HOW TO IMPROVE COCHLEAR IMPLANT IN ADULT
Poor performances in adult CI patients and its remediation

B. FRAYSSE
A number of patients do not reach optimal performance according to their own pronostic factors.

10 to 50% can be considered as poorer performer.
GOAL OF THE STUDY

1. To analyze CI auditory outcomes as a function of delay post activation and the various factors underlying the results

2. To design a predictive model during counselling based on patient related factors and electrode insertion

3. To compare early auditory outcomes to the predictive mode and propose remediation
**POPULATION**

**Inclusion**

- All adults with unilateral CI and profound HL at least one year follow-up and receiving the same aural rehabilitation program

**Study design**

- The percentage of variance (22) expresses the impact of each factor

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**EARLY SENTENCE RECOGNITION IN ADULT COCHLEAR IMPLANT USERS**
Chris James, Chadlia Karoui, Mathieu Marx, Marie-Laurence Laborde, Charles-Edouard Molinier, Benoit Lepage, Olivier Deguine, Bernard Escudé, Bernard Fraysse

Accepted for publication
AUDITORY OUTCOMES / DELAY POSTACTIVATION

1 day / 1 month

\[ y = 22 \ln(x) - 3, \quad r^2 = 0.5058 \]
AUDITORY OUTCOMES / DELAY POSTACTIVATION

1 day / 1 month

12 mois

r² = 0.32, p<0.001

Frequency-place mismatch >>1.5 oct
Nuc Peri 2

Frequency-place mismatch <1.5 oct

Median

(SNR 50%)

Score initial 10 dB SNR

Congenital
Genetic
Infection
Meniere’s
Meningitis
Misc
Noise
Otosclerosis
Ototoxicity
Sudden
Trauma
Unknown
OVERAL RESULTS

N = 118

Quiet

Score in Quiet / 100

Score in Noise / 100

Post activation delay /months

Post activation delay /months
The development of speech understanding with CI does not follow a linear function with time.

High sentence scores can be obtained by only one day after activation.

The first two weeks are as important as the next six months, and the following 2-3 years.
FACTORS TO BE CONSIDERED

- Biographic and audiologic factors
  - Age at implantation
  - Etiology
  - Duration of hearing loss

- Anatomical and surgical factors
  - Insertion depth of apical electrodes
  - Scala location

- Linguistic and neurocognitive skills

  - Patient related
  - Insertion technique
  - Personalized auditory rehabilitation
BIOGRAPHIC FACTORS

- Age at implantation: NS
- Duration of deafness: 9 to 12% total variance
  \(0.46 \text{ pts per year of profound HL}\)
- Etiologies: 20 to 30% total variance
  (Chronic otitis, Meniere diseases)
BIOGRAPHIC FACTORS DATA


20% 10%

3-6 months after activation
1-2 years after activation
ANATOMICAL AND SURGICAL FACTORS BASED ON POSTOPERATIVE CONE BEAM

1. Insertion depth
2. Scalar location

In vivo CT images: Professor Tobias Struffert, University of Erlangen.
THE EFFECT OF INSERTION DEPTH ON AUDITORY OUTCOMES

For perimodiolar electrode negative correlation between insertion depth and auditory outcomes

9% of variance, p<0.001
FREQUENCY ALLOCATION AND TONOTOPIC ORGANIZATION

- Size of the cochlea
- Type of electrode array
- Spacing between electrodes
FREQUENCY ALLOCATION
INSERTION DEPTH

- Moderate shifts may be easily accommodated but larger shifts > 1.5 octave may affect auditory performance and the adaptation process take more time (e.g. Li et al., 2009)

Mean spiral ganglion frequencies (Stakhovskaya et al, 2007)

Matched sound-processor frequency to electrode allocation
HOW CAN WE OPTIMIZE FREQUENCY ALLOCATION?

- By a better surgical planning based on radiological data and electrode type

Pre op.
By reprogramming the electrodes based on post operative insertion angle

<table>
<thead>
<tr>
<th>El</th>
<th>Angle</th>
<th>SG Freq</th>
<th>Filtre Freq</th>
<th>Shift Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>535</td>
<td>335,4</td>
<td>149</td>
<td>1,17</td>
</tr>
<tr>
<td>2</td>
<td>460</td>
<td>498,3</td>
<td>261</td>
<td>0,93</td>
</tr>
<tr>
<td>3</td>
<td>390</td>
<td>724,3</td>
<td>408</td>
<td>0,83</td>
</tr>
<tr>
<td>4</td>
<td>325</td>
<td>1047,5</td>
<td>601</td>
<td>0,80</td>
</tr>
<tr>
<td>5</td>
<td>270</td>
<td>1471,4</td>
<td>854</td>
<td>0,78</td>
</tr>
<tr>
<td>6</td>
<td>225</td>
<td>1993,7</td>
<td>1191</td>
<td>0,74</td>
</tr>
<tr>
<td>7</td>
<td>185</td>
<td>2674,6</td>
<td>1638</td>
<td>0,71</td>
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<tr>
<td>8</td>
<td>145</td>
<td>3680,3</td>
<td>2233</td>
<td>0,72</td>
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<tr>
<td>9</td>
<td>110</td>
<td>4974,1</td>
<td>3028</td>
<td>0,72</td>
</tr>
<tr>
<td>10</td>
<td>70</td>
<td>7192,2</td>
<td>4090</td>
<td>0,81</td>
</tr>
<tr>
<td>11</td>
<td>35</td>
<td>10159,1</td>
<td>5510</td>
<td>0,88</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>13327,4</td>
<td>7175</td>
<td>0,89</td>
</tr>
</tbody>
</table>

Decalage Moyen 0,83

Calcul Chris James, based on Stakhovskaya
## SCALAR LOCATION

<table>
<thead>
<tr>
<th>Type of electrode</th>
<th>Scala tympani</th>
<th>Scala vestibuli or Dislocation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of electrode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Straight (<em>N: 43</em>)</td>
<td>38 (88%)</td>
<td>5 (12%)</td>
</tr>
<tr>
<td>- Perimodiolar (<em>N: 53</em>)</td>
<td>33 (62%)</td>
<td>20 (38%)</td>
</tr>
<tr>
<td><strong>Depth of insertion</strong></td>
<td>432°</td>
<td>403°</td>
</tr>
</tbody>
</table>

*p < 0.01\NS*
In our study the scala dislocation reduced scores by 12 - 25 pts at one year \((p<0.01), r^2=14\%\)

So why use a perimodiolar electrode?
PREDICTIVE MODEL

Based on:

- Duration of deafness
- Etiologies
- Electrode insertion
Based on our biographic data, we may develop a mathematical model during counselling based on biographic factors

- 90 – 0.5/yr HL – (X étiologies)
# VARIANCE OF PERIPHERAL FACTORS ON OUTCOMES

<table>
<thead>
<tr>
<th></th>
<th>In noise</th>
<th>In quiet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etiology</td>
<td>0.34***</td>
<td>0.25**</td>
</tr>
<tr>
<td>Duration of deafness per year</td>
<td>0.06* per year</td>
<td>0.08* per year</td>
</tr>
<tr>
<td>Insertion length per degree</td>
<td>0.09***</td>
<td>0.08**</td>
</tr>
<tr>
<td>Proportion of electrodes in the scala tympani</td>
<td>0.14**</td>
<td>0.13**</td>
</tr>
<tr>
<td><strong>Total impact of peripheral factors</strong></td>
<td><strong>41%</strong></td>
<td><strong>49%</strong></td>
</tr>
</tbody>
</table>
In our study, 50% of the variance at 1 month cannot be explained by auditory peripheral factors.

Speech discrimination in degraded condition (CI or HA to some limit) may be compensated by neurocognitive and linguistic skills.

The evolution of crossmodal plasticity is one of the underlying processes of compensatory mechanisms.
We studied the dynamics of reversed crossmodal plasticity by TEP Brain imaging during auditory speech tracking.
Auditory stimulation determined a reactivation of auditory cortical areas but also a crossmodal reorganization of the cortical visual network.

Clear correlation between individual visual and auditory brain activity and auditory outcomes.
This article confirm the interest to develop specific rehabilitation strategies according to early outcomes in auditory and audiovisual conditions.
ON WHICH BASIS DEVELOP PERSONALIZED REHABILITATION STRATEGIES?

- Optimization of the rehabilitation must take into account the level of:

  1. Phonemic sensitivity and lexical knowledge
  2. Cognitive factors
     - Speed of processing
     - Working memory and attention
     - Executive function

[Image: Research Article
Speech Recognition in Adults With Cochlear Implants: The Effects of Working Memory, Phonological Sensitivity, and Aging
Aaron C. Moberly, Michael S. Harris, Lauren Boyce, and Susan Nittrouer]
One month results

Normal performer

Conventional rehabilitation

Poor performer

Auditory evaluation on objective method

- Frequency allocation
- Scalar location

Working memory and phonological sensitivity evaluation

- Speed of stimulation refractory period
- Channel selectivity spread of excitation

Personalized auditory rehabilitation

« Bottom up » approach

« Top down » approach
PERSONALIZED REHABILITATION PROGRAM

EVALUATION OF PHONOLOGICAL SENSITIVITY

- 2 Normal
  - Motivation Education
  - Linguistic skill
    - Phonological Training progress
      - Auditory cognitive training
    - Working memory area decrease
      - Neurocognitive evaluation
      - 2 Abnormal
## TIMING OF INTERVENTION

<table>
<thead>
<tr>
<th>Predictive Model Counselling patient</th>
<th>Electrode insertion Surgical planning</th>
<th>Optimized Fitting</th>
<th>Sentence recognition score Compare to predictive model</th>
<th>SNR50 as expected ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing story</td>
<td>Size of cochlea</td>
<td>X-Ray electrophysiological Frequency allocation</td>
<td>Data log Lexical knowledge Spread of excitation Recovery period</td>
<td>Data log Loudness growth</td>
</tr>
<tr>
<td>Etiology</td>
<td>Type of electrode</td>
<td></td>
<td></td>
<td>6 MONTHS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluate 2 programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACTIVATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SURGERY</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>PRE OP</td>
<td></td>
<td></td>
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</tbody>
</table>

- 
  - Map rehabilitation refinement
  - Cognitive or auditory Training
CONCLUSION

- Counseling patients with realistic expectations and take into account the patient’s goals (GAS)

- Electrode insertion should avoid dislocation and be adapted to the tonotopic organization

- Develop personalized rehabilitation programs and material based on early outcomes and targeted on specific weaknesses
Thank you for your attention