Validation of the RCHSD Children's Implant Profile (ChIP) Score: Improving Outcomes of Pediatric Cochlear Implant Candidates

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ABSTRACT

Background:
Cochlear implantation (CI) has become the standard of care to provide access to sound for patients with severe to profound hearing loss who do not benefit significantly from hearing aids. Determining candidacy for a CI in the pediatric population is a complex and subjective process. Creation of standard and objective prognostic information would be useful, not only to support decisions about CI in a particular child, but also to help counsel the family about the expectations of possible outcomes and to plan for post-CI services.
The RCHSD Cochlear Implant Team uses a modified Children's Implant Profile (ChIP) to determine CI candidacy. The team includes audiologists, speech and language pathologists, physicians (pediatric otolaryngologists), developmental psychologists, and an educational liaison.

Objectives:
The objective of the study will evaluate the effectiveness of the RCHSD ChIP score by determining a correlation with the communication outcomes after cochlear implantation, evaluating the effectiveness of the ChIP score used to improve family expectations with the surgery, and to determine the best educational setting for the child.

Methods:
39 Pediatric Patients from Rady Children's Hospital Cochlear Implant Program who were evaluated using the RCHSD ChIP tool and had been implanted for 3 years or more were asked to participate in the study. Consents were obtained, and parents were asked to provide school/teacher information. The teacher/educator was asked to complete a questionnaire, based on the AuSpLan (to assess mode of communication and skill level) and the SIFTER (to evaluate the academic placement of children with hearing loss). Statistical analysis was performed.

Results:
We received 39 teacher questionnaires. Decision tree models were constructed to examine the relationship between the response variables assessed. For each model the data was split into two groups based on the explanatory strength of the predictors(s) (R^2), As the tree was built by recursive splitting, the predictors were re-evaluated at each stage until the explanatory contribution of a new predictor in the model was considered not significant. A logistic model for Chip Letter was determined starting with the 10 predictor variables used in the analyses. Predictor variables were successively eliminated from the model if they did not contribute significantly to explain the variable Chip Letter.

Conclusions:
The analysis of the RCHSD ChIP score reveals that the results correlate well with the post-operative receptive spoken vocabulary, age appropriate spoken language, and parent expectations.

INTRODUCTION

The RCHSD ChIP Tool is based on the Children's Implant Profile (ChIP) developed by Hellman (Hellman et al., 1991) and McClatchie & Therres' AuSpLan (Rice, 2005) to formulate a more objective pre-implantation tool that links to postoperative outcomes. The RCHSD ChIP tool used for the current study evaluates the Attention/ Behavior, Family Structure & Support, Family Expectations, Additional Handicaps, Speech/Language Abilities, Educational Environment, and Educational Support Services (Fig. 1). Each member of the CI team performs an assessment of the child, designates a score based on their individual evaluation and ChIP criteria. All scores are added to give a Total Score. Based on the calculation, each patient is given a ChIP Letter (Pre-Implant Rating) (A= 0-6), (B= 7-11), (C=12-16), (D=16+). Patients with an "A" score are predicted to have the best outcomes and considered ideal cochlear implant candidates, whereas patients with a "D" score are predicted to have poorer outcomes and are not considered candidates for cochlear implantation based on the significant concerns of the CI team.

MATERIALS AND METHODS

39 Pediatric Patients from the Rady Children's Hospital Cochlear Implant Program who were evaluated using the RCHSD ChIP tool and had been implanted for 3 years or more were asked to participate in the study. After all proper consents and assents were obtained, we sent the teachers a questionnaire based on the AuSpLan (to assess mode of communication) and the SIFTER to evaluate the academic performance of children with hearing loss. We then compared those results to the ChIP score obtained while undergoing evaluation for cochlear implantation at RCHSD.

The RCHSD ChIP scores were acquired from the subject's electronic medical record using the EPIC System at Rady Children's Hospital San Diego. All PHI were de-identified providing only the RCHSD ChIP Score and the answers to the Teacher Questionnaire. For the protection of confidentiality, all data was stored on a secured database.

Total Score Predictors

How well does the child **express** themselves using **spoken vocabulary**?

a. Below age level (none/emerging)
b. At age level (appropriate)
c. Above age level (high)
d. Not applicable

Do you feel the child's outcomes with the cochlear implant met the **parents expectations** for spoken language development

A. No
B. Yes, somewhat
C. Absolutely
D. Not Applicable/I don't know

Please rate the level of **parent involvement** in the IEP and rehabilitation process.

a. No/Little Involvement
b. Average Involvement
c. High Involvement
d. Not Applicable/Prefer not to answer

How would you rate the child's reading comprehension when they are **reading** by **themselves** with **spoken language**?

Below age level (none/emerging)
a. At age level (appropriate)
b. Above Age Level (high)
c. Not applicable

Factors

Medical
- Medical/Radiologic

Audiology
- Audiologic (Hearing)
- Hearing Aid Use
- Audiology
- Chronological Age
- Functional Hearing (Speech Perception)

Developmental
- Attention/Behavior
- Family Structure & Support
- Family Expectations
- Additional Handicaps

Speech/Language
- Speech/Language Abilities
- Functional Listening Assessment

Educational
- Educational Environment
- Support Services

No Concern (0)
Mild-Mod Concerns (1-3)
Great Concerns (4-5)

Combined Score:
(Pre-Implant Rating) (A= 0-6), **(B**= 7-11), **(C**=12-16), **(D**=16+)
(0) No Concern

The smaller the number of the total score the least amount of concerns there are regarding cochlear implantation

ChIP	Mean	Std Dev
A	2.96	2.51
B	9.25	1.36
C	14.50	1.29

N= 39

CHiP A: n= 23
CHiP B: n = 12
CHiP C: n= 4

ChIP Letter Predictors

How would you rate their ability to follow age appropriate classroom directions using spoken language?

a. Below age level (none/emerging)
b. At age level (appropriate)
c. Above age level (high)
d. Not Applicable

Do you feel the child's outcomes with the cochlear implant met the parents expectations for spoken language development

A. No
B. Yes, somewhat
C. Absolutely
D. Not Applicable/I don't know

How would you rate the child's reading comprehension when reading by themselves with Spoken Language?

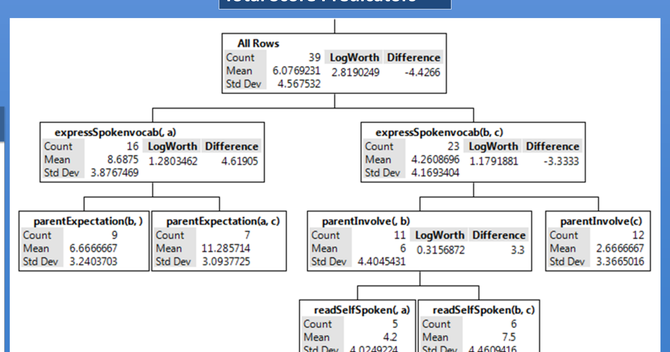
a. Below age level (none/emerging)
b. At age level (appropriate)
c. Above Age Level (high)
d. Not applicable

Decision tree for Chip letter – Blue= A, Pink= B, Red = C

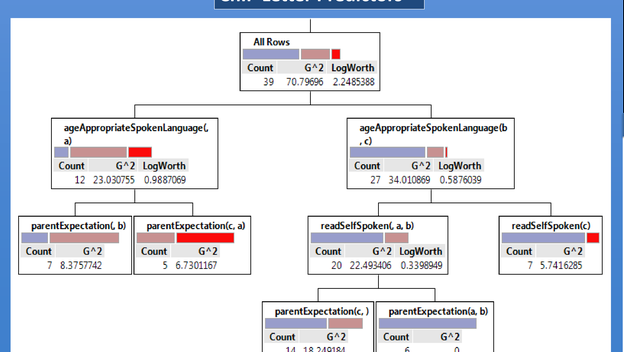
RESULTS

Decision tree models were constructed to examine the relationship between the response variables and the multiple predictors. The potential predictors were evaluated statistically and their predictive value for the response variable assessed. For each model, the data was split into two groups based on the explanatory strength of the predictor(s) (R^2). As the tree was built by recursive splitting, the predictors were re-evaluated at each stage until the explanatory contribution of a new predictor in the model was considered not significant. A logistic model for ChipLetter was determined starting with the 10 predictor variables used in the analyses. Predictor variables were successively eliminated from the model if they did not contribute significantly to explain the variable ChipLetter. **The model is highly significant ($p < 0.0001$) with $R^2 = 0.841$.** Table presents the Confusion matrix that helps to access the model's accuracy. Correct and incorrect predictions obtained with the model are displayed in the matrix, **100% of As and Cs predictions are correct, 75% of Bs are correct.**

Total Score Predicators



ChIP Letter Predictors



DISCUSSION

Creation of an objective tool is essential to provide a measure based on set criteria decisions about cochlear implantation. Cochlear implant centers need a tool to objectify this process, help counsel the family about the range of possible outcomes and to plan for the most appropriate post-CI services. If a patient is determined by the interdisciplinary team to be an appropriate candidate for CI, expected outcomes should drive decisions regarding rehabilitative and educational services. After a thorough evaluation of the patient, if the team does not recommend a cochlear implant, then the objective process behind the team's decision and concerns can be shared. Based on AuSpLan, the following is a list of the predicted outcomes post-implantation:

Long-Term predicted outcome after implantation

- Auditory Verbal/Oral Communication
- Both, auditory/oral communicator with visual assist
- Complementary, auditory verbal/oral skills assist primary visual communication
- Does not benefit from implant

Because each individual is unique in terms of medical condition, auditory ability, and communication skills it is important to consider the complex and subjective nature of the process for evaluating candidacy (Copeland & Pillsbury, 2004). According to Lenarz, CI's can have an impact on increasing aural/oral communicative skills however it is important to consider multiple factors including age of patient, additional handicaps, residual hearing, and cause of deafness to determine candidacy for surgery (1998). Possible factors that may influence outcomes include:

- Educational placement
- Follow up services
- Secondary diagnosis unable to determine at the time of assessment
- Consistent Use of Equipment (Rehabilitative services)
- Use of other communication in the individual's environment
- If child is receiving services from a specialist trained in Listening and Spoken Language

It is important to consider the multiple health disparities that may exist including socio-economic constructs that can limit a child's ability to access appropriate services. Parent's level of education, quality of language instruction, and access to necessary services may contribute to a CI Candidates ability to acquire language.

In October 2015, the preliminary results of this study revealed that the RCHSD ChIP scores matched parents expectations for spoken language development and teacher's perception of level of speech intelligibility as compared to their hearing peers (Carvalho et. al, 2015). **Parent involvement is a key factor to improving outcomes for children who are deaf and/or hard of hearing.**

Previous studies on the utilization of the ChIP tool show it is an effective guide for both the teams and parents to determine the best decision for the family. The information can be used to plan for rehabilitative services post-CI (O'brien et al., 2012). **The data supports the idea that children with parents who are highly Involved in their child's IEP or rehabilitative process are more likely to develop expressive skills at or above age appropriate levels. However, the results of this study may indicate a need to support children in developing reading comprehension skills in order to meet parent's expectations for spoken language development.**

The California Children's Services (CCS) Program has recently adopted Rady Children's Hospital's criteria for the RCHSD ChIP as their objective measure. The tool is currently a requirement for their approval/denial process. Although federal guidelines are not mandated it is important to recognize that many factors contribute to the use and success of a cochlear implant. Therefor a screening process can be beneficial for ensuring quality of care. A previously related study done by RCHSD proved there is little consistency across cochlear implant centers in how decisions are made in determining cochlear implant candidacy. Drivers of positive outcomes with cochlear implants need to be established so that effective pre-candidacy tools and markers can be developed (Needleman & Rose, 2014).

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