

# INTEREST OF VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED CHILDREN: PRELIMINARY RESULTS

I. Pauwels - B. Devroede - A-L. Mansbach

*ENT Department,  
Queen Fabiola University Children's Hospital Brussels*

*World Pediatrics Congress 2017 - Orlando*



Queen Fabiola University  
Children's Hospital

Hôpital Universitaire des  
Enfants Reine Fabiola



# VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED CHILDREN: INTRODUCTION

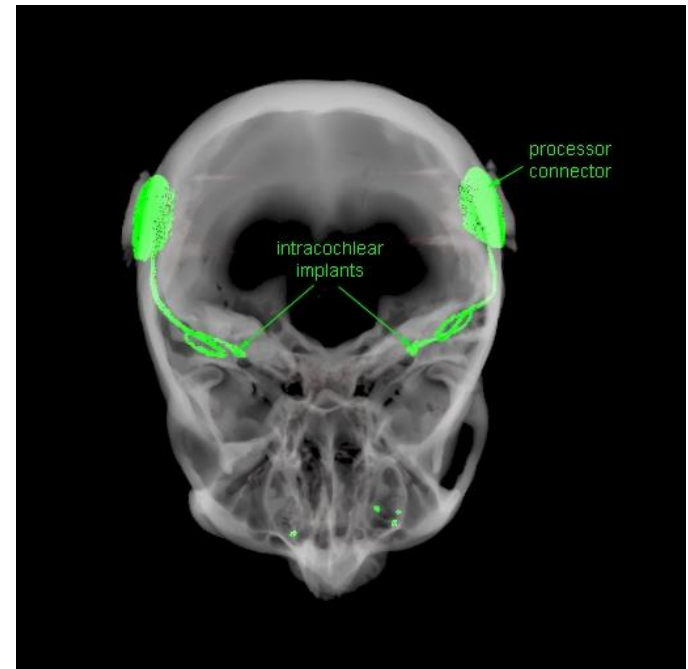
- Many children with **profound sensorineural hearing loss** also display **vestibular disorders** (20 – 85%)
- At present there is evidence supporting:
  - The additional benefit of having bilateral cochlear implantation in deaf children
  - a high probability of postoperative vestibular modifications  
Vestibular modifications in 50% of the cases with 10% of complete vestibular loss after CI

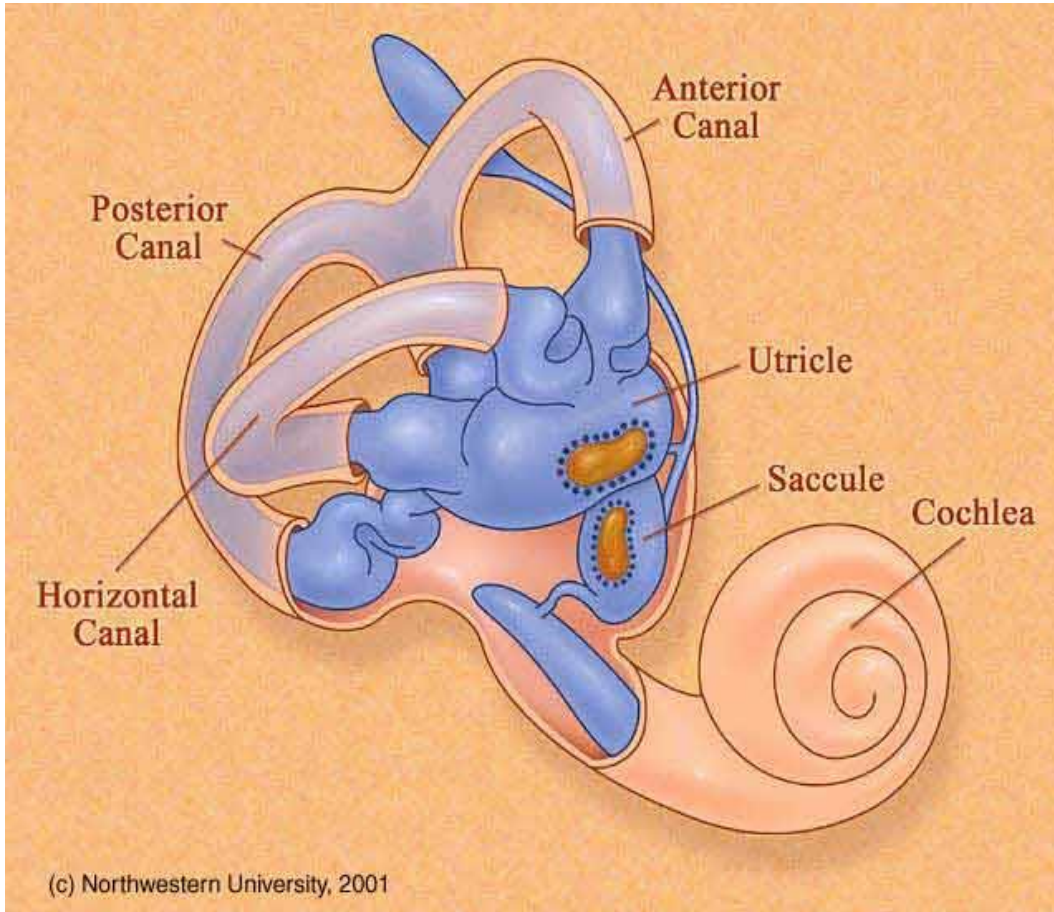


*Cushing et al, 2008; Abramides et al, 2009; De Kegel et al, 2012  
Wiener-Vacher et al, 2008*

# ADDITIONAL BENEFIT OF BILATERAL IMPLANTATION IN CHILDREN

- Better sound localization
- Better speech perception in noise
- Better quality of life





## Labyrinth

- Cochlea
- Vestibule
  - saccule
  - utricle

} Otolith organs
- Semi-circular canals

# A SHORT INTRODUCTION TO VESTIBULAR PHYSIOLOGY

## Vestibular receptors (5)

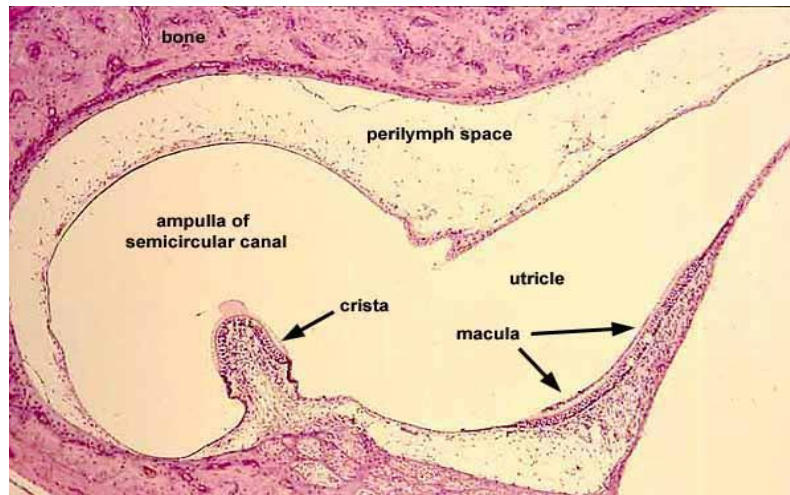
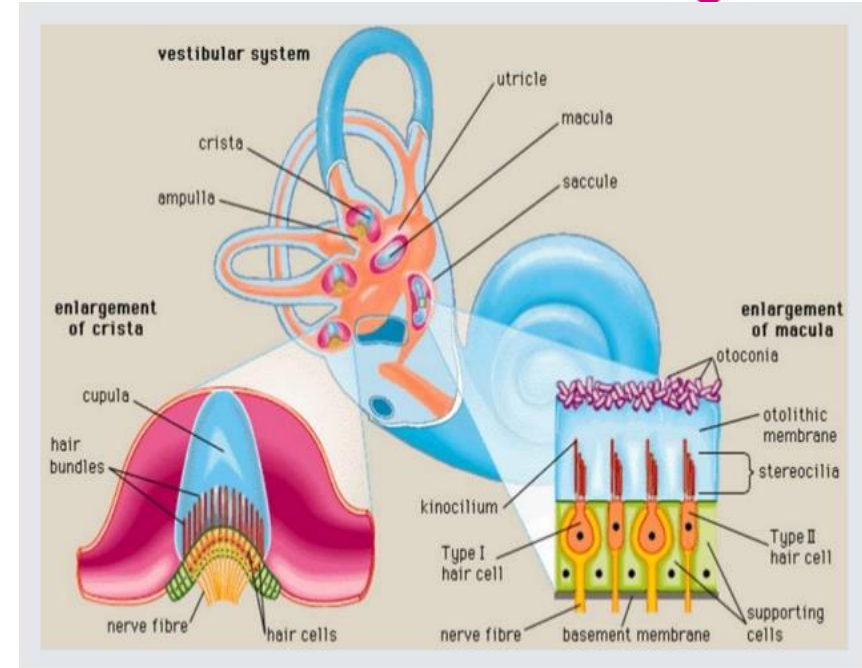
### Ampullary crest

→ angular accelerations

### Utricular and saccular maculae

→ linear accelerations

→ gravity

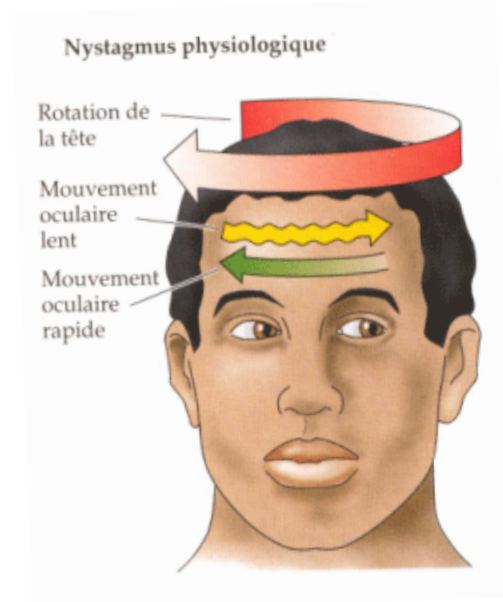
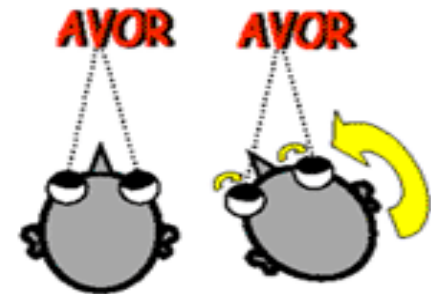


## Functions

- Gaze stabilization (VOR)
- Body/head stabilization and postural adjustment (VCR – VRS)

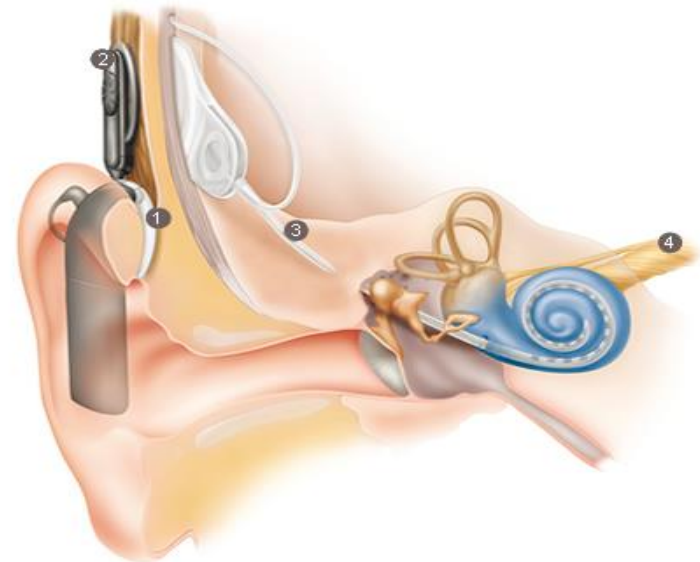
## Vestibulo ocular reflex

- 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



# VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED CHILDREN: OBJECTIVE

- 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



# POPULATION

- From January 2012 to May 2015
- 26 candidates for contralateral implantation

| <b>Population characteristics (n=26)</b> |                      |
|--|----------------------|
| <b>Mean age at first examination</b>     | 6,75 (range: 1 - 13) |
| <b>Brand of Implants</b>                 | Cochlear             |
| <b>Cochleostomy insertion site</b>       | Antero-inferior      |
| <b>Etiology</b>                          |                      |
| Syndromic                                | 6                    |
| Genetic                                  | 7                    |
| Postmeningitic                           | 2                    |
| CMV                                      | 1                    |
| ANSD                                     | 2                    |
| Unknown                                  | 8                    |
| <b>CT scan, MRI</b>                      |                      |
| Normal                                   | 19                   |
| Vestibular malformation                  | 3                    |
| Cochlear malformation                    | 1                    |
| Cochleo-vestibular malformation          | 3                    |



# METHOD

- Vestibular assessment **before** and **3 months after** 2<sup>nd</sup> implantation

- **Complete vestibular clinical evaluation**

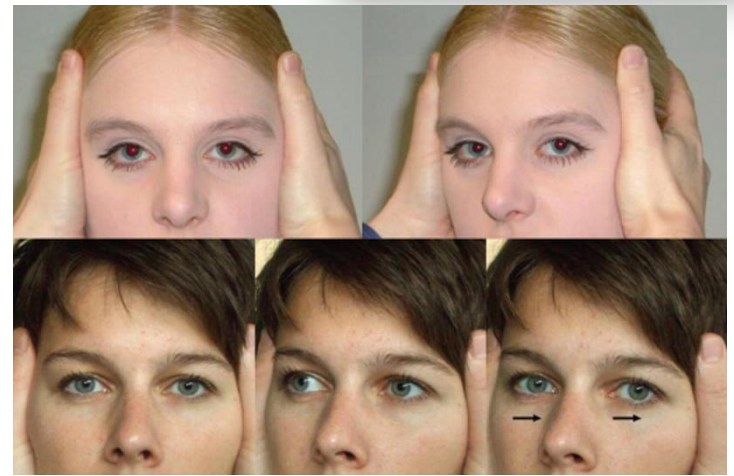
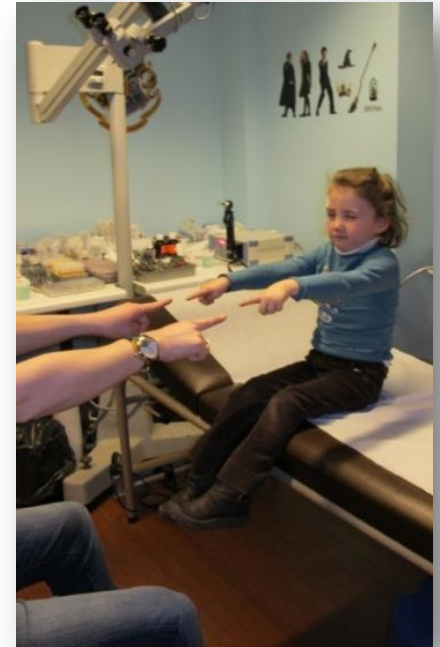
- Patient history (vestibular symptoms?)
- Postural stability, gait, and coordination
- Oculomotor assessment
- Spontaneous or gaze-evoked nystagmus
- Short neurological evaluation

- **Horizontal canal evaluation** (aVOR)

- Halmagyi test
- VOR testing on rotary chair
- **Bicaloric testing** with videonystagmoscopy

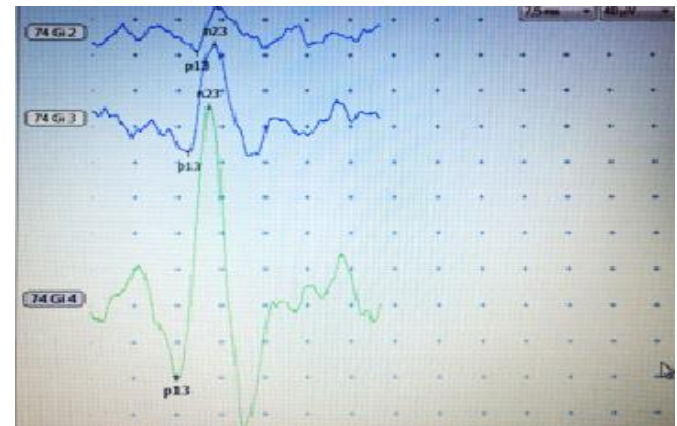
- **Otolithic evaluation**

- **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



# CALORIC TEST

- 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  $\geq 15\%$
- Not well tolerated in young children



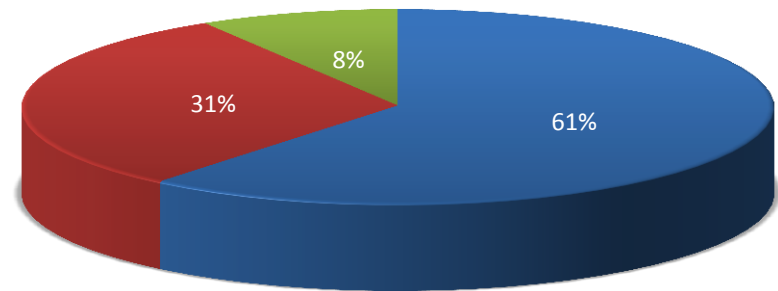
# RESULTS

## VESTIBULAR STATUS OF THE TEST GROUP

### 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)

■ hyporeflexia ■ normal function ■ areflexia

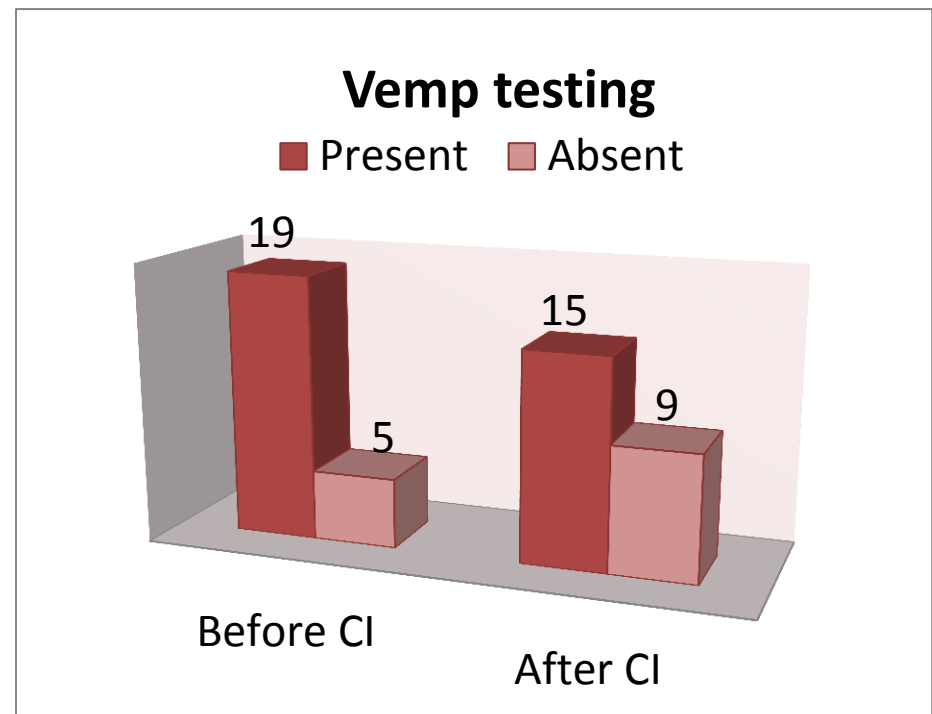
# Results c-VEMP testing

## Otolithic function modifications

### VEMP responses

- ▶ Before 2<sup>nd</sup> CI: present in 19 patients
- ▶ After 2<sup>nd</sup> CI: present in 15 patients

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



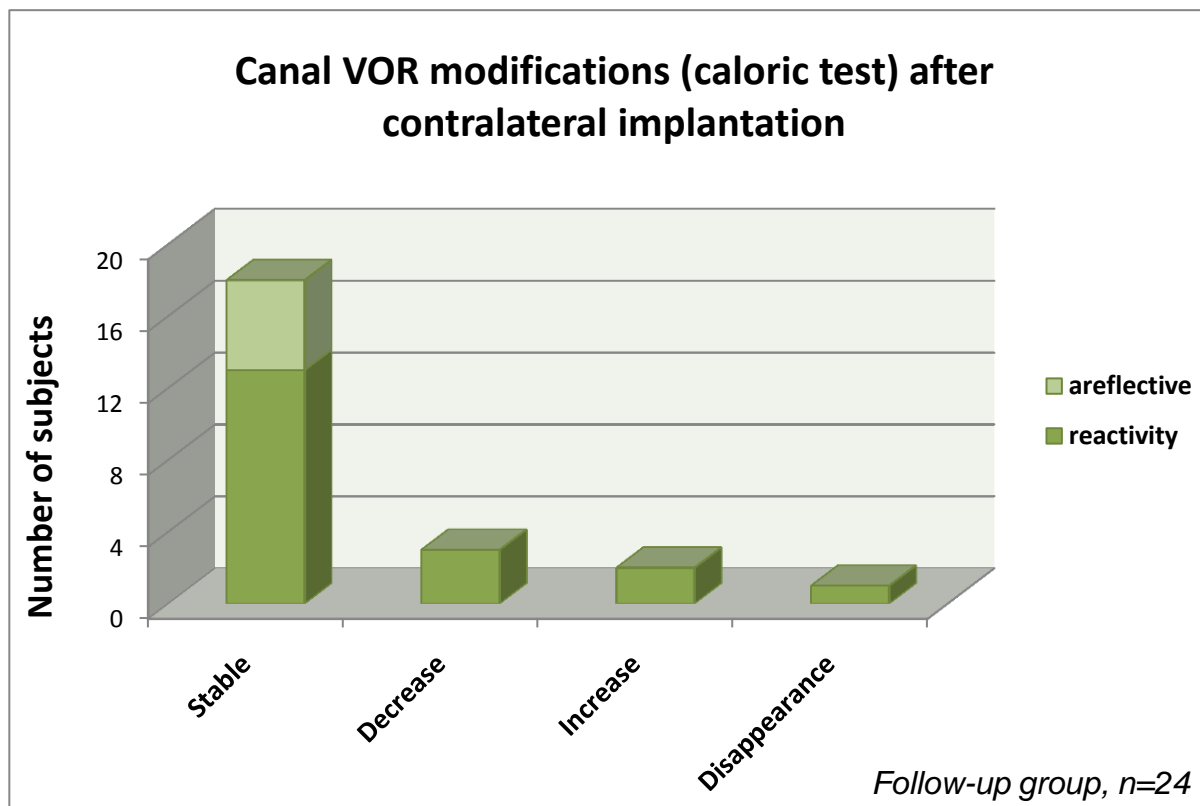
Follow-up group, n=24

# Results bicaloric testing

## Horizontal canal function modifications

- ▶ Identical response: 18 patients (13 reactive – 5 areflective)
- ▶ Decrease: 3 patients
- ▶ Increase: 2 patients (hyperexcitability?)
- ▶ Disappearance: 1 patient

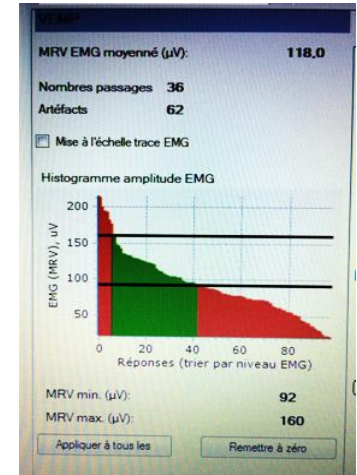
→ Different responses  
in 6/24 patients



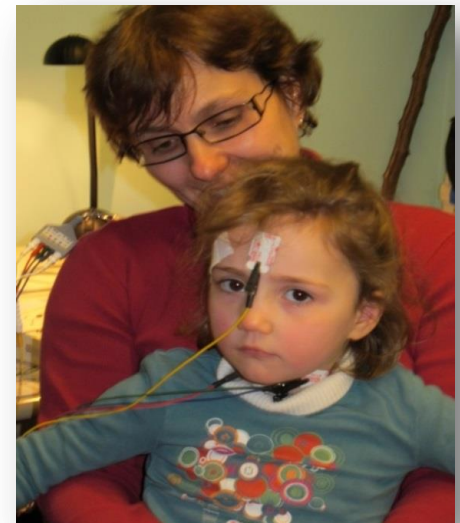
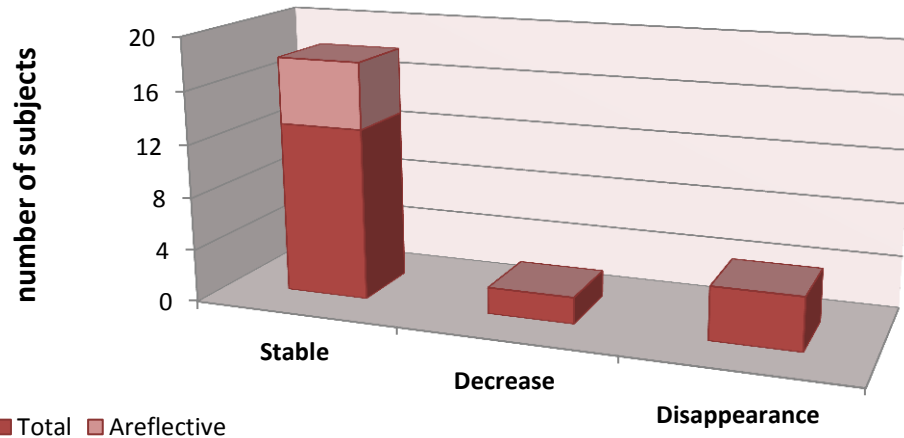
# DISCUSSION: CVEMP TESTING

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

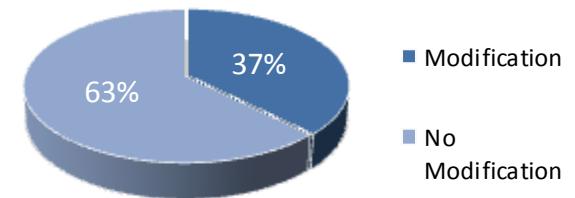


## VEMP amplitude comparison before and after contralateral CI



# 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 2<sup>nd</sup> 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 significant correlation between vestibular loss and inner ear malformation**  
*(Chi-square test,  $p = 0,8077$ )*



# VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED CHILDREN: CONCLUSIONS

- **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



# CLINICAL CASE

26 months old girl, bilateral sequential cochlear implantation  
Horizontal canal areflexia



**VESTIBULAR EVALUATION IN SEQUENTIALLY IMPLANTED  
CHILDREN: PRELIMINARY RESULTS**



***THANK YOU  
FOR YOUR ATTENTION***



## Vestibular evaluation in sequentially implanted children: preliminary results

# Complete test results

| Patients | Etiology        | P1/N1 CI contralat, pre | P1/N1 CI contralat, post | Variation A° | Caloric test pre 2nd CI     | Caloric test after 2nd CI            | Imaging                             |
|----------|-----------------|-------------------------|--------------------------|--------------|-----------------------------|--------------------------------------|-------------------------------------|
| 1        | Unknown         | ✓                       | 65 db                    | =            | Normal                      | Normal                               | Vestibular dysplasia                |
| 2        | Genetic         | ✓                       | 65 db                    | =            | Hyporeflexia left           | Symmetrization (right ↘)             | Normal                              |
| 3        | Syndromic       | 0                       | 0                        | =            | Areflexia                   | Areflexia                            | Normal                              |
| 4        | Syndromic       | 74 db                   | 0                        | *            | Bilateral hyporeflexia      | Bilateral hyporeflexia               | Normal                              |
| 5        | Unknown         | ✓                       | 60 db                    | =            | Hyporeflexia right          | Normal (right ↗, hyperexcitability?) | Normal                              |
| 6        | Genetic         | ✓                       | 65 db                    | ↘            | Normal                      | Normal                               | Normal                              |
| 7        | Post meningitic | ✓                       | 60 db                    | =            | Hyporeflexia left           | Symmetrization (right ↘)             | Cochlear ossification               |
| 8        | Syndromic       | ✓                       | 65 db                    | =            | Areflexia right             | Areflexia right                      | Normal                              |
| 9        | Unknown         | 0                       | 0                        | =            | Hyporeflexia left           | Hyporeflexia left                    | Normal                              |
| 10       | Unknown         | 0                       | 0                        | =            | Hyporeflexia right          | Hyporeflexia right (but ↗ right)     | Normal                              |
| 11       | Genetic         | 74 db                   |                          |              | Normal                      |                                      | Normal                              |
| 12       | Unknown         | ✓                       |                          |              | Important hyporeflexia left |                                      | LVAS                                |
| 13       | Syndromic       | 60 db                   | 60 db                    | =            | Normal                      | Normal                               | cochleo-vestibular dysplasia        |
| 14       | Syndromic       | 0                       | 0                        | =            | Bilateral hyporeflexia +++  | Bilateral hyporeflexia +++           | Normal                              |
| 15       | Genetic         | 65 db                   | 74 db                    | =            | × (tubes)                   | Normal                               | Normal                              |
| 16       | Unknown         | 60 db                   | 65 db                    | =            | Normal                      | Normal                               | Normal                              |
| 17       | Genetic         | ✓                       | ✓                        | =            | Normal                      | Normal                               | Normal                              |
| 18       | Unknown         | ✓                       | ✓                        | =            | Hyporeflexia left           | Hyporeflexia left                    | Normal                              |
| 19       | ANSD            | ✓                       | ✓                        | =            | Hyporeflexia right          | Bilateral hyporeflexia               | Normal                              |
| 20       | ANSD            | ✓                       | 0                        | *            | Areflexia                   | Areflexia                            | Vestibular dysplasia                |
| 21       | Genetic         | ✓                       | ✓                        | =            | × (tubes)                   | Hyporeflexia left                    | Normal                              |
| 22       | Post meningitic | 0                       | 0                        | =            | Areflexia                   | Areflexia                            | Cochleo - vestibular ossification   |
| 23       | Genetic         | ✓                       | 0                        | *            | Bilateral hyporeflexia      | Bilateral hyporeflexia               | Normal                              |
| 24       | unknown         | ✓                       | ✓                        | =            | Normal                      | Normal                               | Normal                              |
| 25       | Syndromic       | ✓                       | 0                        | *            | Hyporeflexia right          | Areflexia                            | LVAS + cochleo-vestibular dysplasia |
| 26       | CMV             | ✓                       | ✓                        | ↘            | Areflexia                   | Areflexia                            | Normal                              |