What is the evidence for recommending cochlear implants for infants less than 12 months?

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Age at Implant:

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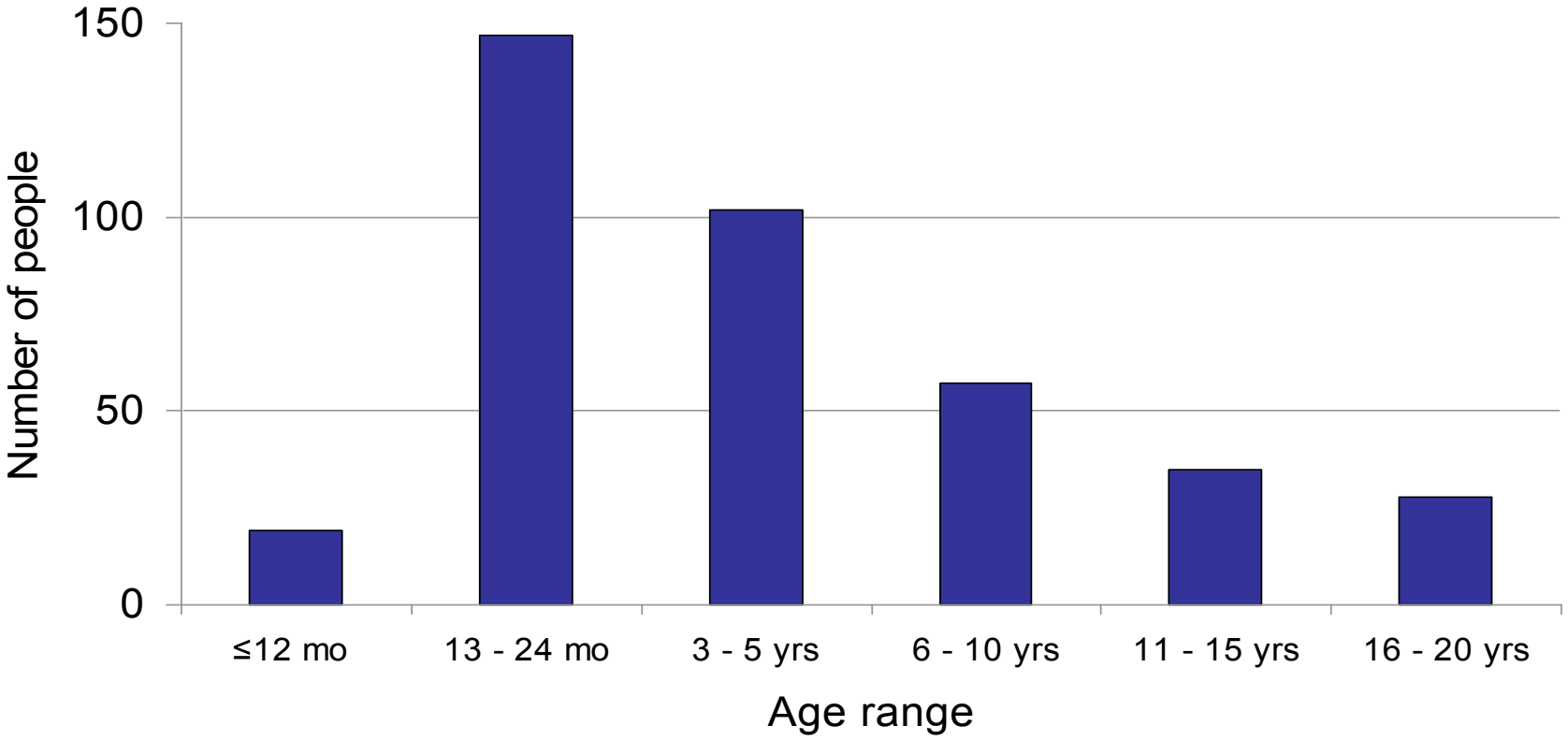


Why consider a cochlear implant between 6 to 12 months?

- Neonatal screening - Early identification
- Auditory evoked potential testing from birth (Rance et al., 2002)
- Reliable behavioral testing is possible from 6 months onwards
- Anatomical and safety studies (Dahm, Shepherd, & Clark, 1993; Eby & Nadol,1986)

Why 6 to 12 months? Do benefits outweigh potential risks?

- Evidence for the ‘earlier is better’ argument
  - **physiological and anatomical studies**
  - studies of children **using hearing aids**
  - studies of children **using CI**

Why 6 to 12 months?

- Evidence for the ‘earlier is better’ argument
  - **Physiological studies**
    - critical periods for neural development (Ruben & Rapin, 1980; Ryugo, Limb, & Redd, 2000)
    - critical periods for phonological development (Ruben, 1997)
    - animal models and examination of the brain’s plasticity (Matsushima, Shepherd, Seldon, Xu, & Clark, 1991; Shepherd, Hartmann, Heid, Hardie, & Klinke, 1997)
    - anatomical and safety studies

Why 6 to 12 months?

- critical periods
  - human foetus' ability to detect sound
  - neonates' preferences for F0 & prosodic cues
  - coupled with a curtailing of perceptual discrimination skills

suggests a phonological critical period from the six month of foetal life to 12 months chronological age (Ruben, 1997).

- If phonological distinctions are not made in the first year post-implant, long term language processing difficulties may result.
- "*Insufficient early phonological input results in flawed semantic and syntactic capacities*" (Ruben, 1997, p. 204).

Why 6 to 12 months?

- Evidence for the ‘earlier is better’ argument
  - studies of children **using hearing aids**

    (Apuzzo & Yoshinaga-Itano, 1995; Markides, 1986; Robinshaw, 1995; White & White, 1987; Yoshinaga-Itano, 2003; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998; Yoshinaga-Itano & Snyder, 1999).
  - studies of children **using CI under 2 years**

    (Bollard, Chute, Popp, Parisier, 1999; Dowell, Blamey, & Clark, 1995; El-Hakim, Levasseur, Papsin, Panesar, Mount, Stevens, et al. 2001; Hammes, Novak, Rotz, Willis, Edmondson, & Thomas, 2002; Kirk, Miyamoto, Lento, Ying, O’Neill, & Fears, 2002; **Nikolopoulos, O’Donoghue, & Archbold, 1999**; Novak, Firszt, Rotz, Hammes, Reeder, & Willis, 2001; Robbins, Bollard, & Green, 1999; **Svirsky, Teoh & Neuburger, 2004**; **Waltzman & Cohen, 1998**)

Studies of children who receive the CI under 2 years

- Waltzman & Cohen (1998)
  - N=11 New York University Medical Centre
  - 14 and 23 months
  - followed up for a period of five years post-implant
- Difficulties inherent in this population
  - general trends were observed but
  - at publication, only 2 had completed the five-year post-implant evaluation.
  - due to the nature of the assessment materials, not possible to make valid comparisons with older children due to the differences in linguistic knowledge.

Studies of children who receive the CI under 2 years

- Nikolopoulos et al. (1999)
  - N= 126
  - 22 and 82 months
  - followed up for a period of four years post-implant

- Data suggested that children who were **older at implant initially performed tests better** due to advanced cognitive skills, longer exposure to language and greater familiarity with test conditions, but that this **advantage diminished over time** as the children who were younger at implant gradually **overtook** and outperformed them.

- need for long-term follow up when attempting to address the affects of **age at implant.**

Studies of children who receive the CI under 2 years

- Svirsky, Teoh & Neuburger (2004)
  - N= 12 CI < 12 mo
  - N= 34 CI 12 to 24 mo
  - N=29 CI 24 to 36 mo

- CI before 2 years of age resulted in significant speech perception and language advantages

- gradual decline in language acquisition as a function of age
- these advantages probably outweigh any additional surgical risk

Studies of children who receive the CI under 12 months

- Lesinski-Schiedat, Illg, Heermann, Bertram, & Lenarz (2004)
  - N= 27 CI<12 months compared to
  - N=89 CI between 12 and 24 months
  - all tested at 2;6 years of age

- no significant differences between the younger or older at implant data (using t-tests) for any of the outcome measures (attribute this to the small sample size of the younger group)

- problem with reporting results in this way is that the younger group had, on average, 18 to 24 months device experience, whereas the older group had, on average, less than 12 months and in some cases only six months device experience

Research Questions

- Are language outcomes for children implanted between 6 and 12 months superior to those implanted between 13 and 24 months?
- Are there any additional surgical or medical issues associated with implanting children between 6 and 12 months?

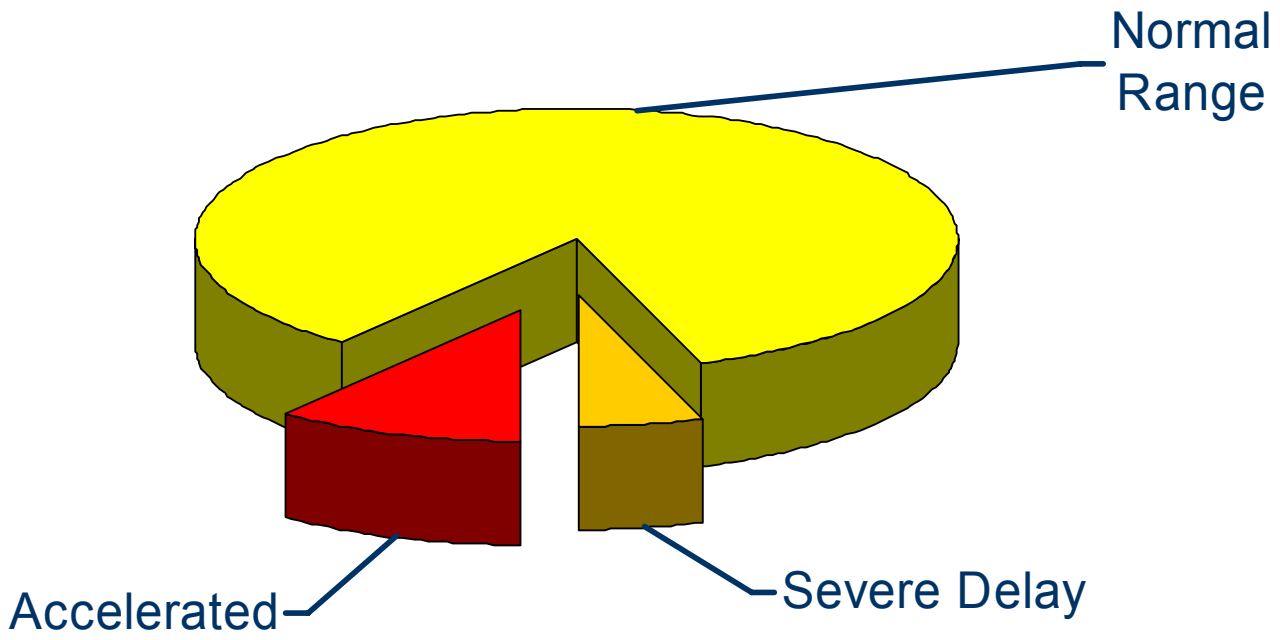
Subjects

Demographic	Group A CI ≤ 12 months N=19	Group B CI at 13 to 24 mo N=87
Mean age at CI	**0.90 yrs** (range 0.61-1.07)	**1.60 yrs** (range 1.15-2.00)
Cognitive delay (≥mild delay)	1 child	9 children
Best unaided PTA	114.5dB HL	113.2dB HL
Mean age at HA fitting	**0.42 yrs**	**0.94 yrs**

Classification of Cognitive Status:

Group A: Children implanted ≤ 12 months

N=19

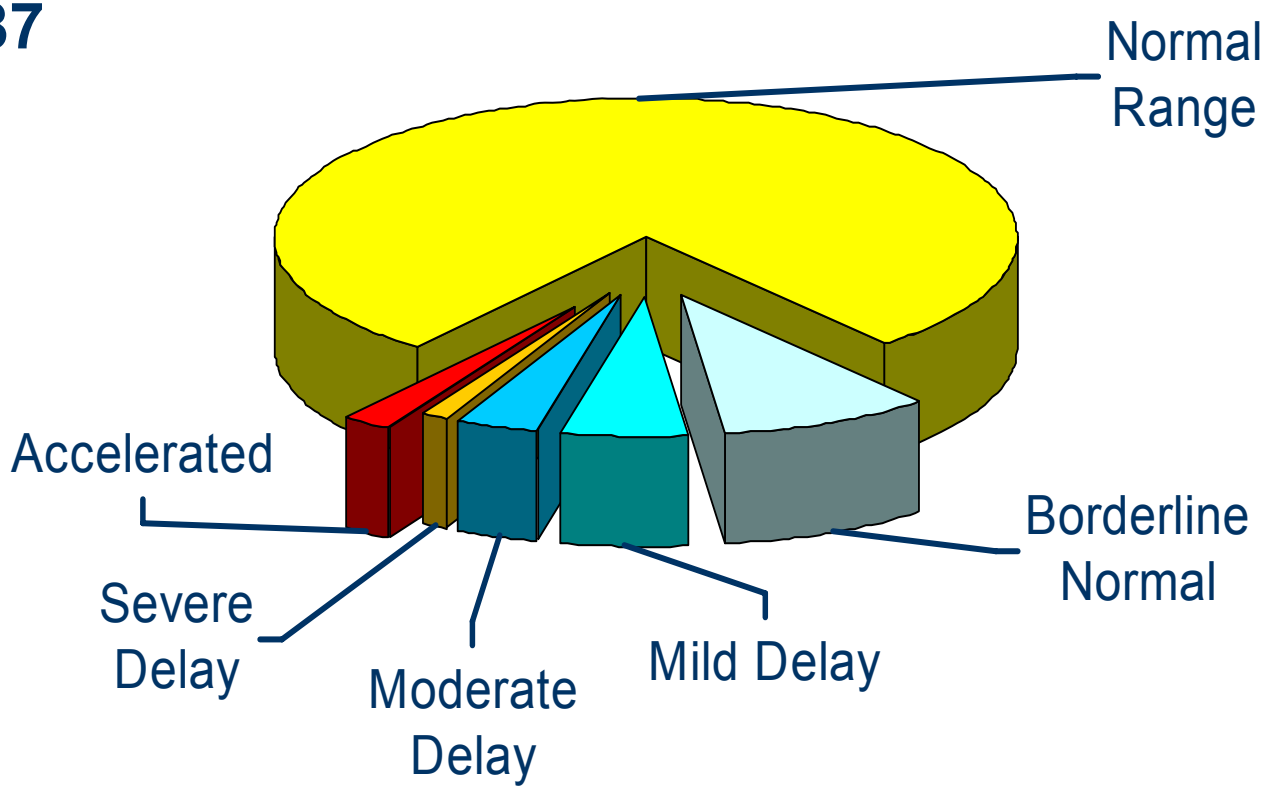


(standard scores obtained from formal testing)

Classification of Cognitive Status:

Group B: Children implanted between 13 and 24 months

N=87



(standard scores obtained from formal testing)

Pre-implant Audiological Assessments

- Unaided and Aided Audiograms
- Tympanometry
- Objective testing:
  - ABR, ASSR and cochlear microphonics and/or OAE

Communication Assessments

- Rossetti Infant-Toddler Language Scale (RI-LTS)
- Cognitive and Motor assessments
  - Educational Psychologist
- Testing completed pre-implant and where possible 1, 2, 3 and 5 years post-implant

Surgical Procedure and Outcomes

Procedure

- Standard procedure for Nucleus CI24R
- Minimally invasive approach used

7 month old child

Surgical outcomes

- No immediate complications
- **Group A: CI ≤12mo**
  - one child developed acute mastoiditis which resolved following treatment with IV antibiotics

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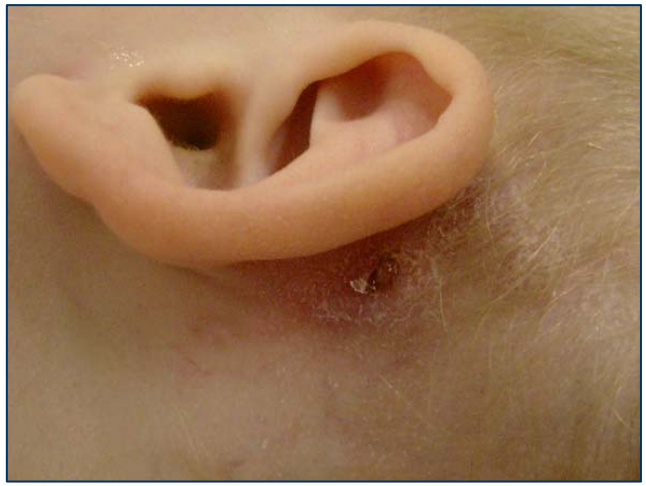


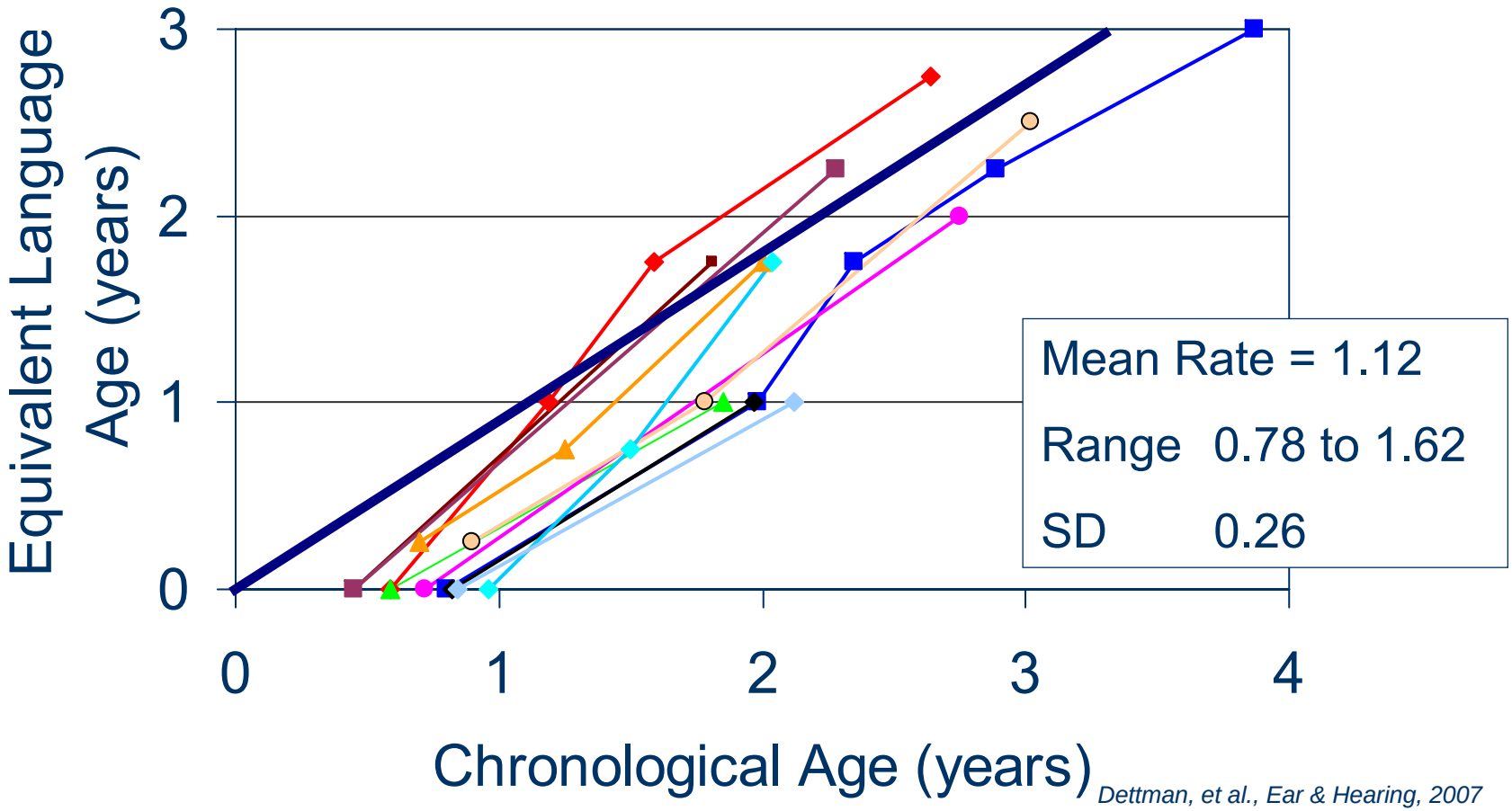
Surgical outcomes

- No immediate complications
- **Group A: CI ≤12mo**
  - one child developed acute mastoiditis which resolved following treatment with IV antibiotics
- **Group B: CI 13 to 24 mo**
  - one child delayed device infection required explantation
  - two device failures
  - all 3 children successfully re-implanted

Language Outcomes:

Group A, CI ≤12 months (N=11)

Individual growth rates for children with 2 or more administrations of receptive language subscale of RI-TLS

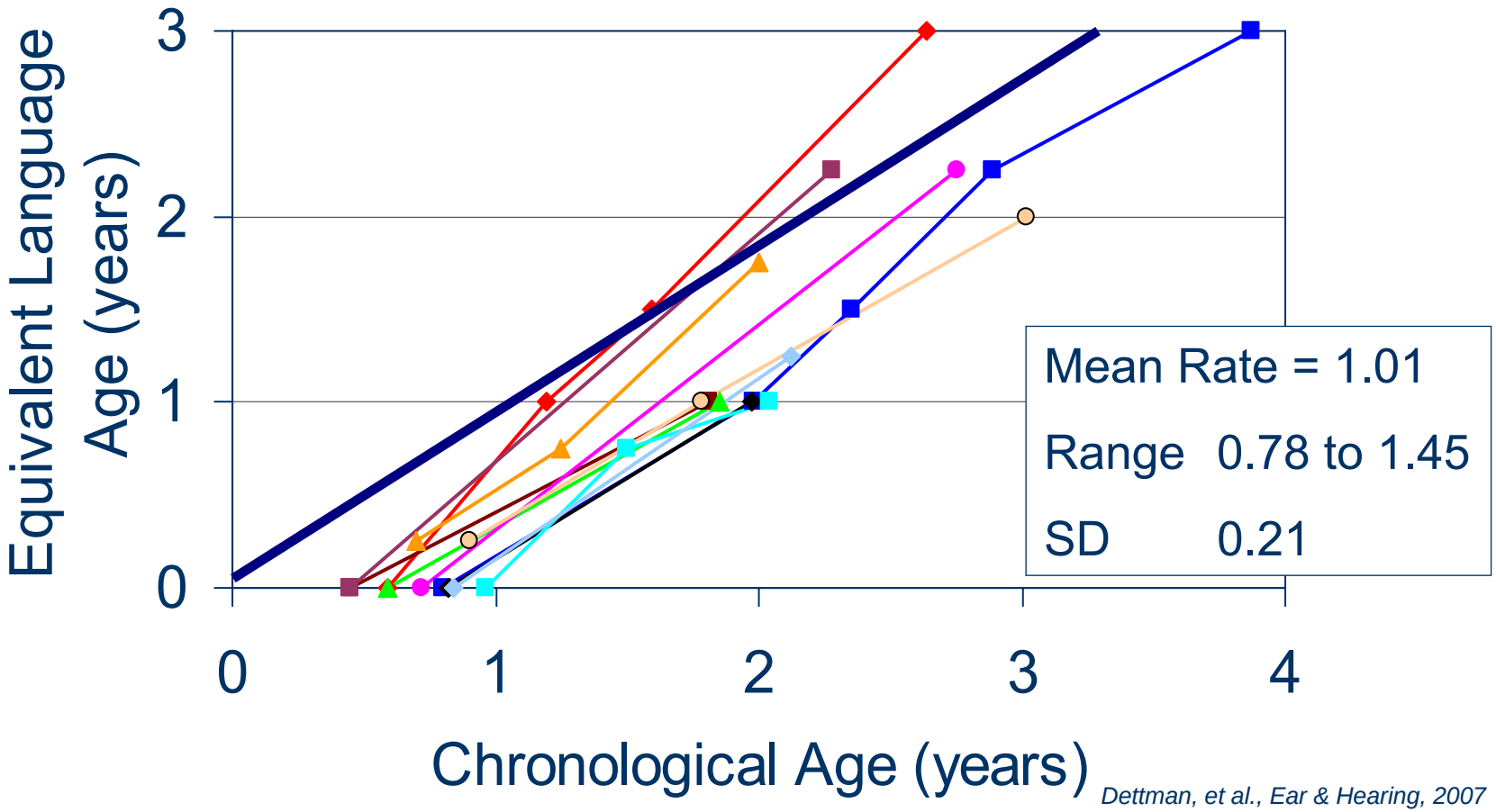


Dettman, et al., Ear & Hearing, 2007

Language Outcomes:

Group A, CI ≤12 months (N=11)

Individual growth rates for children with 2 or more administrations of expressive language subscale of RI-TLS



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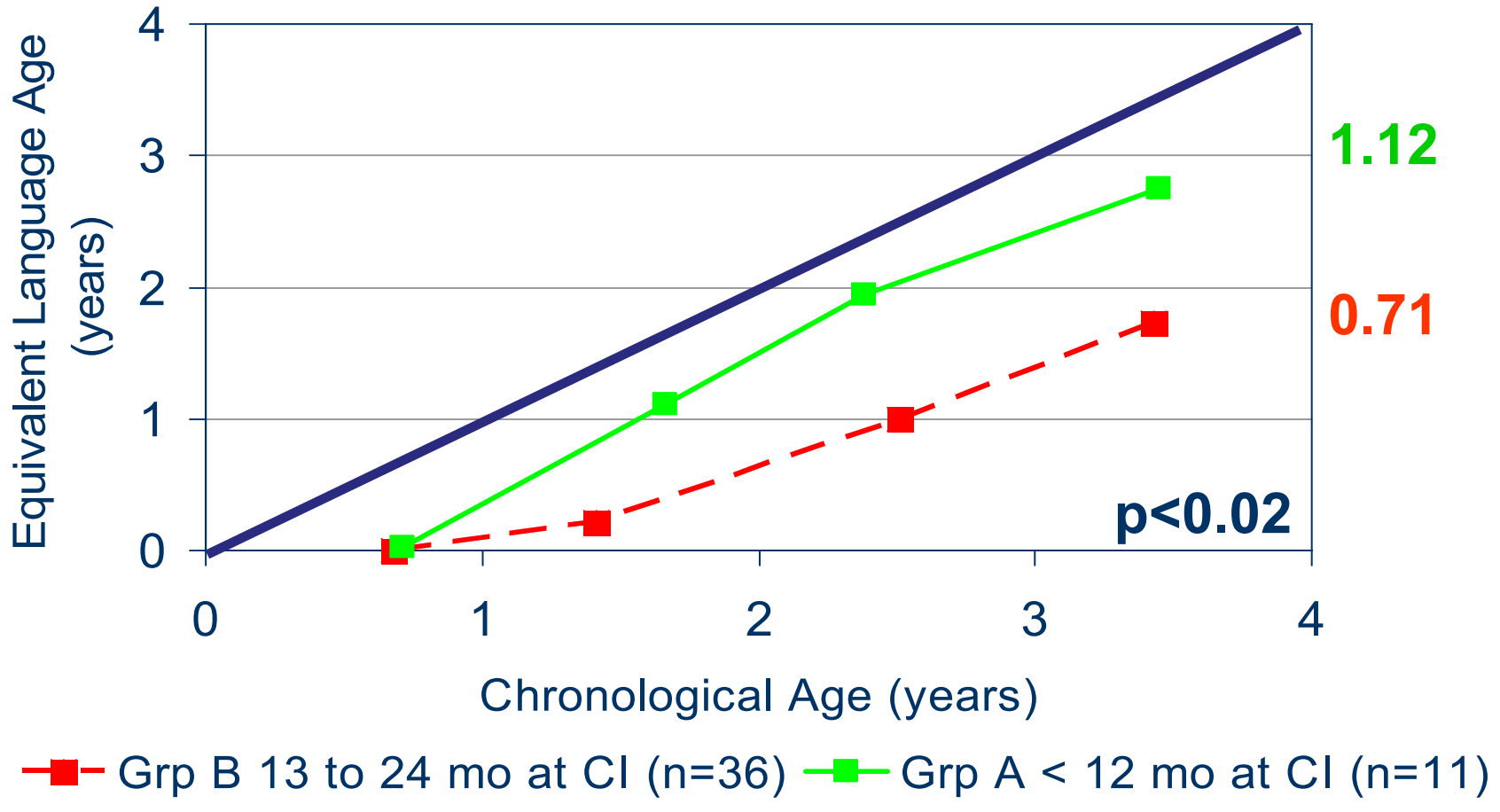
Language Outcomes:

Comparison of Growth Rates for Group A vs Group B

(average rate for children with 2 or more administrations of receptive language subscale of RI-TLS)



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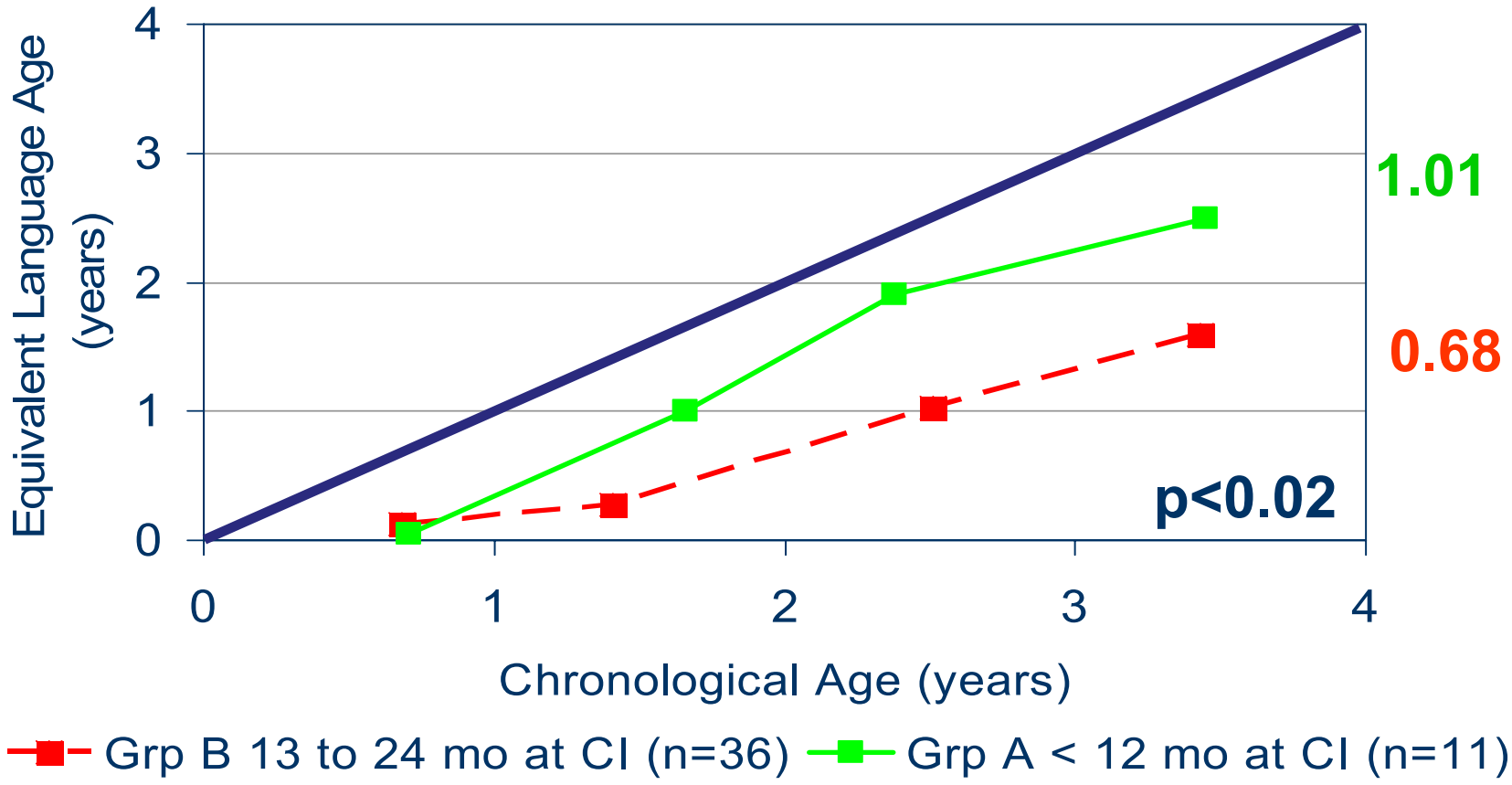
Language Outcomes:

Comparison of Growth Rates for Group A vs Group B

(average rate for children with 2 or more administrations of expressive language subscale of RI-TLS)



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Results

Significant factors affecting…

- Receptive Language
  - age at CI $p<0.014$
- Expressive Language
  - age at CI $p<0.001$

Conclusions

- Cochlear implantation can be performed safely in very young children
- Children receiving cochlear implants under 12 months of age demonstrated language development rates comparable to their normal hearing peers
- These results may be used to provide accurate information to parents to assist decision making

Future Directions

- Range of Outcomes
  - Optimum habilitation
- Age at Hearing - Aid fitting
- Examine
  - Early identification/early CI
  - Early identification/late CI
  - Late identification/late CI