mean C-level counterparts. A correction factor will be needed [3].
- eSRT is recorded on 40% (basal) to 60% (apical) of basal and apical electrodes, respectively. 70% of patients have at least eSRT response in an electrode [3].
- eSRT in intraoperative period were higher than those in the postoperative period and higher than C levels [4].
- eSRT in adults works better than in children in terms of correlation with C-level [4].

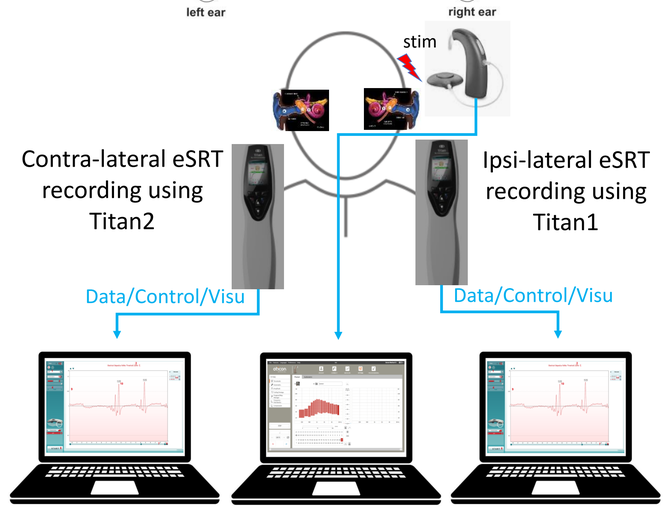
Methodology

- Our study was executed on **five ears** (four CI patients).
- **Ipsi- and contra-lateral** eSRTs were simultaneously recorded using two Interacoustics A/S **Titan** devices.
- Stimulations were applied at **two different pre-set amplitudes**
  - Typical: The amplitude utilized in the main fitting program
  - High: Typical + 10 current unit
- For each stimulation amplitude, the **pulse duration was increased** gradually until the eSRT could be elicited or the uncomfortable loudness level (UCL) was reached.
- Five different areas in the cochlea were investigated: **Basal, High-Mid, Mid, Low-Mid, Apical**
- The procedure was repeated three times for:
  - A single-electrode
  - A group of 3 electrodes
  - A group of 5 electrodes









Results

Our pilot study shows that the shape of the stimulating pulse (i.e., typical vs. high amplitude) has an important effect on the eSRT detection rate.

The stimulations with the higher amplitude (and thus lower width) increase the eSRT detection rate. The eSRT charge level per electrode are expressed in nC in the tables.

eSRT detection rate (Ipsi+Contra)

Group of …	Typical Amplitude	High Amplitude
1	0%	46%
3	22%	56%
5	42%	80%

The right ear (patient 4) and the missing data (patient 1) were excluded

Typical Amplitude

		Group of 1					Group of 3					Group of 5				
		Ap				Ba	Ap				Ba	Ap				Ba
Ear#1	Ipsi	.	.	.	.	.	87	.	31	35	47	80	47	44	24	24
	Contra	.	.	.	.	.	.	.	31	35	47	80	47	44	24	24
Ear#2	Ipsi	.	.	.	.	.	.	.	.	.	25	.	.	.	.	21
	Contra	.	.	.	.	.	.	.	.	.	25	.	.	.	.	21
Ear#3	Ipsi	.	.	.	.	.	.	.	.	.	.	33	.	.	.	.
	Contra	.	.	.	.	.	.	.	.	.	.	32	.	.	.	.
Ear#4	Ipsi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Contra	.	.	.	.	.	.	.	.	.	.	.	32	.	.	.
Ear#5	Ipsi	.	.	.	.	.	.	.	.	.	.	.	34	21	.	.
	Contra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

High Amplitude

		Group of 1					Group of 3					Group of 5				
		Ap				Ba	Ap				Ba	Ap				Ba
Ear#1	Ipsi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Contra	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ear#2	Ipsi	52	57	55	42	26	35	33	37	41	20	28	29	30	37	20
	Contra	52	57	55	42	20	28	33	32	40	20	28	28	28	37	20
Ear#3	Ipsi	.	.	.	.	.	59	.	.	.	.	35	47	33	29	.
	Contra	.	.	.	.	.	59	.	38	.	.	35	47	29	29	.
Ear#4	Ipsi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Contra	42	.	35	.	.	26	.	31	.	.	16	29	23	14	.
Ear#5	Ipsi	.	48	31	.	.	.	33	22	.	.	.	31	20	.	.
	Contra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

- No eSRT response
- X Missing data. Not enough time to execute the protocol
- No response on the Right ear

Conclusion

Our study suggests that eSRT is perhaps invoked by the energy of the stimulating pulses, but not the charge.

It also suggests that eSRT is obtained easier when the stimulation is applied on multiple electrodes because the CI patients can tolerate the injected charge, but still benefit from the loudness summation effect.

References

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