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Auditory verbal skills training is a new approach in adult cochlear implant rehabilitation

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ABSTRACT

INTRODUCTION: Outcome after cochlear implantation in adults varies and is affected by many factors. One factor is auditory training after implantation. No national guidelines for adult auditory training currently exist in Denmark. An auditory verbal skills training (AVST) rehabilitation programme was developed and applied at the East Danish Cochlear Implant (CI) Centre (Rigshospitalet, Gentofte Unit). The AVST intervention was inspired by the auditory verbal therapy practice that is targeted the paediatric population and their families. The objectives were to document the outcome for first-time adult CI users, to apply and explore the effects of the AVST and to examine CI users' possibly extended need for technical follow-up.

METHODS: A prospective comparative study design was used. Ten CI users participated in AVST with a relative. Seven CI users were included in a control group. The outcome measures of speech understanding and quality of life (QoL) were recorded pre-implant and post-implant.

RESULTS: All participants showed improved speech understanding and a higher QoL post-implant. The within-group analyses showed significant improvements in outcome over time. However, no differences were seen in the between-group analyses post-implant. The CI users in the intervention group received more CI fine-tuning.

CONCLUSIONS: The AVST was successfully implemented at the CI Centre. Improvements in speech understanding and QoL were seen in both groups over time, but no differences were seen between the groups. The CI users in the intervention group received more fine-tuning of their processor.

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TRIAL REGISTRATION: Not relevant as the study applied a prospective method study design.

The outcome after cochlear implantation in adults varies and research shows that several factors affect the outcome, including age at onset of the hearing impairment (HI), duration and degree of auditory deprivation, cortical reorganisation, preoperative speech understanding, preoperative residual hearing, aetiology of the HI, duration of the HI, age at implantation and auditory rehabilitation or training [1-11].

No national or best practice guidelines exist for cochlear implant (CI) rehabilitation activities or auditory training in Denmark. In this study, an auditory verbal skills training (AVST) rehabilitation programme for adults was developed at the East Danish CI Centre. We chose to adapt the approach from the broad clinical experience of paediatric habilitation; the auditory verbal therapy (AVT) [12, 13]. This approach is recommended by both the Danish Health Authority and Danish Social Services [14, 15].

The overall objective was to investigate the CI outcome for first-time adult CI users. Additional specific objectives were to apply and explore the effects of the AVST intervention, and to investigate the patients' need for technical follow-up and CI fine-tuning.

METHODS

Study design and inclusion of participants

A prospective comparative study design was used including 17 adult CI users. The CI users were recruited at the East Danish CI Centre from March to July 2017. The inclusion criteria were that the participants should be first-time CI users capable of completing the test battery without help from others. The exclusion criteria were patients getting their second CI sequentially after their first CI (n = 10), timing issues due to project timelines (n = 14), patients receiving a CI because of single-sided deafness (n = 2) or other reasons such as the patient not wanting the treatment or not being suitable for CI treatment after candidacy evaluation (n = 9). Fifty-two patients were seen in the clinic during the inclusion period; 35 were excluded and 17 were included. The 17 patients were informed about the study and gave informed consent. The patients were allocated to either the intervention group or the control group in accordance with their wish to participate in AVST intervention with a relative. Ten patients were placed in the intervention group and seven in the control group. At the CI Centre, the intervention group fol-

ORIGINAL ARTICLE

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TABLE 1

Characteristics of the cochlear implant users in the intervention and control group pre-implant.

Characteristics of participants pre-implant	Intervention group (N = 10)	Control group (N = 7)
Gender, n (%)		
Male	5 (50.0)	3 (42.8)
Female	5 (50.0)	4 (57.2)
Age, median, yrs	69.5	72.0
Min.	27	57
Max	91	80
Pure-tone average, median, dB HL		
CI ear	96.3	88.8
Opposite ear*	80.6	61.3
Duration of hearing impairment, both ears, median, yrs	20.5	20.0
Min.	10	4
Max	55	36
Duration of HA treatment, CI-ear, median, yrs	16.0	18.0
Min.	5	4
Max	37	25
CI treatment, n (%)		
Unilateral CI	9 (90.0)	7 (100.0)
Binaural CI	1 (10.0)	0
Language code, n (%)		
Danish oral language	8 (80.0)	7 (100.0)
Danish oral and sign language	2 (20.0)	0
Living situation, n (%)		
Cohabiting	6 (60.0)	4 (57.2)
Living alone	4 (40.0)	3 (42.8)
Employment, n (%)		
Full-time	2 (20.0)	1 (14.2)
Part time	1 (10.0)	2 (28.6)
On sick leave	1 (10.0)	-
Retired	6 (60.0)	4 (57.2)

CI = cochlear implant; HA = hearing aids; HL = hearing level.
*) $p < 0.05$.

lowed the AVST rehabilitation programme and the control group followed the standard follow-up sessions.

Description of the applied intervention and tests

The AVST rehabilitation programme for adults was developed at the East Danish CI-Centre. The intervention consisted of goal-based and individualised activities, involvement of relatives and the use of auditory verbal strategies and techniques. Long- and short-term goals for each CI user were defined. The long-term goals typically focused on participation in specific activities (e.g., being able to talk with the grandchildren seated in the back seat of the car while driving, or being able to follow the meditation instructor's guidance with soft music playing in the background). The short-term goals focused on the activities that developed the auditory and communicative skills needed to reach a specific long-term goal. The activities were designed to match the CI user's interests and auditory performance to enhance motivation. The activities were practiced in the clinic with the CI users and their relatives, hereby supporting "carry-over" to the home setting. Home training was agreed upon from session to session. The auditory verbal techniques and strategies used were *highlighting, auditory closure, auditory sandwich, auditory before visual and waiting*. The intervention consisted of ten sessions at the CI Centre and included both analytic and synthetic training. The AVST intervention was performed by three speech, language and hearing pathologists with a master's degree in speech, language and hearing therapy (hereafter hearing pathologist). Three workshops including supervision with AVT therapists were conducted before and during the intervention to maximise the use of AVT-inspired activities and Auditory Verbal strategies and techniques.

Dantale I was used for evaluating speech understanding of phonemes in monosyllabic words in quiet and in noise with a signal-to-noise ratio of 0 dB [16, 17]. The phoneme scoring method was used.

The Hearing In Noise Test (HINT) was used for evaluating speech understanding of sentences and words in sentences in quiet and in noise [18]. In noise, two tests were used: One using a signal-to-noise ratio of +10 dB and one using the standard adaptive HINT procedure. The Nijmegen Cochlear Implant Questionnaire (NCIQ) was used for evaluating the patients' self-rated hearing ability and QoL [19]. The questionnaire consists of 60 questions within six subdomains: basic sound perception, advanced sound perception, speech production, self-esteem, activity and social interaction. It was translated into Danish in accordance with the standard procedure with forward and back-translation and was pilot-tested at the East Danish CI Centre [20].

Data analysis

Descriptive analysis and non-parametric statistical tests were used. The Wilcoxon signed rank test was used to compare CI outcome within each group, and the Mann Whitney U test was used to compare CI outcome between groups.

Trial registration: Not relevant as the study applied a prospective method study design.

RESULTS

Description of the cochlear implant users

Table 1 shows the different characteristics of the CI users for both groups. Comparing the groups, we found that the age range of the CI users varied more in the intervention group than in the control group. In the intervention group, two CI users used oral and sign language, and one CI user was implanted with binaural CI simultaneously. Also, the control group had better residual hearing in the non-CI ear. No significant differ-

TABLE 2

Nijmegen Cochlear Implant Questionnaire, median scores (and ranges), in the intervention and control group over time.

	Intervention group			Control group		
Test	**pre-implant**	**3 mo.s**	**6 mo.s**	**pre-implant**	**3 mo.s**	**6 mo.s**
Sound perception						
Basic	28.8 (0-69)	65.3 (39-78)*, a	78.8 (47-92)*, b	30.0 (20-68)	63.8 (25-90)*, a	72.5 (28-95)
Advanced	41.3 (0-73)	58.8 (33-90)*, a	65.0 (35-88)	30.0 (0-43)	44.7 (40-81)	55.0 (33-85)*, a
Speech production	75.0 (43-100)	82.5 (47-100)	92.1 (48-100)	65.0 (42-100)	82.0 (53-100)	70.0 (40-98)
Self-esteem	61.3 (39-86)*	68.8 (58-97)	72.2 (48-90)	44.4 (30-61)*	60.0 (39-91)*, a	60.0 (55-83)
Activity	45.9 (25-82)*	77.5 (56-83)*, a	77.5 (50-94)	33.3 (0-50)*	58.9 (28-89)*, a	65.6 (14-90)
Social interaction	48.3 (25-79)	76.4 (40-97)*, a	79.6 (53-92)	33.3 (19-44)	72.4 (28-89)*, a	60.0 (25-92)

*) p ⟨ 0.05.
a) Improvement compared to pre-implant.
b) Improvement from 3 to 6 mo.s post-implant.

ences were seen between the groups in terms of gender, median age, duration of HI, duration of treatment with hearing aids (HA) and socioeconomic status (living situation and employment). CI systems from three different manufacturers were used in both groups (Cochlear (n = 9), Advanced Bionics (n = 5) and Oticon Medical (n = 3)).

Differences between the groups were also seen in the NCIQ scores pre-implant in **Table 2**. The control group had lower ratings in the subdomains *self-esteem* and *activity*.

Cochlear implant outcome

Table 3 shows median Dantale I and HINT scores in the two groups. Improvements in speech understanding over time were seen in both groups. All individual CI users showed clinically significant improvements in speech understanding after three and six months of CI use. There were no statistically significant differences between the groups comparing the Dantale I and HINT scores at three and six months post-implant.

After three months, both the intervention and the control group showed significant improvement in their Dantale I scores. Furthermore, the intervention group improved significantly between three and six months in the test conditions best aided in quiet and CI alone in noise scores. The control group showed improvement from three to six months as well, but in the test con-

TABLE 3

Dantale I and Hearing In Noise Test, median scores (and ranges) in the intervention and control group over time.

	Intervention group			Control group		
Test	**pre-implant**	**3 mo.s**	**6 mo.s**	**pre-implant**	**3 mo.s**	**6 mo.s**
Dantale I						
Best aided in quiet + lip reading, phoneme score, %	71.0 (19-88)	87.0 (36-98)*, a	91.5 (36-98)	66.0 (53-89)	90.5 (79-95)*, a	91.0 (69-96)
Best aided in quiet, phoneme score, %	46.0 (0-75)	79.5 (0-90)*, a	84.5 (35-96)*, b	51.0 (46-71)	74.0 (61-84)*, a	85.0 (68-93)
Best aided in noise, phoneme score, %	11.5 (0,41)	46.5 (0-79)*, a	49.5 (3-79)	20.0 (8-39)	36.0 (11-55)*, a	49.0 (31-65)*, b
CI ear/CI alone in quiet, phoneme score, %	19.0 (0-57)	69.0 (0-96)*, a	79.0 (35-95)	0.0 (0-40)	74.0 (36-84)*, a	78.0 (43-89)
CI ear/CI alone in noise, phoneme score, %	4.0 (0-29)	43.5 (0-55)*, a	50.0 (3-64)*, b	0.0 (0-20)	39.0 (14-64)*, a	53.0 (13-68)
Hearing In Noise Test						
Best aided in quiet, sentence score, %	27.5 (0-60)	65.0 (0-95)*, a	70.0 (0-95)	20.0 (0-70)	50.0 (20-80)	70.0 (20-100)
Best aided in quiet, word score, %	52.0 (0-86)	88.5 (0-99)*, a	89.5 (0-99)	40.0 (1-82)	76.0 (39-92)	87.0 (49-100)
Best aided in noise, sentence score, %	10.0 (0-55)	45.0 (0-90)	57.5 (0-90)*, a	15.0 (0-40)	45.0 (15-75)*, a	55.0 (15-95)
Best aided in noise, word score, %	31.5 (0-82)	78.0 (0-98)	81.0 (0-94)*, a	39.0 (1-64)	62.0 (35-86)	81.0 (37-96)
Best aided in noise, SNR result, dB SNR	-	6.7 (4-10)	7.3 (3-12)	-	7.4 (7-15)	7.7 (6-25)

CI = cochlear implant; SNR = signal-to-noise ratio.
*) p ⟨ 0.05.
a) Improvement compared to pre-implant.
b) Improvement from 3 to 6 mo.s post-implant.

TABLE 4

Cochlear implant users' and their relatives' participation in intervention, follow-up, fine-tuning and fine-tuning sessions.

Participation rate in intervention,	Intervention group (N = 10)	Control group (N = 7)
AVST intervention at CI-Centre		
CI user participation:		
Rate, n (%)	10 (100.0)	-
Sessions, n, median (range)	10.0 (7-10)	-
Relatives' participation:		
Rate, n (%)	10 (100.0)	-
Sessions, n, median (range)	9.0 (5-10)	-
Standard follow-up at CI Centre		
CI user participation:		
Rate, n (%)	-	7 (100.0)
Sessions, n, median (range)	-	2.0 (-)
Relatives' participation:		
Rate, n (%)	-	2 (28.6)
Sessions, n, median (range)	-	2.0 (-)
Local standard intervention		
CI user participation:		
Rate, n (%)	10 (100.0)	7 (100.0)
Sessions, n, median (range)	8.0 (3-17)	8.0 (3-25)
Relatives' participation:		
Rate, n (%)	3 (30.0)	3 (42.9)
Sessions, n, median (range)	3.0 (1-7)	5.5 (5-6)
Standard CI fine-tuning sessions, CI user participation		
Rate, n (%)	10 (100.0)	7 (100.0)
Sessions, n, median (range)	4.0 (3-4)	4.0 (3-4)
Extra CI fine-tuning sessions, CI user participation		
Rate, n (%)	8 (80.0)	4 (57.1)
Sessions, n, median (range)	2.0 (1-5)	2.5 (1-3)

AVST = auditory verbal skills training; CI = cochlear implant.

dition best aided in noise. The intervention group showed improved HINT scores over time. At three months, there was a significant improvement in performance in quiet; and after six months, there was a significant improvement in performance in noise. The control group also improved over time, and the scores in the test condition best aided in noise (sentence score) were significantly better after three months.

Table 2 shows the CI users' median ratings in each subdomain in the NCIQ. The intervention group improved significantly in basic and advanced sound perception, activity and social interaction after three months and again in basic sound perception after six months of CI use. In the control group, significant improvements were seen in basic sound perception, self-esteem, activity and social interaction after three months and in advanced speech perception after six months. No significant improvement in speech production was seen in either group.

There were no significant differences between the groups when comparing the NCIQ outcome scores at three and six months.

Participation in intervention, follow-up and cochlear implant fine-tuning sessions

Table 4 shows the CI users' participation in intervention and the degree of participation of their relatives at the CI-Centre and at their local Communication Centre (CC). Table 4 also shows the CI users' follow-up and CI fine-tuning sessions at the CI-Centre. In the intervention group, nine CI users participated in ten AVST sessions and one CI user only participated in seven sessions due to lack of motivation. The degree of the relatives' participation in AVST was high in the intervention group, as five relatives participated in every session and five participated in five to eight sessions.

All CI users participated in local standard intervention at the local CC. There was no difference in how many sessions CI users in the groups received at their local CC; and the range in number of sessions varied in both groups. Most sessions at the local CC were without participation of relatives. In the intervention group, only three out of ten relatives participated in 1-7 sessions. In the control group, three out of seven relatives participated in 5-6 sessions.

All CI users had 3-4 standard CI fitting sessions at the CI Centre. More CI users in the intervention group than in the control group had a need for extra fine-tuning sessions. These extra sessions were mostly hearing pathologist-initiated and involved increasing the sound level, improving sound quality and technical support.

DISCUSSION

As no validated method for adult hearing intervention after CI exists, the intervention used in this study was based on the AVT techniques and strategies as a first approach to this study field. The AVT approach is used in the paediatric population in adult-child interactions. In the AVST intervention, specific AVT techniques and strategies were chosen as they could be used in adult-adult interactions to enhance the quality of the auditory input.

Positive evaluations of being enrolled in the AVST rehabilitation programme were received from the participants (both the CI users and their relatives) before, during and after the intervention period.

Improvements in speech understanding and QoL were seen in both groups over time, but no differences were seen between the groups. That no differences were seen between the groups may partly be due to the small sample size in combination with the fact that the heterogeneous groups had significant differences pre-implant. A power analysis and hence a bigger sample size should be used in future studies to be able to detect any differences in outcome due to the described audi-

tory verbal intervention. The timeframe for this study and the duration of the intervention might have been too short to reveal significant auditory improvement owing to changes in cortical reorganisation because of auditory stimulation and training. Also, differences in hearing technology use and settings could affect the results as speech testing was performed with CI alone and in the best aided condition. In this study, the best-aided condition was either CI alone, bimodal use or binaural CI.

The CI users in the intervention group received more fine-tuning caused by a need for sound level or quality adjustment or a need for technical support. Extra fine-tuning could affect the results positively as the functioning of the CI was expected to improve with extra fine-tuning, which should be controlled for in future studies. This study points to a general need for more fine-tuning of the processor in the initial six months of CI use. In the AVST sessions, the hearing pathologists were in closer contact with the CI users and could guide them more closely in terms of when fine-tuning was needed.

CONCLUSIONS

The AVST intervention was successfully applied in the clinical setting at the East Danish CI-Centre. The majority of the relevant CI-users and their relatives were willing to participate. Ten of 17 patients wished to follow the AVST intervention with a relative and the feedback was positive.

Improvements in speech understanding and QoL were seen in the intervention and control group over time, but no differences were seen between the groups. This might be due to factors such as a small number of participants and a variety in pre-implant differences and technology use in the two groups. Further studies should investigate this study field to enable the future use of evidence-based and validated methods for CI intervention.

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