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The French National Cochlear Implant Registry (EPIIC): cochlear implantation in adults over 65 years old.

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Abstract

Objectives: To analyze the performance of cochlear implants in French patients aged 65 and over, implanted between 2012 and 2016, using data from the French national registry for cochlear implants (EPIIC).

Materials and methods: The French national registry incorporates patient data from before implantation and for three years after implantation, stratified in different age groups (18- 39, 40-64 years, 65-74 years and > 75 years). Here we assessed the latter two categories. Hearing was assessed using mono- and di-syllabic words in a silent background. The Category of Auditory Performance (CAP) scale was also implemented and subjects took the Abbreviated Profile of Hearing Aid Benefit (Aphab) questionnaire.

Results: The population aged over 65 accounted for 38% (n = 1193) of the 3178 adult implanted patients. The performances for mono- and disyllabic words in silence, the CAP scores and the APHAB questionnaire answers for ease of communication, background-noise and reverberation were dramatically improved at one year post-implantation (p <0.0001 for each score) and remained stable between one and three years thereafter. The percentage improvement was similar across all age groups. The scores for loud-noise intolerance did not change after cochlear implantation in any age group.

Conclusion: Cochlear implants improve hearing and communication in subjects aged 65 and over, with comparable efficiency to that achieved in younger subjects. Cochlear implantation should thus be proposed whenever hearing aids provide only limited benefit. However, between 2012 and 2016, cochlear implantation was given to less than 1% of the French population aged 65 and over with profound deafness.

Keywords : elderly subject, cochlear implant, Aphab, CAP, intelligibility

Introduction

On the first of January 2018, 20% of French people were over 65 years-old and 9% were over 75 (source INSEE). The prevalence of severe to profound deafness in this age-group is poorly documented. In the 'Disability-Health' survey of 2008, based on questionnaires sent to 39,000 French subjects, 6.5% of patients aged 65 to 75 and 16.7% of over-75s have severe or total hearing impairment [1]. International cohort studies, where the hearing was assessed by pure tone audiometry, found a variable but slightly lower prevalence: 2.2% in the Australian Blue Mountains cohort in patients over 65, and about 1% profound deafness prevalence in an American cohort [2-4].

Cochlear implantation is recommended to help improve communication in cases of severe-to-profound hearing loss, where intelligibility is <50% at 60 dB even with appropriate hearing aids. In France, cochlear implantation is undertaken in the elderly, without upper age limit, after a psycho-cognitive assessment (www.has-sante.fr). However, no guidance is given as to how to carry out this assessment, and it is for each referral center to recommend cochlear implantation if it considers the cognitive impairment severe enough. Centers generally consider lifestyle, family support, overall health and patient motivation. Bilateral implantation is equally undertaken in the elderly, whether it is simultaneous, when there is a risk of cochlear ossification, or sequential, to avoid temporary loss of hearing-aid benefit on the opposite side causing a loss of autonomy.

Numerous studies show that cochlear implantation, benefits young and elderly deaf people alike, conferring an improvement in quality of life, but also in cognitive functions [4-20].

The aim of our study was to analyze the benefit provided by unilateral cochlear implantation in a cohort of French patients aged 65 and over, implanted since 2012, using data from the EPIIC registry (Post-Registration Study of Reimbursed Cochlear Implant Products and Services).

Material and methods

Data, from the EPIIC multicenter registry of unilateral cochlear implanted adult patients, collected in France between 1st January 2012 and 31st December 2016, were analyzed retrospectively. Bilateral implanted patient data and re-implanted patients were excluded from the analysis. The analyzed data included the following three categories: clinical, auditory performance and communication.

- 1) **Clinical information.** This was divided into age, sex, etiology of deafness and complications. Five etiological categories were available in the registry: meningitis, otosclerosis, cochlear malformation, 'unknown' and 'other'.
- 2) **Auditory performance. Hearing of mono and disyllabic words** at 60 dB. Hearing tests were performed in silence. The tests were conducted in optimal conditions for hearing, that is to say, with hearing aids before implantation if used, and with the contralateral hearing aid after implantation if it was always used.
- 3) **Communication** was evaluated on the CAP (Category of Auditory Performance) scale [21] and through the Aphab questionnaire (Abbreviated Profile of Hearing Aid Benefit) [22]. CAP scores were assessed by the audiologist with 8 possible rankings from 0 to 7 (Box 1). The Aphab is a self-taken questionnaire, of 24 items divided into 4

subgroups (ease of communication, background noise, reverberation, aversion), which evaluates communication in various scenarios, both in silence and noise. Individual question scores are calculated on a scale from A ("Always") To G ("Never") and the overall test is expressed in % (Appendix). The higher the score, the more difficult the communication.

We analyzed auditory performance and communication assessment data from before implantation and at 1, 2 and 3 years after the date of implantation surgery. Relatively little data was available at the four-year follow-up so this was not analyzed. The implant devices came from four companies: Oticon Medical, Med-el, Cochlear and Advanced Bionics.

Quantitative variables were expressed as mean \pm standard deviation with minimums and maximums. Patient performance was analyzed by age group: 18-39, 40-64, 65-75 and over 75. The evolution of the quantitative variables and the comparison of the performances between the age groups were analyzed by a 1-factor analysis of variance (Anova) with a Tukey post-test. The qualitative variables were expressed in % and compared by a Chi-square test (χ^2). The results were considered significant with a p value <0.05 . The analysis was performed with GraphPad Prism 7.0 software.

Results

Here we studied a registry of 3,178 implanted adult patients amongst whom 1,193 (38%) were aged 65 and over. Patients were 65-94 years old at the time of implantation with an average of 74 ± 6.1 years. Nineteen patients reported being in full employment at the time of implantation, including four patients over 75. The demographic characteristics of the full registry compared

by age group (18-39, 40-64, 65-74, 75 and over) are reported in Table 1. The causes of deafness by age-group are detailed in Figure 1. The post-operative complication rate was 6.3% in subjects aged 65 and over, a value similar to that of other age groups (Table 1). Among the complications reported in the registry, the percentage of dizziness leading to re-hospitalization (2%) and skin complications (1%) was similar for the different age groups.

Before implantation, hearing of di-syllabic and mono-syllabic words in a silent background was similar in all age groups, with the exception of those of the youngest patients (18-39 years) whose performance was poorer than the 65-74 age-group (disyllabic words: $22 \pm 26.6\%$ versus $27 \pm 28.9\%$, $p < 0.05$; monosyllabic words: $18 \pm 23.1\%$ versus $24 \pm 24.0\%$, $p < 0.05$).

One year after implantation, auditory performance was significantly improved compared to pre-implantation in all age groups, with a similar benefit of cochlear implantation across the age groups (Figure 2). In the 65-74 year olds improvements were $+41 \pm 35.0\%$ (disyllabic, $p < 0.0001$) and $+33 \pm 29.2\%$ (monosyllabic, $p < 0.0001$). In the over-75s improvements were $+36 \pm 34.4\%$ (disyllabic, $p < 0.0001$) and $+35 \pm 28.4\%$ (monosyllabic, $p < 0.0001$).

Between one and three years' post-implantation, hearing ability was stable regardless of age-group or test used, whether mono- or di-syllabic (Figure 2). At one year post-implantation, CAP scores were also significantly better than pre-implantation scores in all age groups ($p < 0.0001$). Between one and three years' post-implantation, the results were stable regardless of the age group (Figure 3).

Before implantation, the Aphab scores for ease of communication, background noise, and reverberation were similar across age groups. At one year post-implantation, scores were significantly improved in all age groups ($p < 0.0001$ for each age group and subdomain), then remained stable between the one and three-year time-points (Figure 4). The improvement in scores for each subdomain was comparable across age groups, except for the improvement in reverberation, which was lower in patients over 75 than in those aged 18 to 39 years (-23 ± 27.02 versus -11.5 ± 27.5 , $p < 0.05$). This reflects greater discomfort in reverberation situations in older subjects. Before implantation, there was less aversion, or intolerance, to noise in younger subjects (18 to 39 years), who had lower scores (25.2 ± 26.9) in this test, compared to subjects in all other age groups: 40 to 64 years (35.0 ± 30.9 , $p = 0.001$), 65 to 74 years (35.7 ± 31.3 , $p < 0.005$) and over-75s (35.1 ± 29.4 , $p < 0.01$). Implantation did not change these aversion scores in any age group.

Discussion

It has become possible to analyze the auditory performances in a large cohort of patients thanks to the follow-up of patients who received cochlear implants in France in the framework of a national registry that has been running since 2011. These patients have been rehabilitated with the latest internal parts and latest-generation processors. The large number of subjects has also allowed comparison of four different age groups. Implants considerably improved hearing of words in a silent background in the over-65s, as much as in younger subjects. Similar improvements were even observed in patients aged 75 and over.

Our results corroborate previous studies, of smaller numbers of patients, with similar performances between different groups. In most studies the maximum age was 65 or 70 years [5, 6, 8, 13, 14, 19]. Some studies in the aged, however, found poor hearing performance in both silent [11, 12, 18] and noisy backgrounds [11, 13, 14, 16, 19, 20].

Hearing performance in noisy situations was not recorded in the French registry for unilaterally implanted patients. However, subjective assessment of CI through the Aphab questionnaire found a very significant improvement when there is background noise or several people speaking at the same time, or in situations of reverberation (conference, theater, church, etc.), without major difference between age groups. Intolerance to loud noises (work, traffic, alarms, etc.), which is lower in the youngest subjects, is not modified after cochlear implantation for any age-group, despite the noise-treatment algorithms in the latest-generation processors. As expected we found a similar rate of CI complications between older and younger subjects [7, 14]. However, the complication rate was lower than that previously reported in the literature, probably due to lack of some details in the French registry, especially in the recording of minor complications [23].

We surmise that cochlear implantation should be offered to the elderly in all cases where hearing aids have limited benefit, i.e. where they confer $\leq 50\%$ intelligibility in silence. Cochlear implantation performs stably over the long term, even in the elderly [17, 24]. All studies show an improvement in the quality of life, in the short and long term, despite the aging of the population [17, 25]. Numerous epidemiological studies have shown that deafness significantly increases the risk of cognitive impairment and dementia, which is five-fold higher in cases of severe-to-profound deafness [26-29]. A French multicenter prospective study with

a 7-year follow-up post-implantation found that auditory rehabilitation by cochlear implant improved short-term cognitive function and curbs cognitive decline in the long term. This is thus an additional argument for proposing cochlear implantation in this age group, even where cognition is already impaired before implantation [15, 17] .

On the 1st January 2018, 13 million French people were over 65 (source INSEE). If we estimate that 2% of these people have severe-to-profound bilateral deafness (<https://drees.solidarites-sante.gouv.fr>), this means there are approximately 260,000 potential French recipients of cochlear implants over the age of 65. It is therefore striking that in the 4 years of this study, which covers all patients in France, only 1193 patients were implanted, or just a half-of-one-percent of the profoundly deaf over-65-year-old population. Since cochlear implantation is covered by Social Security in France at all ages, the only limitation to implantation in the elderly who desire it should be an exceptionally poor general condition, or if they live in an institution or conditions that render treatment and monitoring difficult. Better information for health professionals and the public authorities on the consequences of the absence of hearing rehabilitation and the benefit provided by the cochlear implant, is essential, to drastically reduce the number of elderly that are and weakened and isolated by the severity of their deafness.

Conflict of interest: The authors declare that they have no conflict of interest.

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Figure 1: Distribution of etiologies by age group. The number of patients, by etiologies and age group, are indicated under the graph.

Figure 2: Hearing Performance in silence at 60 dB for (A) two-syllable and (B) one-syllable words, before implantation and at 1, 2 and 3 years after implantation. Average performances \pm SD are given. The number of data points per year and age group is shown on the x-axis.

Figure 3: Scores on the CAP (Category of Auditory Performance) scale, before implantation and at 1, 2 and 3 years after implantation. The number of data points per year and age-group is shown on the x-axis.

Figure 4: Score from the Ahab (Abbreviated Profile of Hearing Aid Benefit) questionnaire, by age-group, before implantation and at 1, 2 and 3 years after implantation. Scores are expressed as mean \pm SD; note, the lower the score the better the communication. The number of data per year and age group is indicated in the key.

Appendix: Ahab (Abbreviated Profile of Hearing Aid Benefit) Questionnaire [22]

APHAB – FORMULAIRE A

Instructions:

Veillez sélectionner les réponses qui correspondent le mieux à votre expérience quotidienne. Si vous n'avez pas connu la situation que nous décrivons, essayez d'imaginer comment vous répondriez dans une situation similaire que vous connaissez.

- A** Toujours (99%)
- B** Presque Toujours (87%)
- C** En général (75%)
- D** La moitié du temps (50%)
- E** Parfois (25%)
- F** Rarement (12%)
- G** Jamais (1%)

	Non appareillé	Appareillé
1. Quand je suis dans un supermarché plein de monde et que je parle avec la caissière, j'arrive à suivre la conversation.	A B C D E F G	A B C D E F G
2. Quand j'écoute une conférence, beaucoup d'informations sont perdues pour moi.	A B C D E F G	A B C D E F G
3. Des bruits inattendus, tels qu'un détecteur de fumée ou une sonnerie d'alarme, me sont pénibles.	A B C D E F G	A B C D E F G
4. J'ai de la peine à suivre une conversation quand je suis chez moi, avec quelqu'un de ma famille.	A B C D E F G	A B C D E F G
5. J'ai de la peine à comprendre les dialogues au cinéma ou au théâtre.	A B C D E F G	A B C D E F G
6. Quand j'écoute les informations en voiture et que des membres de ma famille sont en train de parler, j'ai de la peine à entendre les nouvelles.	A B C D E F G	A B C D E F G
7. Quand je dîne avec plusieurs personnes et que j'essaie d'avoir une conversation avec l'une d'entre elles, j'ai de la peine à comprendre ce qu'elle dit.	A B C D E F G	A B C D E F G
8. Les bruits de la circulation sont trop forts.	A B C D E F G	A B C D E F G
9. Quand je parle avec quelqu'un à travers une grande pièce vide, je comprends ses paroles.	A B C D E F G	A B C D E F G
10. Quand je suis dans un petit bureau, en train de poser ou de me faire poser des questions, j'ai de la peine à suivre la conversation.	A B C D E F G	A B C D E F G
11. Quand je suis dans une salle de cinéma ou de théâtre et que les gens murmurent et froissent du papier autour de moi, j'arrive quand même à comprendre le dialogue.	A B C D E F G	A B C D E F G
12. Quand j'ai une conversation avec un ami et que nous parlons doucement, j'ai de la peine à comprendre.	A B C D E F G	A B C D E F G

Appendix

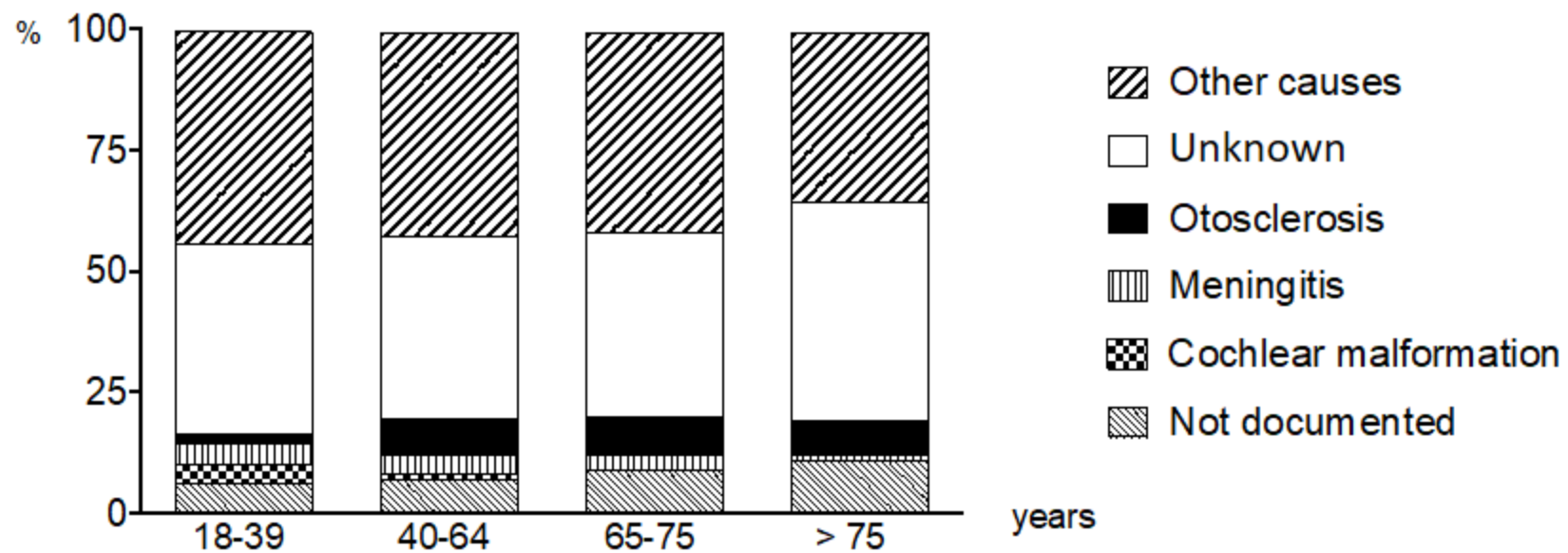
Box 1. CAP (Category of Auditory Performance) scale

- 0 Unaware of surrounding sounds
- 1 Aware of surrounding sounds
- 2 Responds to speech sounds
- 3 Identifies the sounds of the environment
- 4 Discriminates some speech sounds without lip reading
- 5 Understands common sentences without lip reading
- 6 Understands conversation without lip reading
- 7 Use the telephone with a known contact

Table 1: Demographic characteristics of the population

Distribution by age group: n (%)		
	18-39 years old	541 (17 %)
	40-64 years	1442 (45 %)
	65-74 years	726 (23 %)
	≥ 75 years	469 (15 %)
Age: average ± SD (year)		
	18-39 years old	30 ± 1.0 years
	40-64 years	54 ± 1.0 years
	65-74 years	70 ± 2.9 years
	≥ 75 years	80 ± 3.8 years
Post-operative complications: n (%)		
	18-39 years old	49 (9.1 %)
	40-64 years	120 (8.3 %)
	65-74 years	47 (6.5 %)
	≥ 75 years	28 (6.0 %)
Etiologies of deafness in people over 65: n (%) ^a		
	Cochlear malformation	4 (0.3 %)
	Meningitis	29 (2.4 %)
	Otosclerosis	95 (7.8 %)
	Unknown	498 (40.7 %)
	Other	472 (38.6 %)
	Not entered in the register	127 (10.2 %)

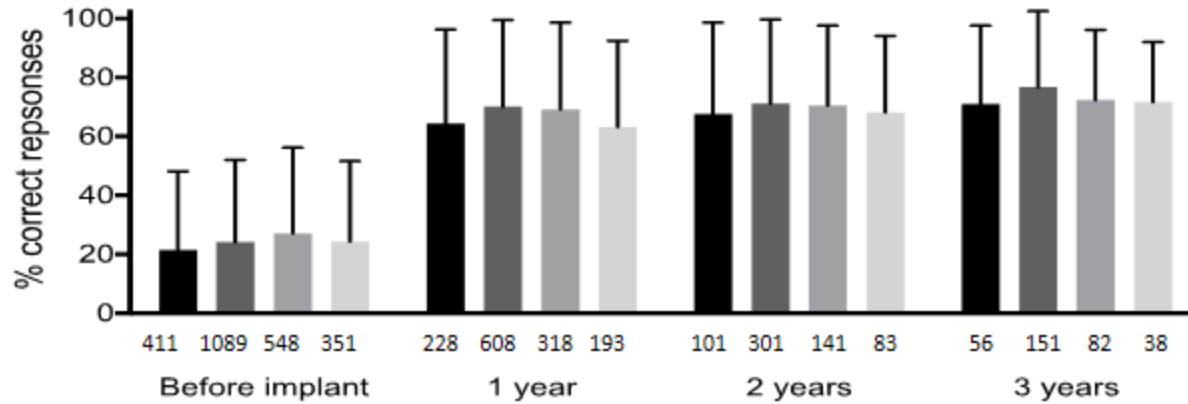
a. Several possible etiologies



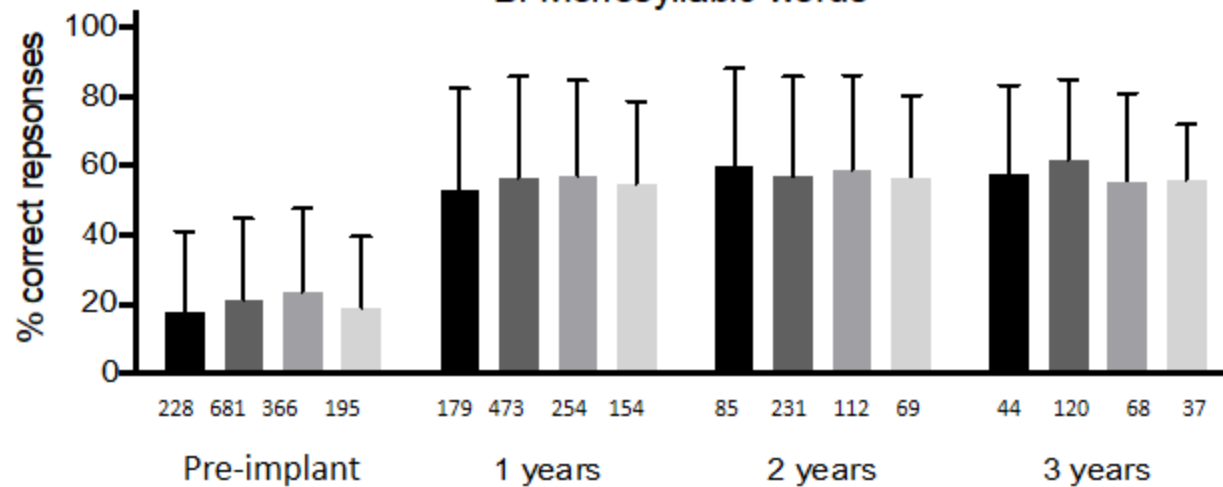
Other causes	246	627	304	168
Unknown	218	570	283	215
Otosclerosis	10	105	62	33
Meningitis	24	63	25	4
Cochlear malformation	23	16	3	1
Unknown	36	110	71	54

18-39 years
 40-64 years
 65-74 years
 ≥ 75 years

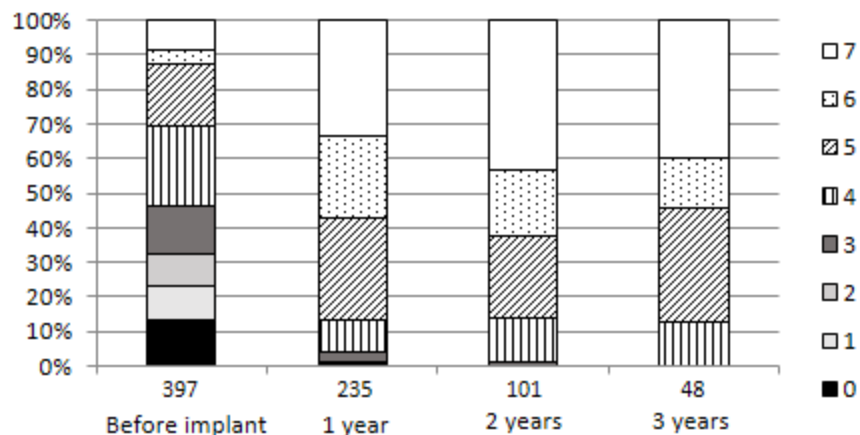
A. Disyllabic words



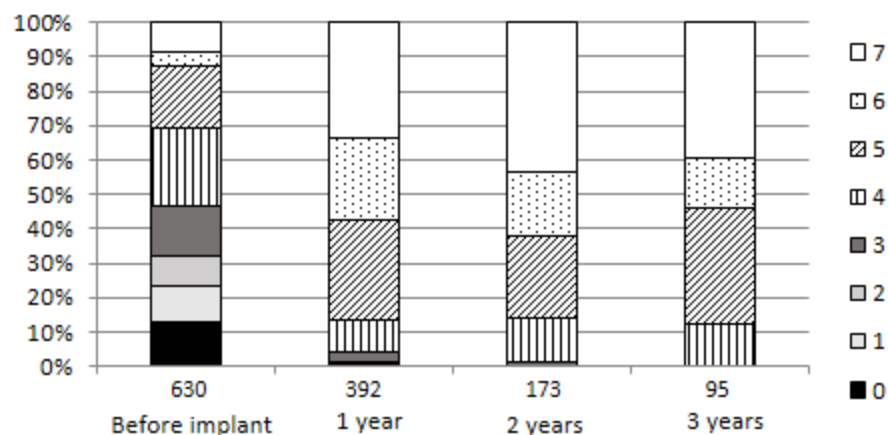
B. Monosyllabic words



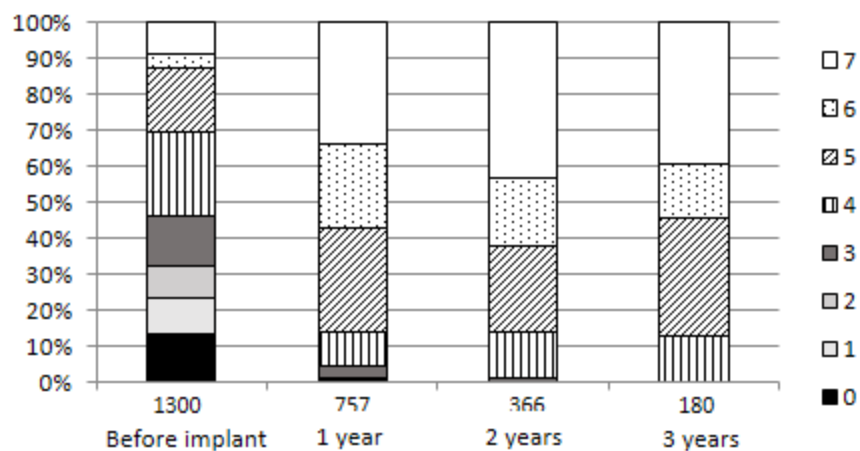
> 75 years



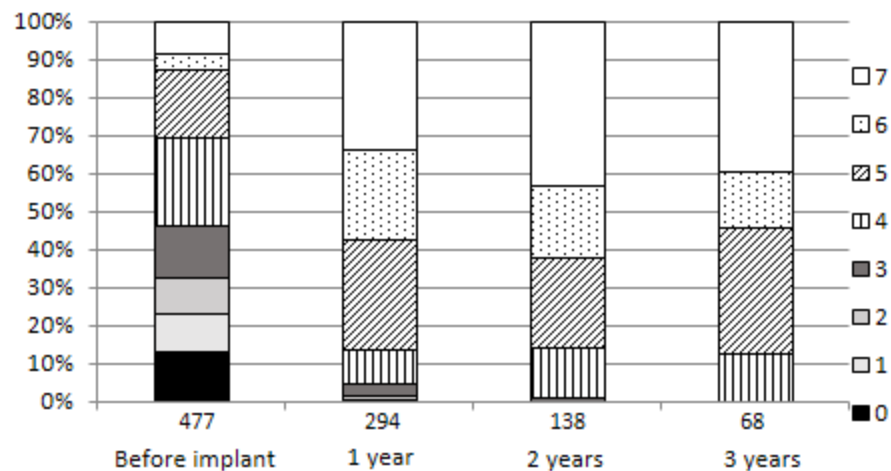
65-74 years



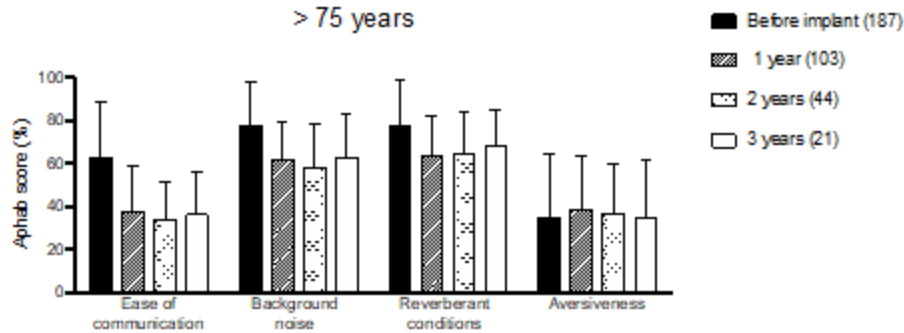
40-64 years



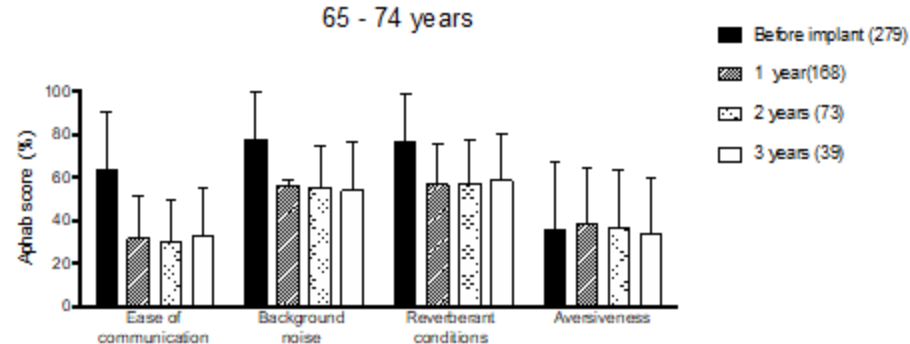
18-39 years



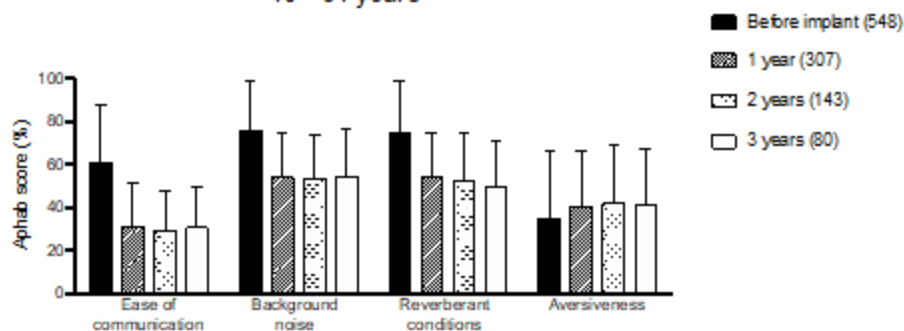
> 75 years



65 - 74 years



40 - 64 years



18 - 39 years

