SSD – indication and results of cochlear implantation, bone conduction devices and CROS hearing aids in children

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2 Cases- both Single Sided Deaf

(6 months of age)

Diagnosis with NHS

Case 1:

- Unilateral sensorineural deafness
- Morphology of the pinna unremarkable

Case 2:

- Unilateral atresia of external ear canal
- Malformation of the pinna
- Conductive hearing loss in objective evaluation

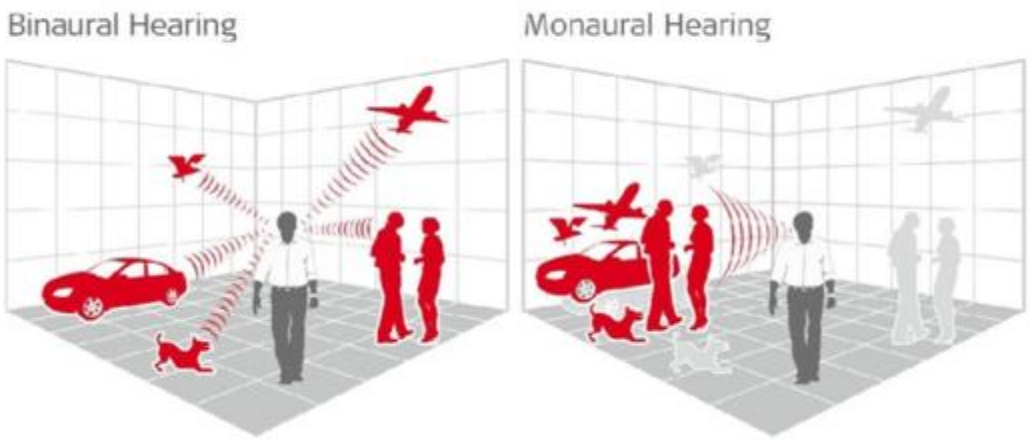
→ different treatment methods

Common complaints of patients with unilateral deafness

- 70-93%: high degree of difficulties in hearing in background noise
  (Coletti et al. 1988; Ruscetta et al. 2005; Priwin et al. 2007; Wie et al. 2010)

- Difficulties in localization
  (Wie et al. 2010, Hol et al. 2010, Flynn et al. 2010)

- 54-84%: tinnitus
  (Quaranta et al. 2004; Priwin et al. 2007; Wie et al. 2010)



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- Frequent headaches, stress, fatigue
  (Borton et al. 2010, Wie et al. 2010)

- Social isolation, psychological problems
  (Borton et al. 2010, Wie et al. 2010)

Special problems in children with unilateral deafness

- 12-41%: need of additional educational assistance
  (Bess & Tharpe 1986; Bovo et al. 1988)

- Increased need for speech therapy in comparison to their normal-hearing peers
  (Lieu et al., 2010, 2012)

- 22-35%: increased rate of grade failures
  (Bess and Tharpe 1988; Brockhauser et al. 1991; Cho Lieu et al. 2004)

- Low self-esteem and increased fatigue; negative affect on academic success of children
  (Kuppler 2013)

Treatment options

Rehabilitation in patients with SSD/AHL 1

Treatment options

- Contralateral Routing of Signals ((Bi)CROS)-Hearing aids

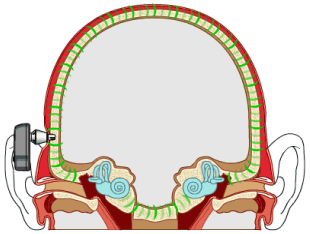
A Rehabilitative Approach to the Problem of Unilateral Hearing Impairment: The Contralateral Routing of Signals (CROS)
HARFORD E, BARRY J., J Speech Hear Disord. 1965;30:121-38.

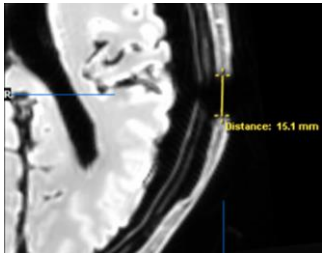
advantage: non invasive, no artefacts in MRI examination

disadvantage: hearing aids on both ears, no binaural hearing, no prevention of unilateral auditory deprivation

- Bone Conduction hearing Implants (BCI) percutaneous/ soft band

[The monaural pseudo-stereophonic hearing aid (BAHA) in unilateral total deafness: a study of 29 patients].
Vaneecloo et al. Rev Laryngol Otol Rhinol (Bord). 2001;122(5):343-50. F





artefact in MRI: app. 0.6 inches

advantage: no/ minimally invasive, minimal artefacts in MRI

disadvantage: wound infection, no binaural hearing, no prevention of unilateral auditory deprivation

Arndt et al. 2007

Rehabilitation in patients with SSD/AHL 2

Treatment options

- FM systems

advantage: non invasive, provide an increased SNR in educational settings, no artefacts in MRI examination

disadvantage: modus operandi is a big obstacle for application in everyday life, no binaural hearing,
no prevention of unilateral auditory deprivation

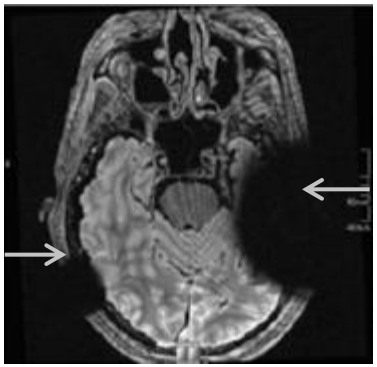
Rehabilitation in patients with SSD/AHL 3

Treatment options

- Cochlear Implant

Incapacitating unilateral tinnitus in single-sided deafness treated by cochlear implantation. Van de Heyning et al. Ann Otol Rhinol Laryngol. 2008 Sep;117(9):645-52.
Comparison of pseudobinaural hearing to real binaural hearing rehabilitation after cochlear implantation in patients with unilateral deafness and tinnitus. Arndt et al. Otol Neurotol. 2011 Jan;32(1):39-47.

artefact in MRI:



without magnet app. 1.5 inches

with magnet app. 4 inches

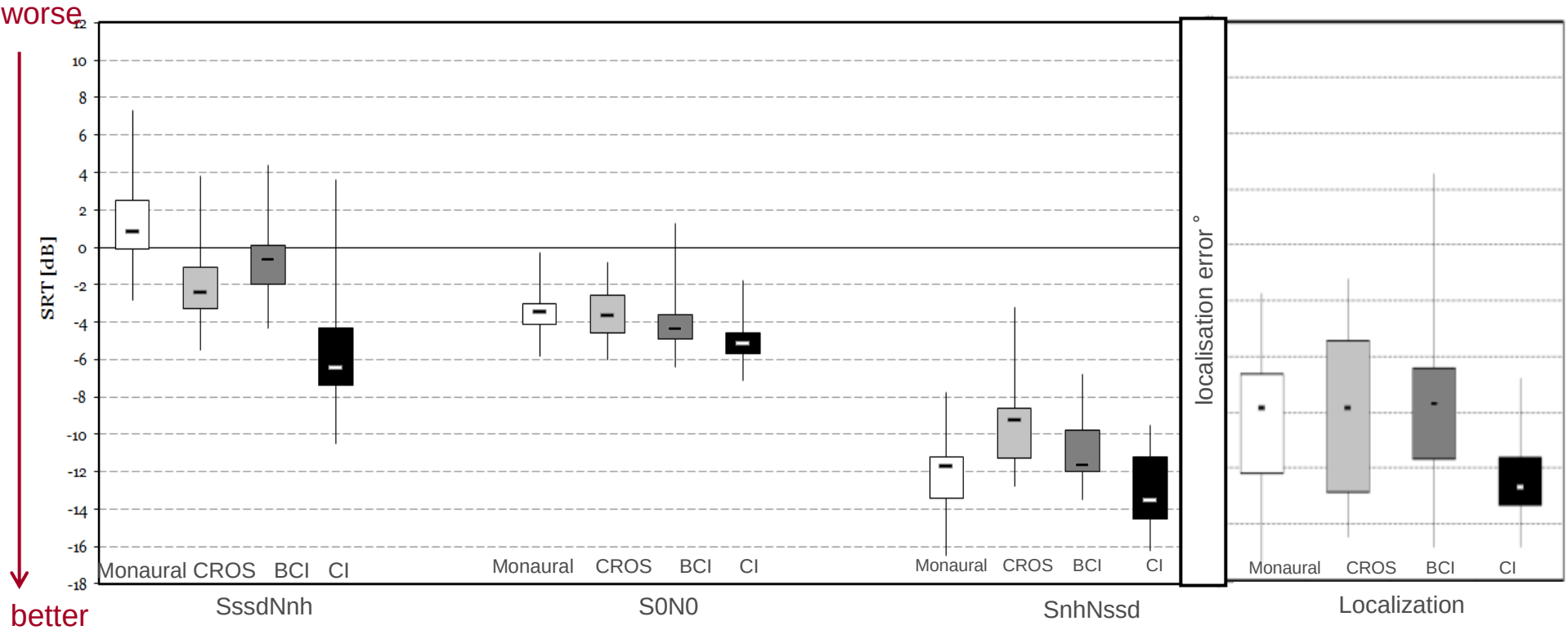
advantage: binaural hearing possible, intact skin (transcutaneous), no (further) deprivation of auditory pathway

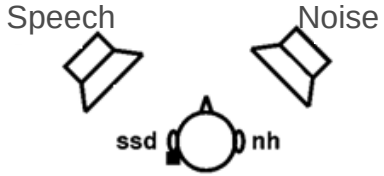
disadvantage: invasive, rehabilitation, excessive artefact in MRI

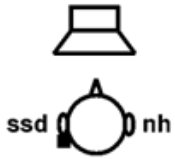
Results of different treatment options in adults

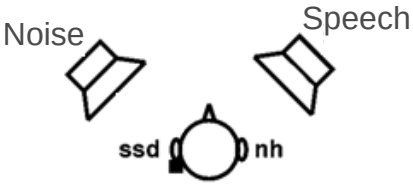
Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

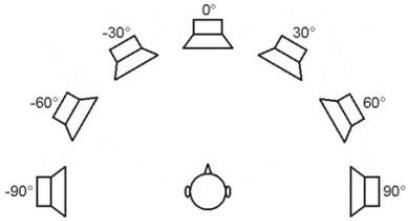
37 adult SSD patients with acquired hearing loss





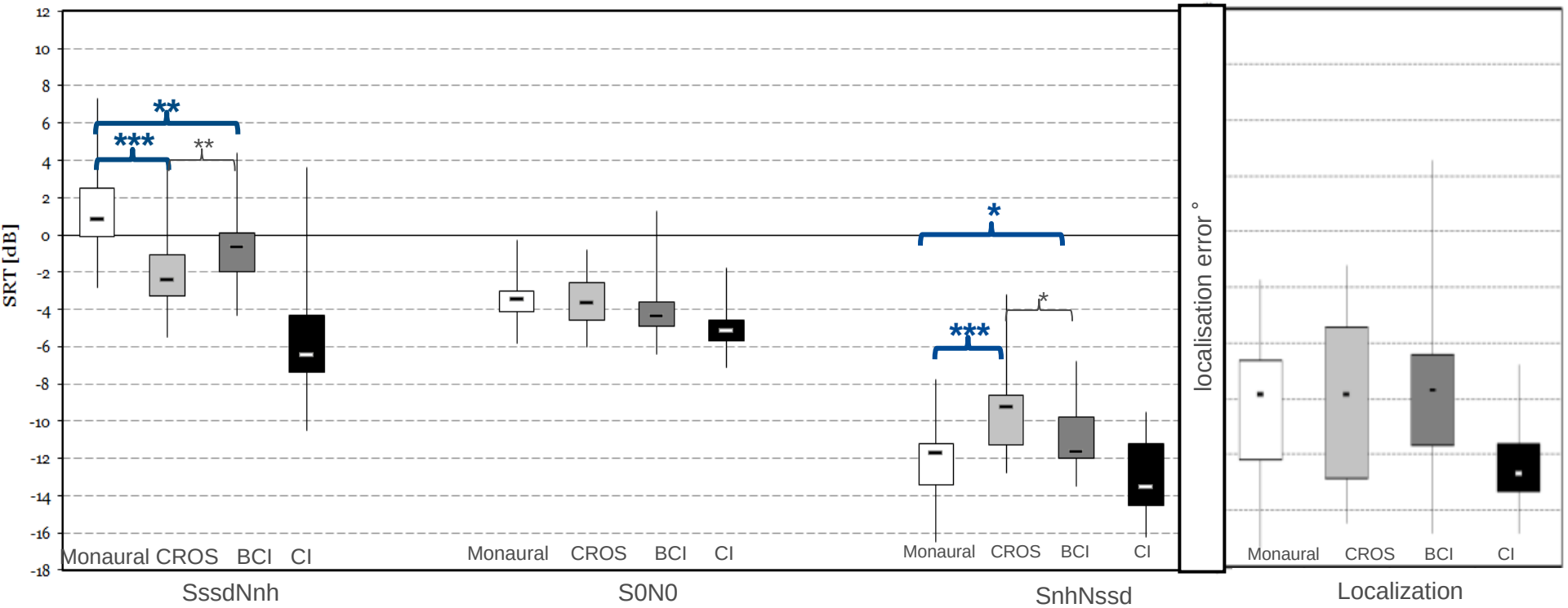






Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

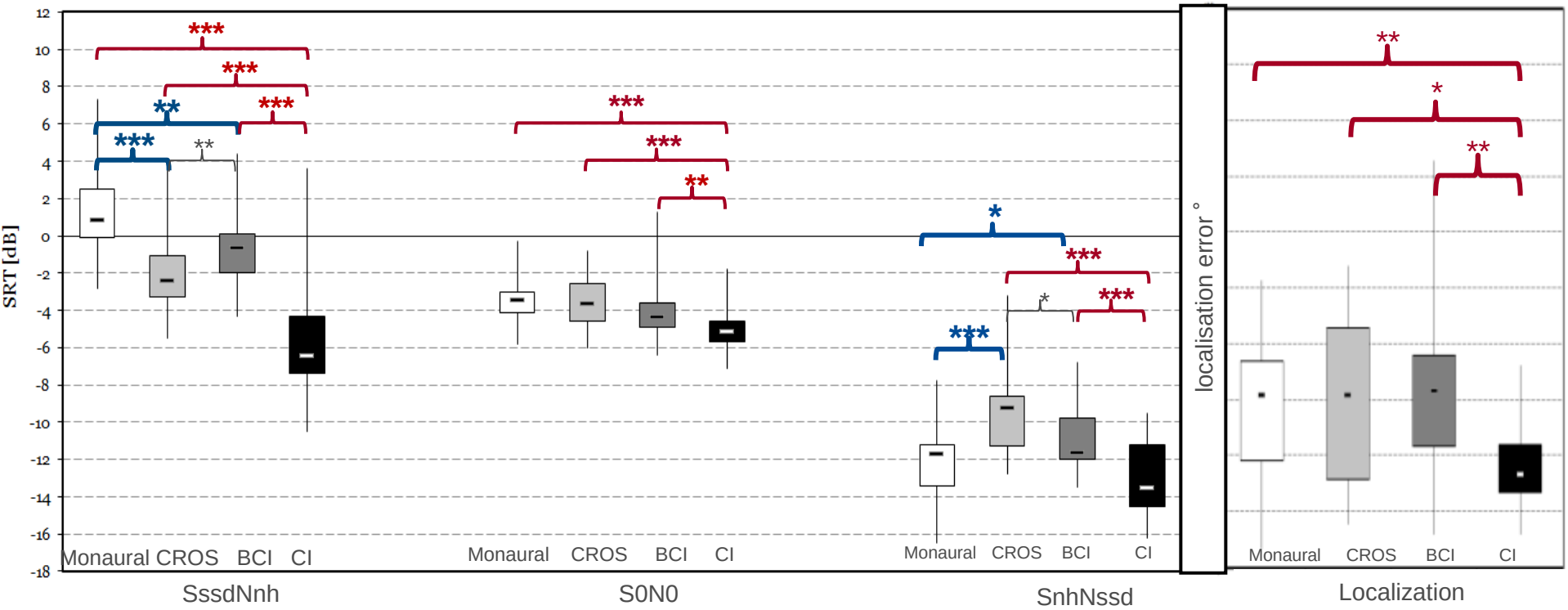
37 adult SSD patients with acquired hearing loss



- **with CROS and BCI s**ignificant superior results (blue brackets) vs. unaided in **only one** speech in noise condition
- **CROS and BCI** reduce SNR in one condition, no improvement in localization

Unaided vs. CROS-test vs. BCI-test vs. CI (12 months)

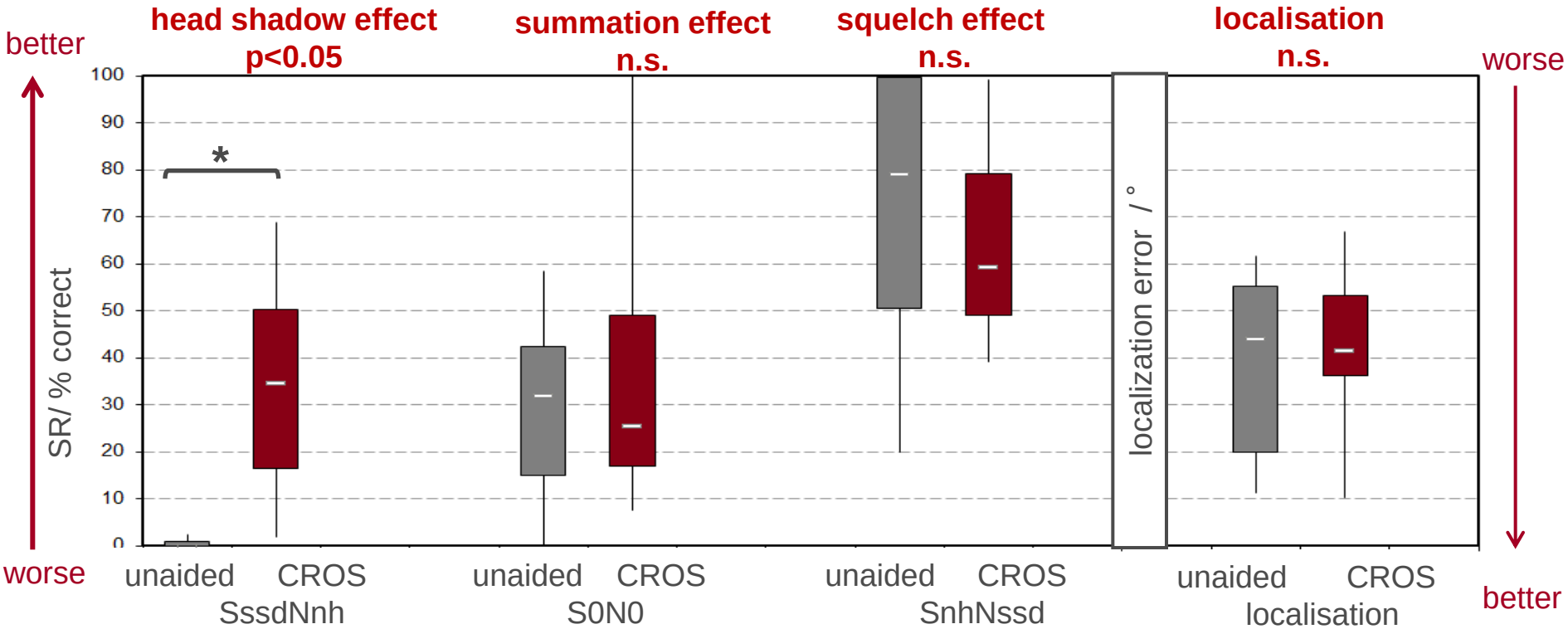
37 adult SSD patients with acquired hearing loss



- **with CROS and BCI** significant superior results (blue brackets) vs. unaided in **only one** speech in noise condition
- **CROS and BCI** reduce SNR in one condition, no improvement in localization
- **with CI** significant superior results (red brackets) in **all** SR conditions in noise compared to all treatment options and localization
- **CI** is the only option to increase the SNR in all conditions due to (partial) restitution of binaural hearing

Binaural benefits with conventional CROS HA?

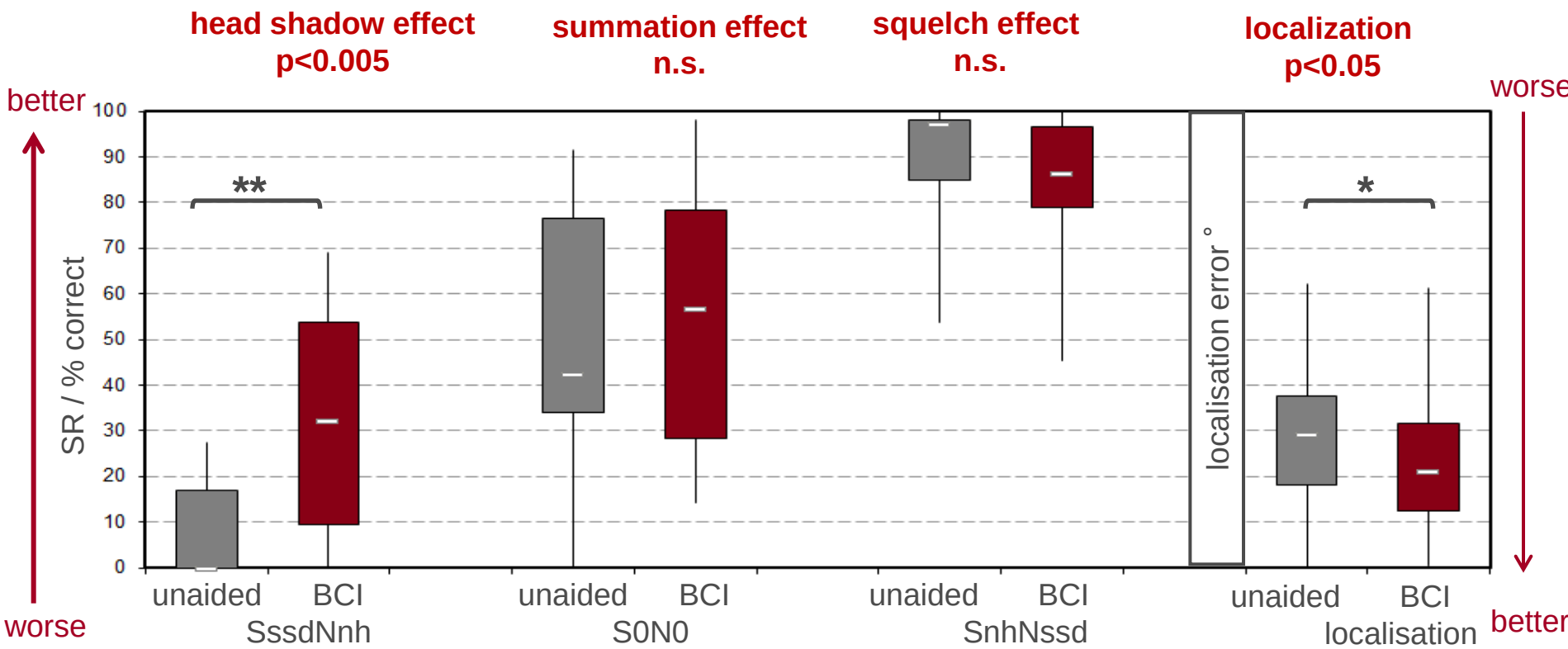
n=7 adults ; 12 months device experience; HSM sentence test, localization



- significant improvement of speech recognition in only one configuration representing the head shadow effect
- deterioration of speech SR when noise presented to poorer ear (n.s.)

Binaural benefits with percutaneous bone conduction implants?

n=17 adults; 12 months device experience; HSM sentence test, localization



- significant improvement of speech recognition in one configuration representing the head shadow effect
- improvement in localization

Results of different treatment options in children

CROS hearing: decrease or no improvement of speech comrehension in most conditions, difficult for the child during speech development

indicated in school aged children after speech development

Cochlear implantation in SSD-children

UNIVERSITÄTS KLINIKUM FREIBURG

Freiburg study of CI treatment in SSD/AHL Children

Pre-examination in SSD

- Subjective (paed)audiometry comprising thresholds, SR of monosyllables, sentences in quiet and noise (if measurable in respect to age)
- Objective audiometry including ABR thresholds, ABR latencies, electrocochleography
- HR-CT **and** MRI
- Neuropediatric examination, if other developmental disorders are known or suspected

Extensive counselling with regard to

- Ramifications for daily life (localization, SR in noise)
- Availability of BCI /(BI)-CROS and other assistive technology
- Necessity for participation in a mandatory rehabilitation phase

Arndt et al. 2015

Freiburg study of CI treatment in SSD/AHL Children

Audiometric tests

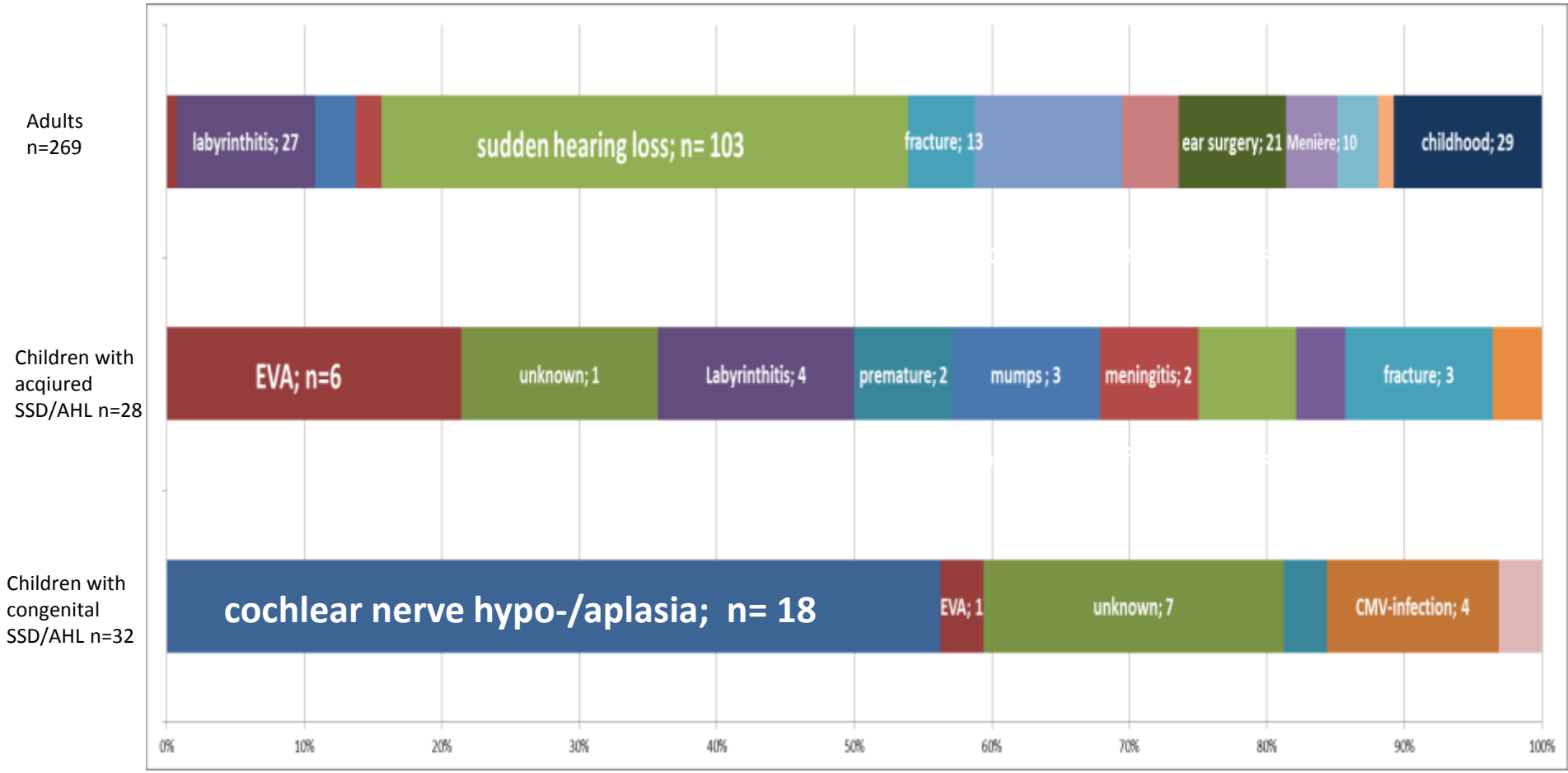
- Tests according to the children‘s age ➡ difficult to compare the results
- Speech tests in children
  (Mainz -, Göttingen speech test, Oldenburg sentence test for children: OlKiSa)
- If possible: OlSa for adults in 3 test conditions with background noise
- Categories of auditory performance (CAP; Archbold et al. 1998)
- CI-usage time indicates potential benefit in children.

Subjective evaluation

- For children younger than 9 years: Child self-report and a parent report using the adapted SSQ-version for children and parents (Galvin 2007)
- For children older than 9 years: adult version of the SSQ originally developed by Gatehouse and Noble

Cause of deafness of all SSD/AHL pre-Evaluations

328 patients: 269 adults; 59 children



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Therapeutic decisions after preevaluation

	congenital (n=32)	acquired (n=28)
Cochlear Implant (CI feasible)	11 (12)	24 (28)
CROS-HA	5	1
Bonebridge	1	
Baha		1
iSense (FM receiver)	1	
nothing	14	

Cochlear implant indications in SSD/AHL-children

	Congenital SSD/AHL (PE: n=32)	Acquired SSD/AHL (PE: n=28)
number of indicated CI‘s	11	28
	⬇	⬇
number of CI surgeries	10	24
age at surgery/yrs	5.7 (1.5 – 13.8)	11.1 (5.7-17.9)
duration of deafness/yrs	5.7 (1.5 – 13.8)	2.4 (0.3-10)

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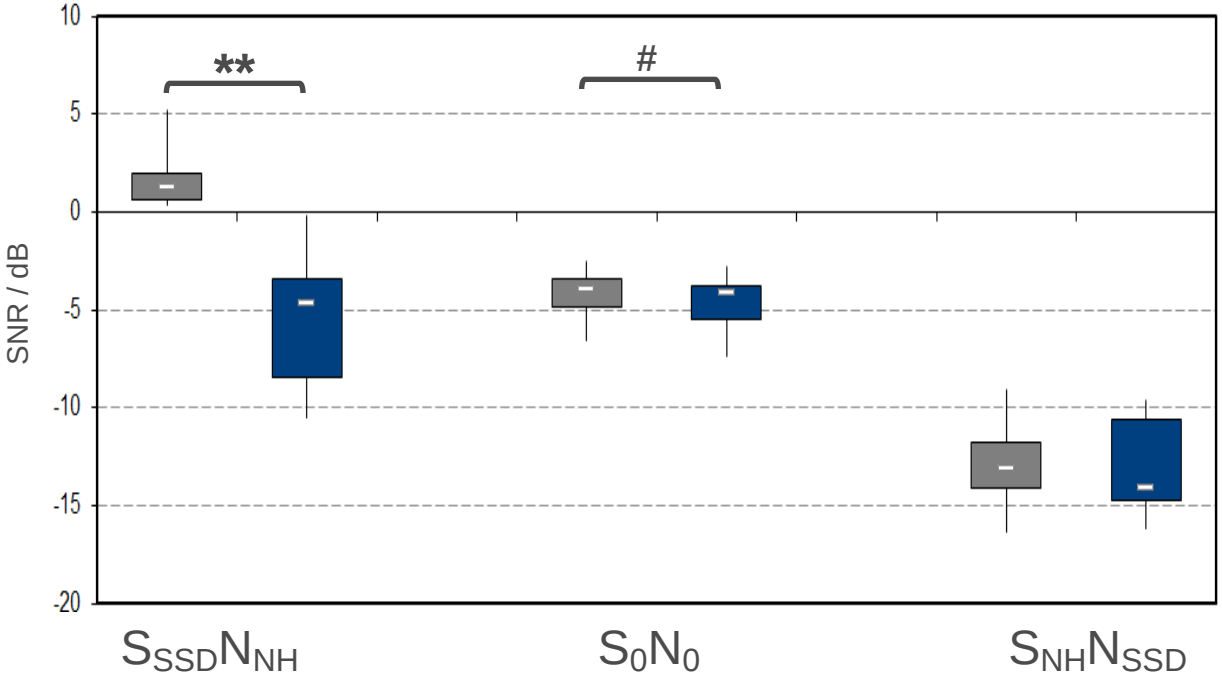
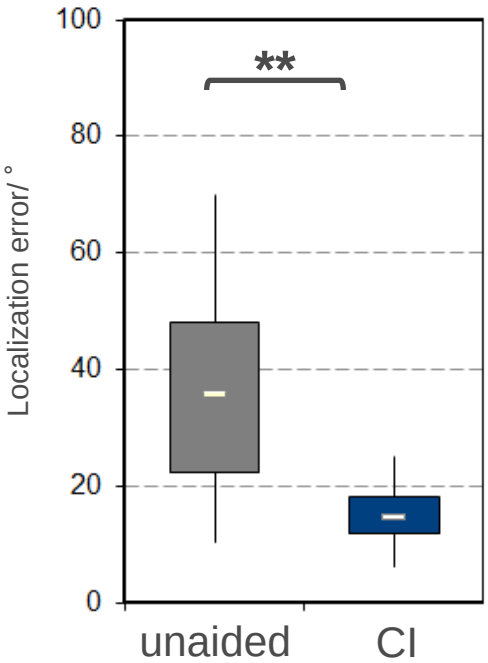
Results: acquired SSD/AHL in children

CI-OP: 18 children; results 12 months post-activation: OlSa (n=10); OlKiSa (n=4)

speech recognition OlSa (n=10)



localization (n=10)

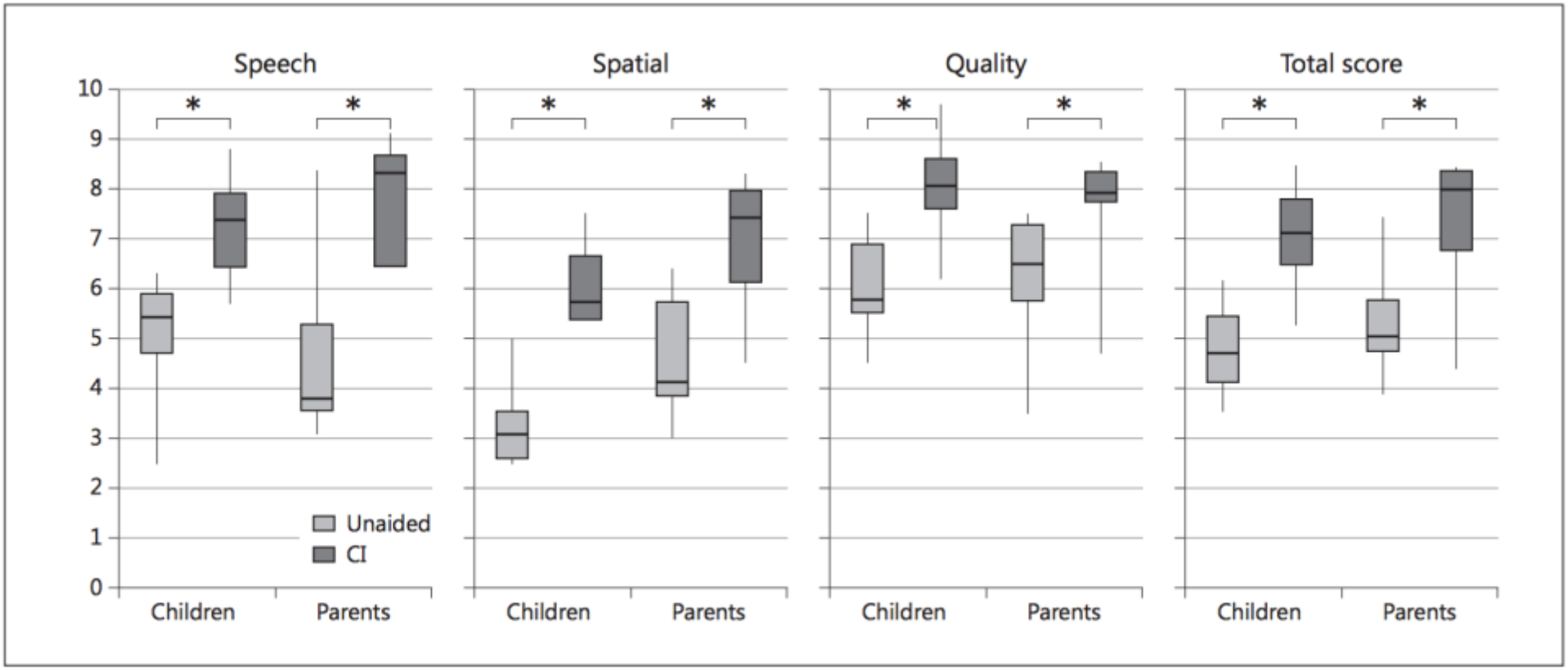


- results comparable to adult CI patients with acquired SSD

Arndt et al. 2015

Results: acquired SSD/AHL in children

SSQ results: adapted version for children and parents (Galvin 2007): 12 months post-activation (n=10)



- significant improvement in all subscores of child and parent version of SSQ
- **Use of CI all day long in all children!!**

Arndt et al. 2015

Different situation in congenital SSD children

- The development of auditory pathways is determined by neural plasticity and needs auditory input
- asymmetric hearing influences brainstem development and poses hurdles for the realization of true binaural processing

It is still unclear in congenital SSD

- whether the normal hearing ear sustains the formation of pathways at least partially
- or if the extensive asymmetry accelerates lateral inhibition and reduces the window for successful intervention

Assumption

- age for cochlear implantation in children with asymmetric hearing loss would not differ much from those with bilateral hearing loss

Overview: congenital SSD in children

Child	age @ diagnosis (year; month)	age @ surgery (year; month)	Etiology	BERA threshold (SSD ear, dB)	BERA threshold (better ear, dB)	education
1	NHS	1;10	CMV	>90	20	-
2	NHS	1;9	unknown	>90	20	-
3	NHS	3;0	hypoxia	>90	30	kindergarden
4	2;6	3;2	CMV	>90	20	kindergarden
5	NHS	4;0	unknown	>90	20	kindergarden
6	NHS	4;4	CMV	>90	20	kindergarden
7	NHS	4;8	EVA	>90	20	kindergarden
8	NHS	5;2	unknown	>90	20	kindergarden
9	4;5	6;8	ototoxic	>90	20	school
10	0;4	13;10	CMV	>90	20	school

Arndt et al. 2015

Results

CI-usage; speech comprehension; subjective evaluation

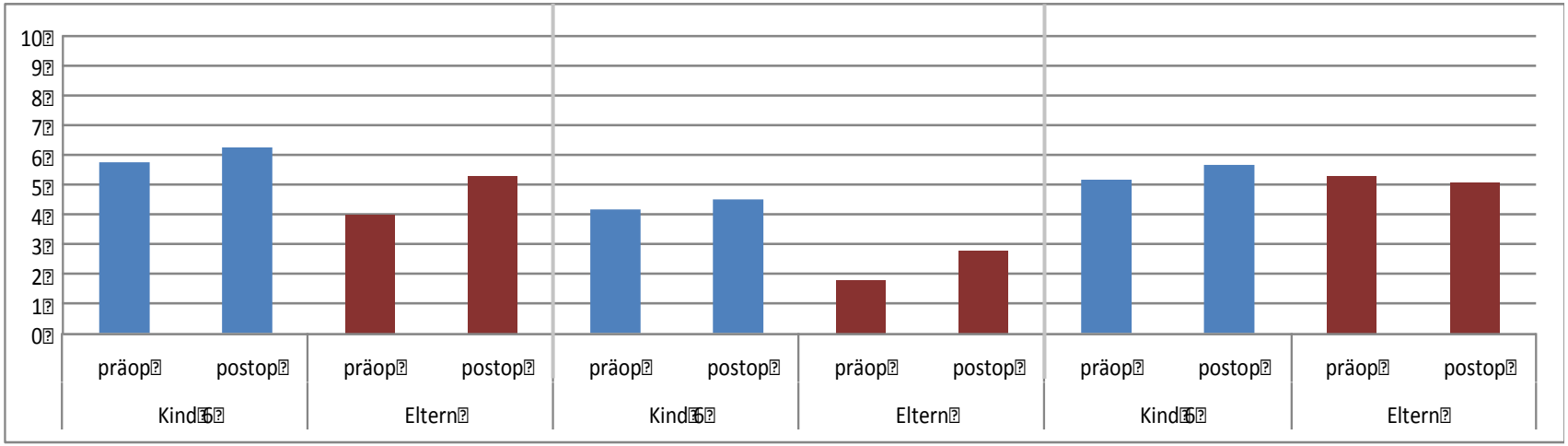
Child	Age (y;m)	Time after 1th fitting (y;m)	CI-usage	CAP	Speech test @ 65 dB	Speech comprehension with CI only	Subjective evaluation
1	2;1	1;0	all day	-	too young	-	Delayed general and motor development
2	2;7	1,0	all day	3	Mainzer I	100%	Repeats words and imitates sound heard by CI only
3	3;4	0;6	all day	-	Mainzer I	60%	Repositions transmission coil, shows localization
4	5;1	2;0	all day	5	Göttinger II	80%	Describes hearing with CI similar to unimpeded ear
5	5;0	1;0	all day	5	Göttinger II	70%	Asks for speech processor, immediate feedback, when batteries are empty
6	7;8	3;6	school	3	Göttinger II	0%	No speech discrimination with CI only, tendency towards non-use
7	5;2	0;6	all day	5	Göttinger II	0%	Improved speech discrimination, localization improved
8	5;9	0;6	all day	5	Göttinger II	0%	Mainstream school planned
9	7;5	0;6	all day	5	Freiburg monosyll.	20%	Checks status, changes batteries
10	15;2	2;0	school	5	Freiburger monosyll.	0%	Focus on contralateral side, tendency towards non-use

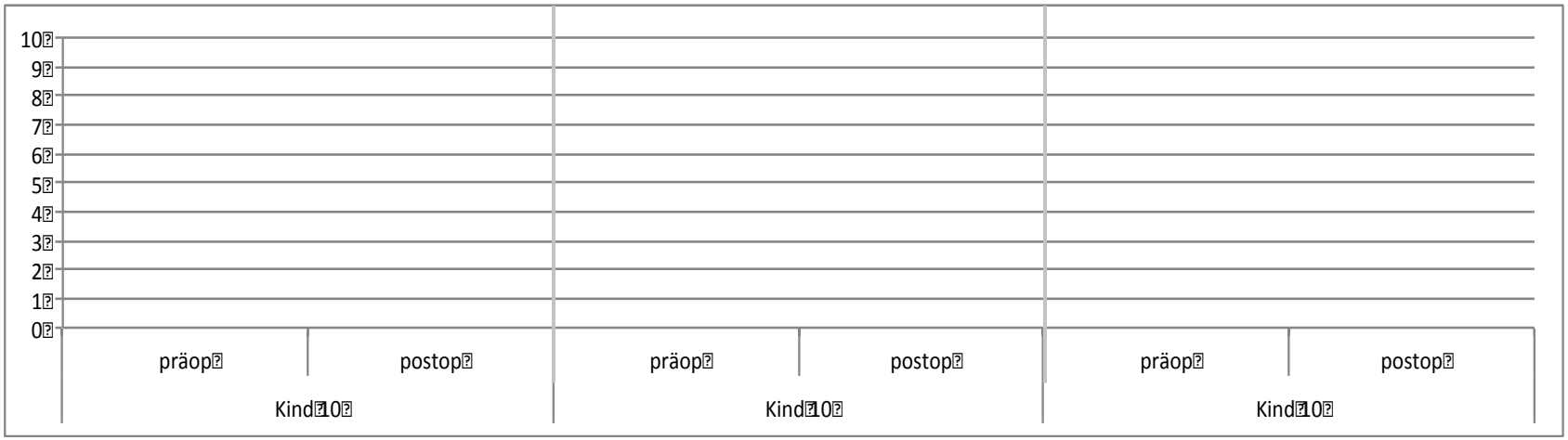
Results – children > 4 years at implantation

SSQ scale for children and parents (Galvin 2007)

Tendency towards non-use

Speech | Spatial | Quality





Summary: **Treatment of SSD/AHL in Children**

Acquired SSD/AHL

- Comparable results to adult CI patients with acquired SSD/AHL

➡ CI: Favorable treatment option for this special group of SSD children, as it is the only opportunity to restore binaural hearing abilities

Congenital SSD/AHL

- Anatomy should be evaluated with caution: app. 60% aplasia of the auditory nerve
- Limited results in two children, most likely due to late implantation or as a result of their CMV infection
- Promising results in children with implantation before age of 4 yrs
- Outcomes of auditory habilitation with CI vary significantly

➡ Intensive counseling of parents and patients is indispensable!

- CROS hearing: decrease of SNR in most conditions, difficult for the child during speech development- maybe wise later
  FM in Kindergarden or preschool?