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International Journal of Pediatric Otorhinolaryngology (2004) **68**, 1167—1174

International Journal of Pediatric Otorhinolaryngology

www.elsevier.com/locate/ijporl

The influence of potentially limiting factors on paediatric outcomes following cochlear implantation

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Received 28 October 2003; received in revised form 16 March 2004; accepted 18 March 2004

KEYWORDS
Cochlear implant;
Child;
Limiting factors;
Implantation outcome measures

Summary ***Objective:*** Children with isolated hearing impairment who have received cochlear implant at the optimal age mostly achieve remarkable results that are assessed by objective speech perception and production measurements. Different outcomes may be expected in case of conditions which may have a negative impact on postoperative performance. The aim of this study was to assess the influence of potentially limiting factors on postimplant outcomes. ***Methods:*** Four groups of examinees (11 in total) were involved by the study: (A) four children with additional disabilities, (B) three children with cochlear malformation and/or ossification, (C) three reimplanted children, (D) a child with retrocochlear (cochlear nerve) pathology. Hearing, speech perception and production were examined by pure tone audiogram, speech audiogram, categories of auditory performance, speech intelligibility rating, listening progress profile, and monosyllabic trochee polysyllable test. Postoperative positive life changes were assessed by a questionnaire. ***Results:*** Group A: perception skills better than expected, less satisfactory speech development. Group B: good sound perception, poor understanding. Group C: after reimplantation undisturbed conditions for continuation of optimal rehabilitation course. Group D: unsatisfactory results of pure tone hearing as well as speech perception and production. ***Conclusion:*** In spite of unfavourable conditions all examinees, except a child with retrocochlear pathology, were found to have a considerable benefit after cochlear implantation (with regard to obvious heterogeneity within each group). Evaluation of success, especially in children with multiple handicaps, also has to include subjective indicators of positive life changes, even those not directly associated with hearing.

1. Introduction

Excellent results after cochlear implantation, achieved by children without additional disabilities operated at the optimal age, have been well known and undoubtful. Their success is measured by indicators of perceptive and expressive speech skills in everyday communication [1—6]. However, cochlear implantation also results in positive personality changes enabled by a mere hearing even before development of understanding and speech.

Selection criteria for CI candidates have broadened over the years. Nowadays, as candidates

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doi:10.1016/j.ijporl.2004.03.016

are considered also children with limited abilities to develop open speech understanding which are usually identified during preoperative assessment [7].

On the other hand, postoperative rehabilitation could sometimes be retarded and limited by some factors independent of candidate, but related to device [8].

After almost 200 cochlear implantees included in mapping procedures and rehabilitation in our Centre we met numerous star patients, but also some less successful cases.

How could we be sure what is the main reason for less than optimal, or less than expected postoperative performance?

According to our experience we suggest procedure algorithm (Fig. 1). Checking systematically all suggested factors, step by step, is the most secure way to identify or rule out different possible impairments, from outer parts of device, to incorrect electrode position or device failure, as well as additional handicaps and disabilities of candidates, from retrocochlear pathology to pathologies that are independent of device, mapping, or even hearing pathways, and are diagnosed by psychologists, neurologists or psychiatrists. We should always bear in mind that there may be more than one unfavourable condition, and more than those identified during preoperative evaluation.

The aim of this work was to assess the influence of potentially limiting factors on postimplant outcomes.

2. Methods

The study included 11 children involved in mapping, rehabilitation and/or diagnostic follow up in our Centre. They all have received their CI during first 4 years of life, except one postlingually deafened child that was operated at the age of 6.11 years.

Four groups of patients were isolated:

A: four children with additional disabilities (a child with communication disorder, two children with moderate psychomotor retardation, one of them with additional syndrome of attention disorder with hyperactivity, and a child with a left-sided brain hemiatrophy);
B: three children with cochlear malformation (one of them with malformation and ossification);
C: three children after reimplantation;
D: a child with retrocochlear (cochlear nerve) impairment (cochlear nerve pathology—possibly too low number of surviving fibres—was assumed after thorough examination performed since the child with otherwise normal psychomotor development and neuropediatric status showed no postoperative progress with different map parameters. Proper electrode placement was confirmed by computerised tomography, and possible implant malfunctions were excluded by two separate implant integrity tests. Neural response telemetry (monopolar and bipolar mode) failed to elicit response to stimulation at different electrodes, and electrically evoked stapedial reflexes (ipsy or contralateral) could

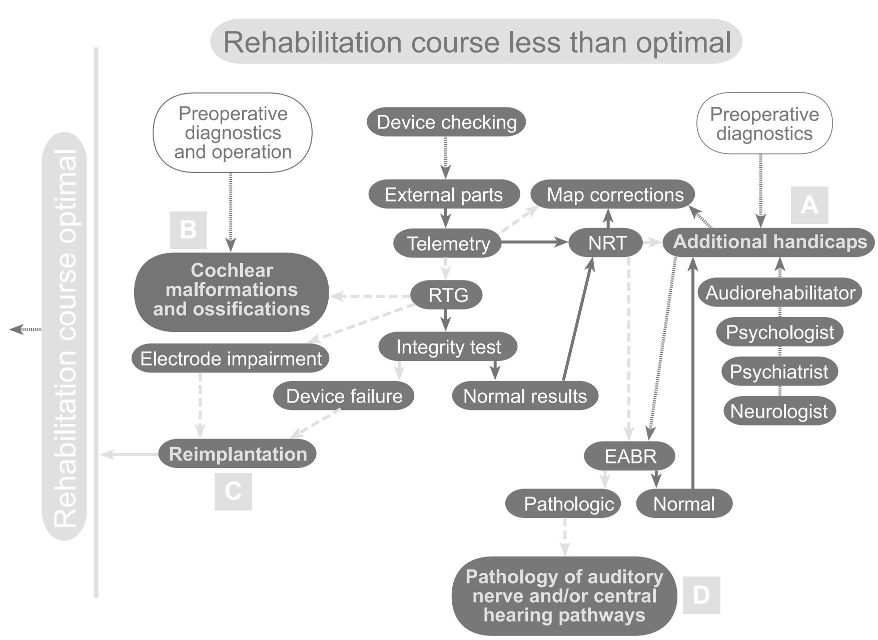

Fig. 1 Diagnostic algorithm.

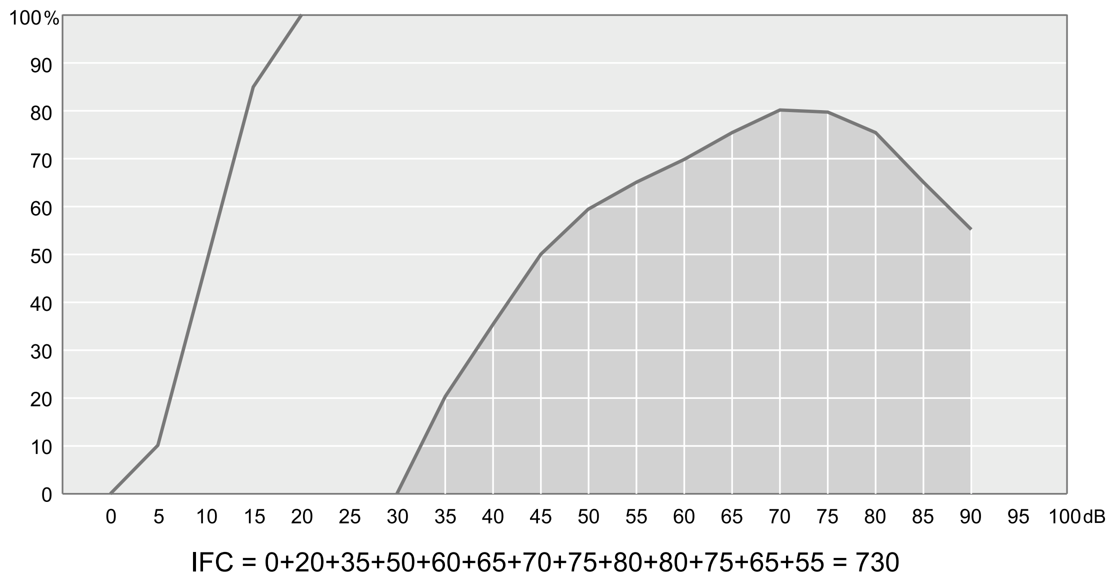

Fig. 2 Intelligibility field capacity.

not be elicit at highest stimulus levels. Electrically evoked auditory brainstem response was also performed without any response).

The age of the patients was between 4.4 and 11.2 years. The age at implantation varied from 2.3 to 6.11 years. The follow up period ranged between 12 and 58 months.

The etiology of hearing impairment was heterogeneous, hereditary as well as pre, peri or postnatally acquired deafness.

Pure tone audiogram (mean threshold at 500, 1000 and 2000 Hz).

Speech audiogram the results of which are expressed as intelligibility field capacity IFC (Fig. 2).

Table 1 Tests results

Patient	Age (years)	Time after operation (months)	PTA (dB)	SA (IFC) (%)	CAP	SIR	LIP (%)	MTP (%)
X	5	36	30	30	7	5	100	100
A1	9.3	58	49	0	5	2	67	100
A2	7.3	53	35	0	5	2	95	88
A3	4.7	30	50	0	4	2	18	0
A4	5.3	12	60	0	2	1	0	0
A	6.7	39	48	0	4	2	45	47
B1	11.2	54	40	0	4	3	95	39
B2	10.7	58	43	2	4	3	100	66
B3	5.7	14	40	0	4	3	42	26
B	9.2	42	41	0	4	3	79	44
C1	4.4	12/10[a]	33	0	5	2	92	66
C2	7	24/3[a]	43	5	4	3	100	89
C3	5	25/2[a]	32	30	5	4	97	77
C	5.5	20/5[a]	36	12	5	3	96	77
D	5.3	34	110	0	1	2	42	0

Patient X: ''star patient'' for comparison; PTA: pure tone audiogram; SA: speech audiogram; IFC: intelligibility field capacity; CAP: categories of auditory performance; SIR: speech intelligibility rating; LIP: listening progress profile; MTP: monosyllabic trochee polysyllable test.

[a] Time after reoperation.

IFC enables numerical expression of the entire field under the audiogram curve, as a single number or percentage of normal audiogram. It is the sum of intelligibility percentages at all intensities at 5 dB intervals. Maximal value is 1850. The results are presented as percentage of normal value, for example 180:1850 = 9.7%. It helps us to more easily compare audiograms and evaluate effects of rehabilitation.

Categories of auditory performance (0—7).

Speech intelligibility rating (0—5).

Listening progress profile and monosyllabic trochee polysyllable test—second level of difficulties with six words, from EARS battery (tests were presented in live voice, children were tested in the auditory only condition, and speech perception measured without lip-reading).

Questionnaire for parents consists of 15 questions: concerning 13 questions, five possible answers are offered to each question: ''never'', ''rarely'' ''occasionally'', ''frequently'' and ''always''. The answers ''frequently'' and ''always'' are those that confirm positive changes that occurred due to cochlear implantation.

3. Results

All results here presented (Table 1) are related to the latest performed tests. Postoperative follow up is presented for each child (column 3), ranging between 12 and 58 months. Each child was examined by pure tone audiogram, speech audiogram, categories of auditory performance, speech intelligibility rating, listening progress profile and monosyllabic trochee polysyllable test—second level of difficulties with six words, from EARS battery (columns 4—9).

Both individual and group results are presented in Table 1.

The results of group A are very heterogeneous as are their additional handicaps and postoperative follow up, ranged between 1 and almost 5 years. Therefore, we chose to concentrate on results of each child, rather than to the average group outcomes. Anyway, their perception skills are better than expected (two children with longest follow up achieve fifth level in CAP and 88 and 100% in MTP). Production of speech is less satisfactory, and is mainly on an unintelligible level.

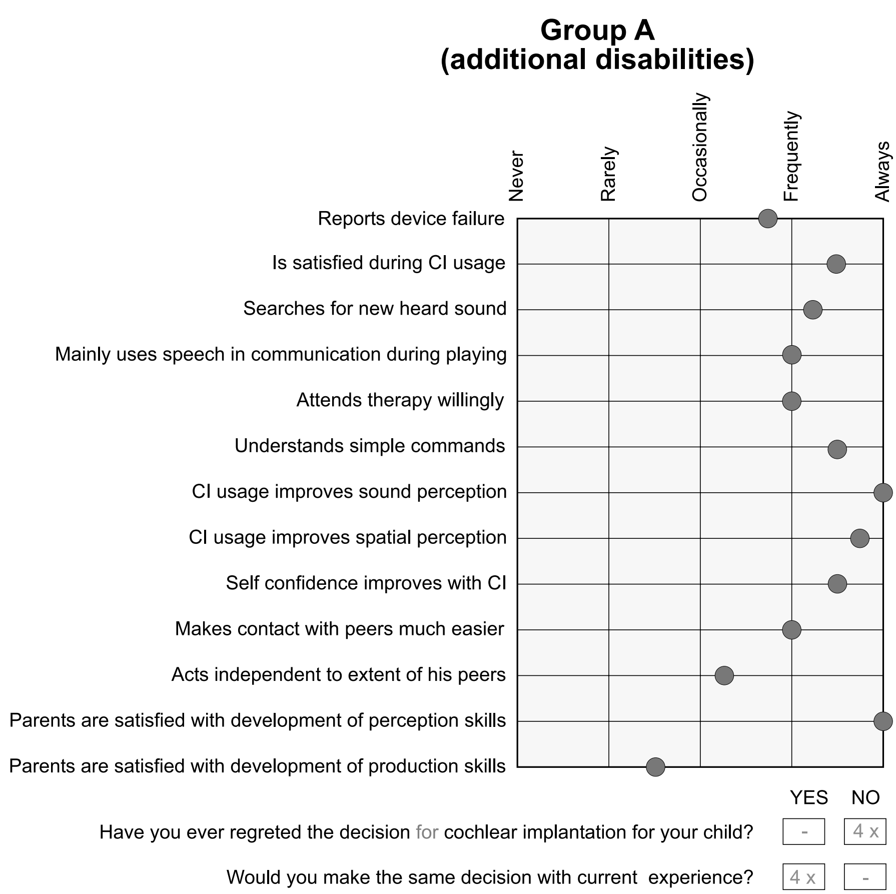

Fig. 3 Questionnaire results for group A.

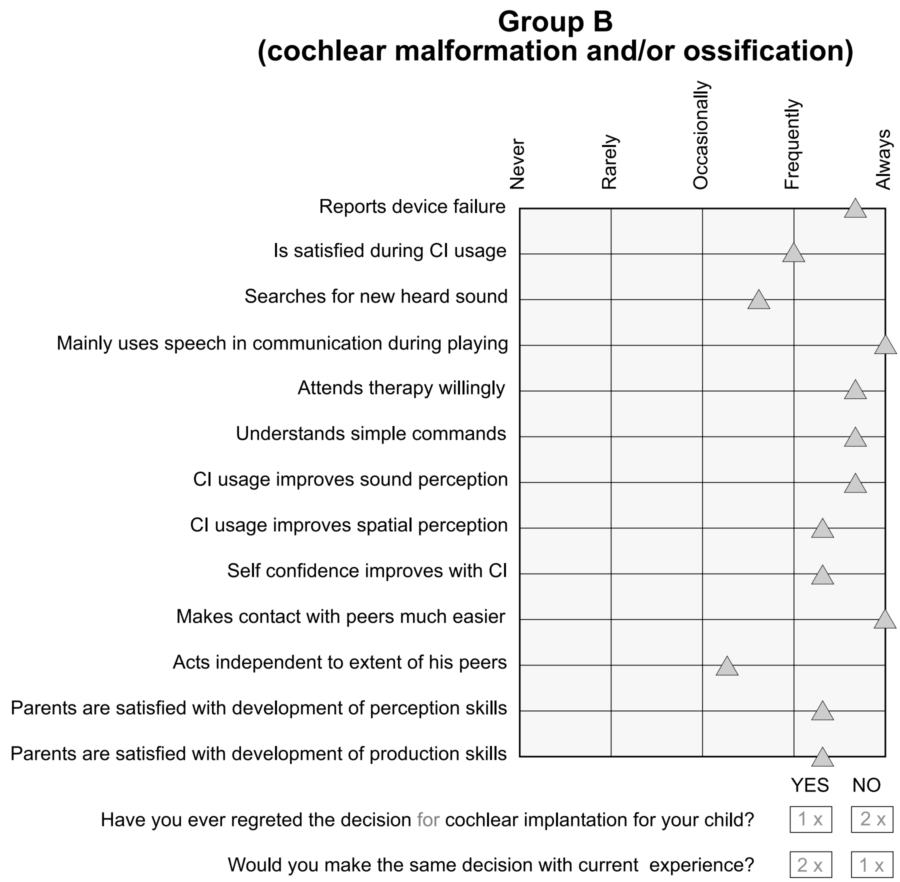

Fig. 4 Questionnaire results for group B.

Group B is characterized by a good sound perception (average PTA 41 dB), especially considering that two arrays are completely extracochlear, but understanding is less satisfying, as well as speech production.

Group C is composed of children that have been reimplanted due to device failure. After the reimplantation, conditions for continuation of optimal rehabilitation course were undisturbed and all tests results were satisfying. It is important to notice that follow up period was short after implantation, and especially after reimplantation.

Group D consists of just one member, a child with an unanticipated retrocochlear pathology. Results of pure tone hearing are unsatisfactory (mean PTA 110 dB), as well as speech perception and production, since almost 3 years after the implantation the child is just aware of environmental sounds, and her speech is unintelligible.

Besides objective indicators of hearing, open set understanding and speech development, we applied a questionnaire to assess the changes in children behaviour that have been observed by their parents after the surgery. The answers to some questions are presented for each group in Figs. 3—7.

4. Discussion

Children with additional disabilities make an especially heterogeneous group among CI users.

Literature reports on postimplant outcomes of children with multiple handicaps which negatively influence speech and language development are rare and heterogeneous. Their results vary from quite poor to considerable benefit. The differences in results might be due to different criteria used to assess the benefit [9—12]. According to the literature, most of children with multiple handicaps which have a negative impact on speech and language development, e.g. significant psychomotor delay, autism, etc. do not achieve open set word recognition and speech.

The results of our investigation of such patients with longest follow up period have shown that satisfactory perception skills are possible, but only after several years of rehabilitation. Less satisfying results were obtained in speech development, due to their additional disabilities, since speech is qualified as unintelligible even after several years [13].

Children with extracochlear electrodes obtain a relatively good sound perception, but poor under-

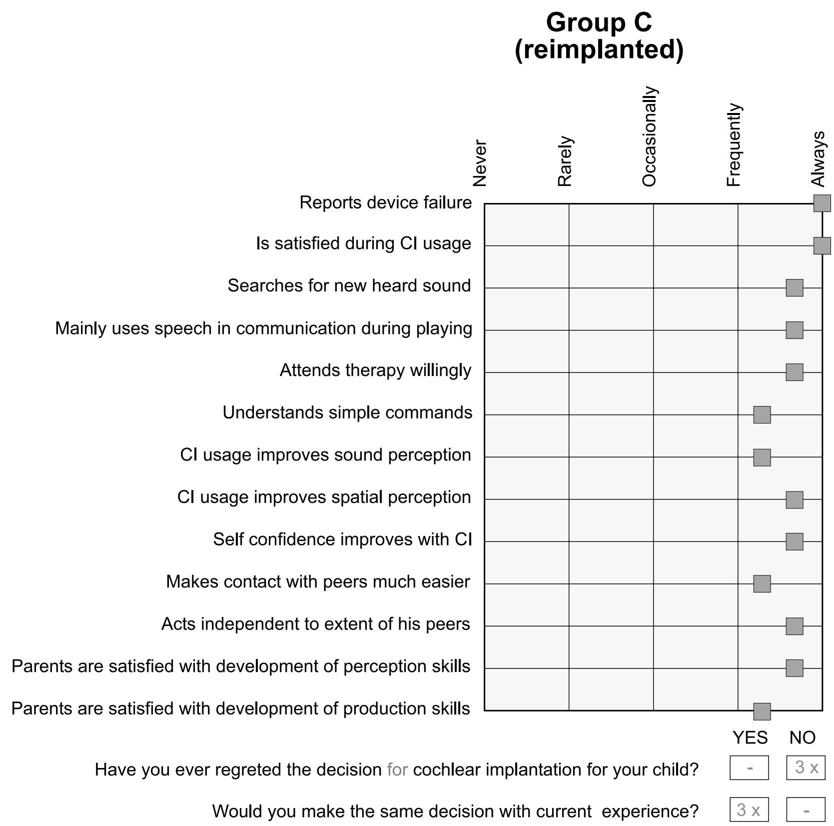

Fig. 5 Questionnaire results for group C.

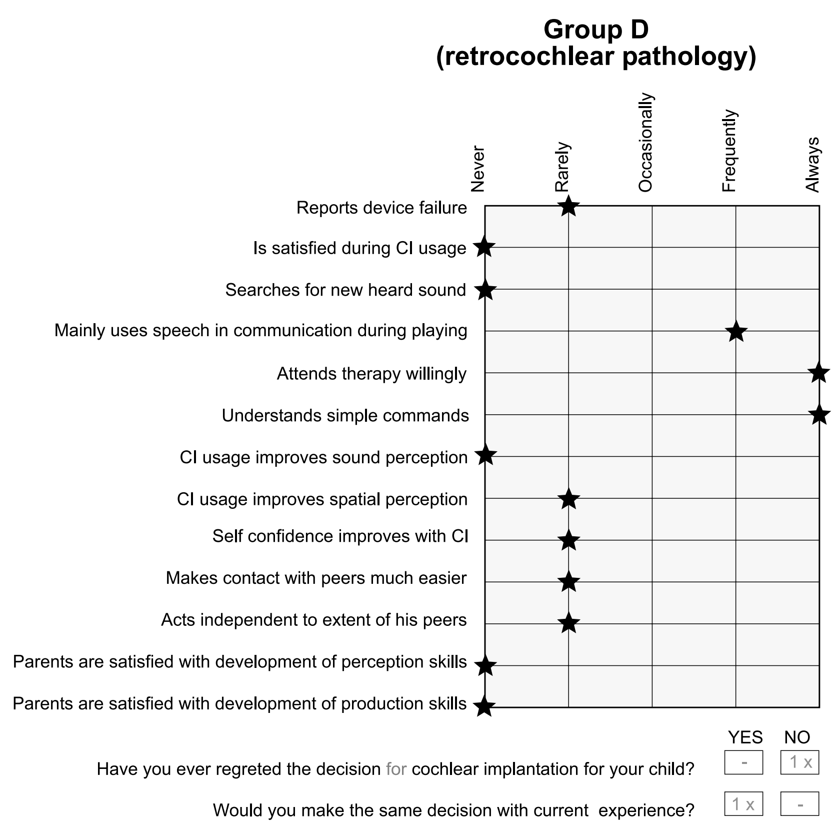

Fig. 6 Questionnaire results for group D.

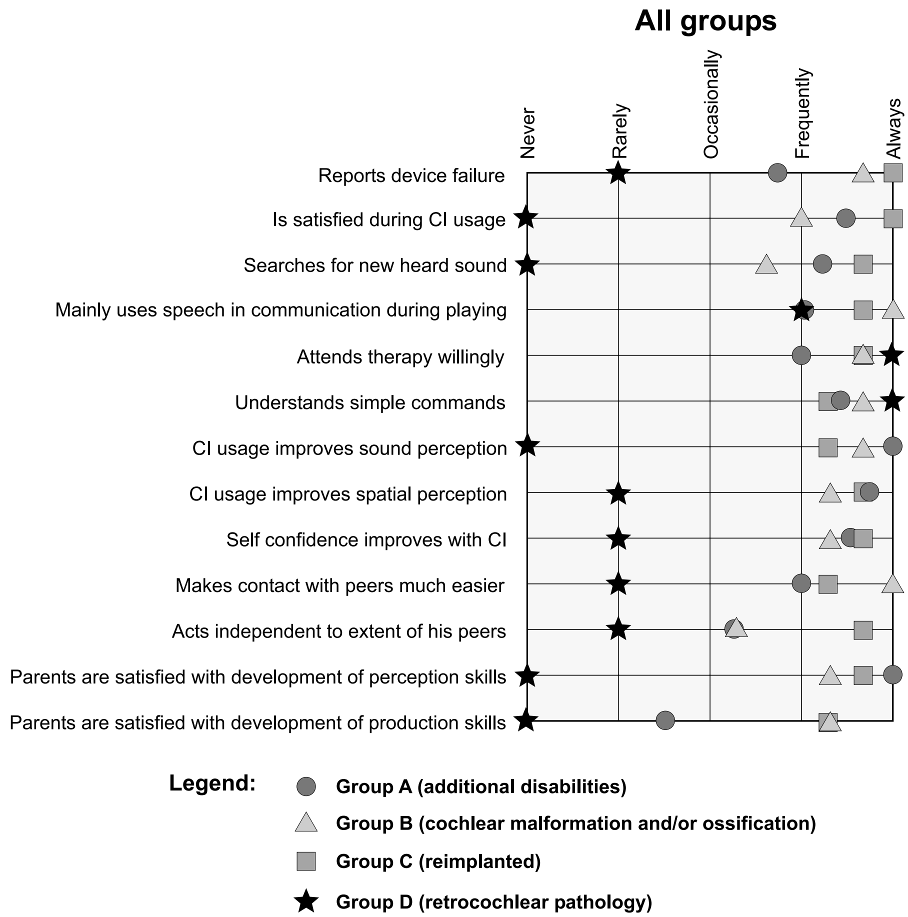

Fig. 7 Questionnaire results for all groups.

standing even after 5 years of rehabilitation, due to very poor frequency discrimination. It is still too early to confirm a better outcome with short electrodes, because a child with such device was operated only a year ago.

Our reimplanted children outcomes fully correspond to already published good outcomes following reimplantation [14,15]. Pure tone thresholds remained at the same level as before device failures have happened, as are speech audiograms, enabling continuation of optimal rehabilitation course.

Child with retrocochlear impairment which is verified on the nerve level, achieved unsatisfactory performance. Even by electrical stimulation it was not possible to obtain adequate neural synchrony in that child [8,16,17].

The questionnaire revealed subjective but interesting data. The fact that all children, except a child with retrocochlear impairment, are satisfied when using CI, that all of them are now more confident, all improved both spatial and sound perception, now have a much easier contact with peers, as well as that all parents but one mother are satisfied with listening progress of their children and have never regretted decision for cochlear implantation, points out the importance of subjective indicators of positive life changes, even those not directly related to hearing and speech.

5. Conclusion

Systematic preoperative and postoperative diagnostics and follow up are important to identify factors responsible for less than optimal postoperative performance, and then for adequate expectations and rehabilitation. Even when it is clear that the slower progress is due to additional disabilities, it is also important to rule out the device related causes. In spite of unfavourable conditions all our examinees, except a child with retrocochlear impairment, have had a considerable benefit after cochlear implantation (with regard to obvious heterogeneity within each group). Evaluation of success, especially in children with multiple handicaps, has to include subjective indicators of positive life changes too, even those not directly connected with hearing.

Even though our groups of examinees were too small to provide statistically significant conclusions, we hope that presented procedures and results could be useful in finding out reasons for less than expected postoperative performances, as well as help in preoperative decision and parents' counselling about cochlear implantation.

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