Evaluating FM performance for hearing impaired children

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Background-1

• With the development of Hearing screening technology, hearing impairment can be detected earlier
  – Newborn hearing screening has been popularized
  – Newborn genetic screening technology has also been applied

• With the active promotion of the prevention of deafness, more and more caregivers’ awareness have been raised
  – So far, “Ear-care Day” has been successfully carried out 15th
  – The screen refusal and follow-up default is becoming rare

• Early detection, early diagnosis and early intervention
• With the development of hearing technology, children with HAs and CIs may significantly improve their speech intelligibility
  – Hearing Aid
    • Noise reduction processing, directional microphone, bluetooth technology
  – Cochlear Implantation
    • Since the advent of cochlear implants, nobody is too deaf to benefit from a prosthetic device
    • For children with severe-to-profound hearing loss, they can consider CI
    • Noise reduction processing, directional microphone, bluetooth technology
• We have paid much efforts to audiology education and training, and the quality of hearing services significantly increased in the past few years
  – In our center, there are more than 200 hearing-impaired children in training
  – Hearing devices: most of the students use sophisticated and appropriate amplification technology
  – Optimize the effect of hearing without delay
    • Hearing management
    • Cooperation of Audiologists, rehabilitation teachers and parents
    • To assess the effect of hearing regularly and optimized in time
A key component to early intervention and positive spoken language outcomes is use of consistent and appropriate amplification technology, such as HA or CI.

However, even with the most sophisticated amplification technology, children in a classroom setting are faced with the task of listening and attending to teacher despite the presence of background noise and varying physical distance from the teacher.
• The troubles encountered by our kids in group teaching activities, multi-media teaching, outdoor activities, et al

  – Behaviour Problems
    • Some kids are not listening to the teachers, but moving as their own wishes
    • Some kids disturb other students, and annoy teachers
    • Some kids are normally copying other children’s movement when they can not hear well, they smile when seeing other kids smiling

  – Attention problems
    • Some kids can’t concentrate and not listen to teacher’s instructions
Purpose

• So, we have used FM system in our teaching practice since 2009

• Purpose of this research
  – To evaluate the effects on children with hearing impairment of using hearing instruments with an FM system
Study Sample

- 27 cases of Hearing-impaired children
- Age range: 3.48-5.50, average age: 4.02 ± 0.61
- All of them suffered prelingual sensorineural hearing loss
  - The play audiometry method was used to get the hearing threshold of the subjects, the average of 500, 1000, 2000, 4000Hz was calculated

<table>
<thead>
<tr>
<th></th>
<th>HA-HA</th>
<th>CI-HA</th>
<th>CI-/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral ≤90dB HL</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Monaural ≤90dB HL</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Bilateral &gt;90dB HL</td>
<td>1</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>17</td>
<td>1</td>
</tr>
</tbody>
</table>
Study Sample

• All hearing aids were optimally adjusted to meet targets using a prescriptive method designed to measure or estimate the audibility of amplified speech, so as to the CIs.

• The hearing-impaired children could hear a mixture of sound coming from the transmitter, and sound being picked up by the HAs and CIs local microphone (FM+M).

• FM systems were manufactured by Phonak, included
  – Inspiro Classic with iLapel transmitters
  – There were two kinds of receivers
    • 26 cases used MicroMLxS, which is compatible with hearing instrument via audio shoes or MicroLink CIs
    • 1 child used Mylink, which features a neck-loop and is compatible with his CI with a T-coil
Evaluation questionnaire

- A questionnaire was used to evaluate use and benefit of HAs or CIs and FM systems for young children
  - FM Listening Evaluation for Children
- The auditory skills of the kids were evaluated in four kinds of listening environments
  - Quiet, Noise, Auditory only, Distance
- There are 5 questions
  - Child responds to his/her name when spoken to
  - Child attends to person speaking
  - Child distinguishes between words that sound alike (e.g., Bay for day, sink for think, or sun for fun)
  - Child responds accurately to spoken directions
  - Child comprehends oral instruction & concepts
Method

- This questionnaire includes a scoring system and an opportunity for situational analysis.
  - The questionnaire has 35 items.
  - 10 items - listening skills in quiet.
  - 15 items - listening skills in noise.
  - 5 items - listening skills with auditory only.
  - 15 items - listening skills with distance.
  - Each skill divided into five grades of 1-5: 1 - never, 2 - rarely, 3 - sometimes, 4 - often, 5 - always.
  - Total score was 175 points, total score of quiet situation was 50 points; total score of noise situation was 75 points; total score of auditory only was 25 points; and total score of distance was 75 points.
  - To score, subtract any NA (not applicable) items from the total, then determine percent for total performance and for each situation.
Method

• Each question requires a subjective score based on the child’s response
• It can be completed by a parent or professional working with the child
• In this study, the questionnaire was completed by two rehabilitation teachers, who are in charge of the same class and are experienced
  – The score are very subjective
  – The score of parents were likely higher than that of teachers
  – There were differences between different teachers
Statistical method

• We apply the SPSS 19.0 statistical software for statistical analysis

• Paired t-test to compare measurement data
  – The score of with and without FM system were statistically analyzed

• ANOVA (analysis of variance) randomized block design
  – The score in 4 different situations were statistically analyzed
Results

• Questionnaire scores of different listening modes

<table>
<thead>
<tr>
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<th>Percentage of questionnaire score (%) (n=27)</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>M</td>
<td>67.55 ± 15.9</td>
</tr>
<tr>
<td>FM+M</td>
<td>84.35 ± 13.5</td>
</tr>
</tbody>
</table>
Results

The listening effect with local microphone only ("M")

- There were significant differences between 4 situations
- \( F=49.53, \ p<0.05 \)

[Bar chart showing percentage of questionnaire score (%) for Quiet, Noise, Auditory only, and Distance situations.]
Results

The comparison of the effect between “FM+M” and “M”

- The effect of “FM+M” is significantly better than “M”
Results

The listening effect with “FM+M”

• There were significant differences between 4 situations

• F=24.80, p<0.05
Discussion-1

• These results suggest that hearing impaired children with CIs or HAs can develop speech recognition in quiet listening situations

• Despite this achievement, children with CIs or HAs often experience reductions in noise or distance situations relative to quiet listening conditions

• Teachers in this study did report that FM usage in quiet and other complex situations was beneficial
Discussion-2

• When listening with local microphone only (“M”), the listening effect of auditory only was significantly better than the listening effect in noisy and distance situations

• Possible reason: In the rehabilitation procedure, we use Auditory-Verbal Therapy, which emphasis the auditory training
Discussion-3

- One kid in this study: bilateral hearing loss over 90dB HL
- Unfortunately, he did not receive cochlear implant and he cannot achieve effective compensation with hearing aids

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<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>M-average</td>
<td>67.55</td>
</tr>
<tr>
<td>M-the case</td>
<td>22.86</td>
</tr>
<tr>
<td>FM+M-this case</td>
<td>39.43</td>
</tr>
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- The results suggest that even if we wear the FM, optimization of hearing aid / cochlear implant is a prerequisite for rehabilitation effect
Discussion-4

• When listening with “FM+M”, there were still significant differences between the quiet situation and other complex situations
  – The listening effect in the latter situations was worse than in quiet situation

• At the same time, there were some complain about FM system from parents and children
  – Children: some children (1-2%) will tell their teachers that the volume is too loud after wearing FM system
  – Parents: Some parents give feedback that children rely on FM product too much so when they are home the parents need to increase volume or repeat many times when they speak to their child. Especially for those children who have better residual hearing, their parents have more feedback on this aspect
Discussion-4

• Possible reason
  – The subjects are at a very young age
  • preschool children
  – Our educational mode
  • Individualized instruction: Auditory-Verbal therapy
    – 0.5-1 hour a day
  • Group activity: To organize one-day life through the subject
    – Most of the time
    – the same as mainstream kindergarten
• The difference between kindergarten and primary/middle school
  – The children spend most of the time in playing games
  – The preschool environment is more noisy and make speech, language and cognitive development especially difficult for young children with HL when the incoming speech signal is degraded by noise
• In our practice, we combine the wireless and local microphone ("FM+M"), so that the children can hear a mixture of sound coming from the transmitter, and sound being picked up by the hearing aid microphone.

• While this allows a nearby talker to be heard, the hearing aid microphone continues to pick up noise and reverberation even when the teacher is talking into the transmitter, potentially removing most of the advantage provided by the wireless system.
• The effects of noise on very young children with HL are particularly significant given these children’s immature auditory and linguistic systems

• However, few studies have investigated the benefit of using hearing assistive technology in preschool populations
• Lauri H et al recommended that there may be periods of the preschool day in which the use of the assistive technology may not be beneficial

• Teachers should be purposeful in understanding when the technology is beneficial and when it might be counterproductive
A common-used solution aimed at solving this problem is a processing scheme known as dynamic FM

In this system, the degree of FM advantage automatically increases as the background noise level (sensed by the transmitter) increases. As would be expected, increasing the priority given to the FM signal increases speech intelligibility when there is background noise.

The effects on infants and young children in our center with hearing impairment of using hearing instruments with an dynamic FM system should be further observed.
• Dillon H recommended that the best system seems to one that automatically gives the wireless signal a large (eg. 20dB) level advantage when the transmitter receives input from a nearby source, delivers it to both ears, and switches the wireless signal off otherwise.
Summary and Clinical Implications

- An FM system improves the listening experience of hearing impaired children in a complex acoustic environment.

- However, processes and programs for preschool hearing impaired children should be further standardized and improved when fitting FM systems.
谢谢
• AAA无线调频系统临床使用指南指出给患者验配FM后需要主观及客观的验证、调试
Discussion-5

• 助听器耦连FM系统
• 测试设备
  – Frye Fonix 7000
• 输入刺激声
  – 65 dB SPL数字言语声
  – 90 dB SPL纯音
• 测量数据
  – 750、1K、2K Hz3个频率点的声输出
  – EHA90, EFM/HA90; EHA65, EFM/HA65
  – 比较仅助听器和助听器耦联FM系统两种模式下的
    • FM offset: EFM/HA65-EHA65
    • OSPL90 similarity: EFM/HA90- EHA90

AAA-指南
Erin C. Schafer, 2007
• FM offset 在±2dB 范围之外，FM 需要调试
• OSPL 90 similarity 数值接近 0，表明助听器耦合 FM 前后输出频响曲线接近
• 因此佩戴FM后客观的验证非常重要
• 但是，指南中只提供了FM耦合助听器后的验证方法，没有CI的相关内容
• 2个与各机构交流的问题：
  – 在临床工作中用哪个标准验证FM效果？
  – CI的效果如何验证？
• 期待进一步交流、合作