INTEREST OF VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED CHILDREN: PRELIMINARY RESULTS

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• Many children with **profound sensorineural hearing loss** also display **vestibular disorders** (20 – 85%)

• At present there is evidence supporting:

  – The additional benefit of having bilateral cochlear implantation in deaf children
  
  – a high probability of postoperative vestibular modifications
  
    Vestibular modifications in 50% of the cases with 10% of complete vestibular loss after CI

*Cushing et al, 2008; Abramides et al, 2009; De Kegel et al, 2012 Wiener-Vacher et al, 2008*
→ Better sound localization
→ Better speech perception in noise
→ Better quality of life
A SHORT INTRODUCTION TO VESTIBULAR PHYSIOLOGY

Labyrinth

- Cochlea
- Vestibule
  → saccule
  → utricle
  Otolith organs
- Semi-circular canals

(c) Northwestern University, 2001
A SHORT INTRODUCTION TO VESTIBULAR PHYSIOLOGY

Vestibular receptors (5)

Ampullary crest
→ angular accelerations

Utricular and saccular maculae
→ linear accelerations
→ gravity

Functions
- Gaze stabilization (VOR)
- Body/head stabilization and postural adjustment (VCR – VRS)
Vestibulo ocular reflex

- Stabilizes gaze during head movement
- Physiological nystagmus
- Generated by vestibular receptors
  - aVOR (SCCs)
  - tVOR (otolithic organs)
- Most used in daily clinical practice is horizontal aVOR
• The **objective** of this study is to evaluate

  – the impact of cochlear implants on vestibular function in sequential implantation

  – the risk of inducing a complete areflective status after second implantation
- From January 2012 to May 2015
- 26 candidates for contralateral implantation

<table>
<thead>
<tr>
<th>Population characteristics (n=26)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at first examination</td>
<td>6.75 (range: 1 - 13)</td>
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<tr>
<td>Brand of Implants</td>
<td>Cochlear</td>
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<tr>
<td>Cochleostomy insertion site</td>
<td>Antero-inferior</td>
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<tr>
<td>Etiology</td>
<td></td>
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<tr>
<td>Syndromic</td>
<td>6</td>
</tr>
<tr>
<td>Genetic</td>
<td>7</td>
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<tr>
<td>Postmeningitic</td>
<td>2</td>
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<tr>
<td>CMV</td>
<td>1</td>
</tr>
<tr>
<td>ANSD</td>
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<td>CT scan, MRI</td>
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<tr>
<td>Normal</td>
<td>19</td>
</tr>
<tr>
<td>Vestibular malformation</td>
<td>3</td>
</tr>
<tr>
<td>Cochlear malformation</td>
<td>1</td>
</tr>
<tr>
<td>Cochleo-vestibular malformation</td>
<td>3</td>
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</tbody>
</table>
Vestibular assessment before and 3 months after 2nd implantation

- **Complete vestibular clinical evaluation**
  - Patient history (vestibular symptoms?)
  - Postural stability, gait, and coordination
  - Oculomotor assessment
  - Spontaneous or gaze-evoked nystagmus
  - Short neurological evaluation

- **Horizontal canal evaluation** (aVOR)
  - Halmagyi test
  - VOR testing on rotary chair
  - **Bicaloric testing** with videonystagmoscopy

- **Otolithic evaluation**
  - **cVEMP exam** with tone bursts
VESTIBULAR EVOKED MYOGENIC POTENTIALS: C-VEMPS

• Elicited from the SCM muscle
• Assesses saccular and inferior vestibular nerve function (sacculospinal pathway)
• Recorded with standard ABR equipment and surface electrodes
• Stimulus: 500 Hz tone bursts, 74 dBnHL bone conduction
• P1-N1 wave, amplitude and latencies

• **Pitfalls:** - SCM contraction
  - Otitis media with effusion
• Bithermal caloric stimulation: ear irrigation at 30°C and 44°C during 30 sec

• Observation of eye movements by videonystagmoscopy (or VNG)

• Information about lateral SCCs only

• Canal paresis if Jonkees formula values ≥ 15%

• Not well tolerated in young children
Vestibular status before contralateral implantation

Before contralateral implantation

- 31% normal bilateral vestibular function
- 61% unilateral or bilateral hyporeflexia
- 8% bilateral areflexia

High prevalence of vestibular dysfunction in our test group (n=26)
VEMP responses

- Before 2\textsuperscript{nd} CI: present in 19 patients
- After 2\textsuperscript{nd} CI: present in 15 patients

→ 4/24 patients lost their VEMP responses (16%)

Follow-up group, n=24
Identical response: 18 patients (13 reactive – 5 areflective)

Decay: 3 patients

Increase: 2 patients (hyperexcitability?)

Disappearance: 1 patient

Different responses in 6/24 patients
Only presence/absence of cVEMP response was considered.

- Thresholds could not be determined for all children
- Amplitude strongly depends on muscle contraction
- Biofeedback allows more precision
DISCUSSION

- Vestibular status before first implantation is mostly unknown

- Compliance for VEMP testing was high, in contrast to compliance for caloric testing

- **37% of patients had their vestibular function modified** after their second implantation. However, none of the patients with a normal vestibular status at the 2nd implanted ear became areflectic

- **12% (3/24) patients completely lost their saccular function and 4% (1/24) became areflectic** after second implantation

- In patients with vestibular function modifications, **one third manifested transitory postoperative vestibular symptoms (3/9)**. 
  Age-related? *(Chi-square test, p = 0.079)*

- No significative correlation between vestibular loss and inner ear malformation *(Chi-square test, p = 0.8077)*
• High prevalence of vestibular dysfunction among our test group

• Horizontal canal function seems more preserved than saccular function

• 16% of our children presented a loss of saccular and/or horizontal canal function after second implantation. Amongst these children, which percentage will have balance problems in older age?

• Larger series of patients are required in order to confirm our results about the impact of contralateral implantation on balance function

• This study confirms the importance of vestibular assessment before sequential implantation to prevent bilateral vestibular areflexia, especially if
  - there is hyporeflexia on the not yet implanted ear
  - independent walking is not acquired yet
26 months old girl, bilateral sequential cochlear implantation
Horizontal canal areflexia
THANK YOU FOR YOUR ATTENTION
**Complete test results**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Etiology</th>
<th>P1/N1 CI contralat, pre</th>
<th>P1/N1 CI contralat, post</th>
<th>Variation A°</th>
<th>Caloric test pre 2nd CI</th>
<th>Caloric test after 2nd CI</th>
<th>Imaging</th>
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<td>65 db</td>
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<td>Vestibular dysplasia</td>
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<tr>
<td>2</td>
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<td>65 db</td>
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<td>Hyporeflexia left</td>
<td>Symmetrization (right ≠)</td>
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<tr>
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<td>65 db</td>
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<td>Normal</td>
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<tr>
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<td>Post meningitic</td>
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<td>60 db</td>
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<td>Symmetrization (right ≠)</td>
<td>Cochlear ossification</td>
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