# Audiological Outcomes of Cochlear Implantation in Ramathibodi Hospital

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***Objective:*** *To evaluate the outcomes of the patients at 1-year post cochlear implantation emphasized on audiological outcomes.*
***Materials and Method:*** *Retrospective study of hearing response follow in three, six, and 12 months of 143 ears undergoing cochlear implantation between 1995 and 2009. Only 77 ears were found to have the completed data for analysis. Deaf patients were categorized into five groups in which they were operated by four different cochlear implant devices. The two parameters used to evaluate the outcomes included the aided response (AR), assessing the hearing threshold of cochlear implant user, and the Categories of Auditory Performance (CAP) which assess their auditory receptive abilities.*
***Results:*** *Demographic data showed male: female ratio was 4:3. Age ranged from 2 to 68 years. Although the aided hearing threshold among five groups of deafness showed improvement without statistical difference, the auditory ability showed significance higher score in post-lingual than pre-lingual deaf patients ($p < 0.05$). Patients with aural communication prior to surgery also showed higher auditory ability than those without aural communication ($p < 0.05$). The outcomes of CAP were analyzed among patients operated with different cochlear implant devices. Users with Pulsar CI 100 Opus 2, HiRes 90K Auria, and HiRes 90 K Harmony showed better auditory ability than with Combi 40+ Tempo+. Both mean scores of AR and CAP were higher at six and 12 months than at three months. At 12 months the scores were higher than at six months ($p < 0.05$).*
***Conclusions:*** *Cochlear implant surgery resulted in good hearing, however the improvement of speech understanding need more time to practice. Patients using cochlear implant at 12 months showed more improvement of hearing and performance than those using for less than 12 months.*

***Keywords:*** *Cochlear implant, Audiological outcome, Aided response, Categories of auditory performance*

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Cochlear implantation is safe and effective for treatment of profound deaf in adults and children. It increases the likelihood of children to remain in mainstream education and seems to improve academic performance[1,2]. In the previous report[3], we described the results of the cochlear implantation emphasized on the clinical and surgical outcomes. The present study will report the audiological outcomes at 1-year post cochlear implantation between groups of deafness and between different cochlear implant devices in Ramathibodi Hospital.

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## Material and Method

This was a retrospective review of hearing response of 143 ears operated with cochlear implantation in Ramathibodi Hospital between 1995 and 2009. Since the hearing outcomes should be assessed in continuum of three, six, and 12 months, only 77 ears were found to have the completed data but large enough for statistical analysis. The present study was approved by the committee on human rights related to research involving human subjects at Faculty of Medicine Ramathibodi Hospital, Mahidol University.

***Patient selection***

Seventy-seven cochlear implant patients were categorized into five groups.

Group 1: Pre-lingual deaf patients age 0-3 years

Group 2: Pre-lingual deaf patients with aural communication age 4-7 years

Group 3: Pre-lingual deaf patients with aural communication age $\geq$ 8 years

Group 4: Pre-lingual deaf patients without aural communication

Group 5: Post-lingual deaf patients

***Cochlear implant devices***

Prior to surgery, the eligible patients and their relatives were invited to attend the cochlear implant advisory clinic, which gave the basic knowledge of the cochlear implant devices and surgical method including risks and complications[3]. They were allowed to make their own decision in choosing the currently available models at that time in the hospital.

From the present study, the recruited patients were operated with four different cochlear implant devices.

Device 1: Combi 40+ cochlear implant system and the Tempo+ behind the ear speech processor from MED-EL (MED-EL, Innsbruck, Austria)

Device 2: Pulsar CI 100 cochlear implant system and the Opus 2 behind the ear speech processor from MED-EL (MED-EL, Innsbruck, Austria)

Device 3: HiRes 90K cochlear implant system and the Auria behind the ear speech processor from AB (Advanced Bionics Corporation, Valencia, CA, U.S.A.)

Device 4: HiRes 90K cochlear implant system and the Harmony behind the ear speech processor from AB (Advanced Bionics Corporation, Valencia, CA, U.S.A.)

***Audiological evaluation***

Patients undergoing cochlear implantation were evaluated with two audiological parameters: Aided response (AR) and Categories of Auditory Performance (CAP). AR is the hearing sensitivity threshold after aided with cochlear implant. The score of AR represents the average threshold of four frequencies (500, 1000, 2000, and 4000 Hertz), therefore the lower the score of AR, the better the patient's hearing. CAP is the functional performance evaluation that was developed as a part of assessment of the Nottingham Cochlear Implant Program and has been designed as a global assessment of auditory receptive abilities[4]. The present study used the version that has been modified for the Thai language[5]. The score of CAP comprises of a nonlinear scale on which patient's developing auditory abilities can be rated in eight categories of increasing difficulty from level 0-7, which ranges from no awareness of sound to using the telephone[5]. The scores of AR and CAP were assessed at three, six and 12 months.

***Statistical analysis***

Statistical analysis was done using descriptive statistics and two-way repeated measure ANOVA. Due to variation of sphericity assumed, the present study used Mauchly's test of sphericity: epsilon (Huynh-Feldt) for rebustness of statistical hypothesis testing[6]. A p-value of less than 0.05 was considered statistical significant difference.

**Results**

***Demographic results of 77 cases*** (Table 1)

The results showed that there were 44 male and 33 female. Candidates' age range from 2 to 68 years old (median age 11 years old). Pre-operative evaluation revealed 17 patients were pre-lingual deaf young children age 0-3 years, 24 patients were pre-lingual deaf patients who used hearing aids and aural communication in which 16 cases were children 4-7 years and eight cases were 8 years and over, 23 cases were pre-lingual deaf patients without aural communication, these included those using sign language, and lastly 13 cases were post-lingual deaf patients.

Among the MED-EL cochlear implant devices, 34 and 17 ears received the Device 1 (Combi 40+ Tempo+) and Device 2 (Pulsar CI 100 Opus 2), respectively. Among the AB cochlear implant devices, 10 ears received the Device 3 (HiRes 90K Auria) and 16 ears received the Device 4 (HiRes 90K Harmony).

***The results of AR***

***The scores of AR on different groups of deafness***

The mean scores of AR between five groups of deaf patients were similar and were not statistical significant difference. However when compared the mean scores of AR between three time-intervals at three, six, and 12 months, it revealed that at least two time-intervals had statistical difference ($p < 0.001$). The mean scores of AR at six and 12 months were

**Table 1.** Demographic data of patients (n = 77)

| Demographic data | Frequency | Percentage |
|---|---|---|
| Gender | | |
| Male | 44 | 57.1 |
| Female | 33 | 42.9 |
| Age (age range from 2 years old to 68 years old; median age 11 years old) | | |
| Groups of deaf patients | | |
| Gr. 1: pre-lingual deaf patients 0-3 years | 17 | 22.0 |
| Gr. 2: pre-lingual deaf patients with aural/oral communication 4-7 years | 16 | 20.8 |
| Gr. 3: pre-lingual deaf patients with aural/oral communication $\geq$ 8 years | 8 | 10.4 |
| Gr. 4: pre-lingual deaf patients without aural/oral communication | 23 | 29.9 |
| Gr. 5: post-lingual deaf patients | 13 | 16.9 |
| Type of devices | | |
| MED-EL device | | |
| Combi 40+ Tempo+ (device 1) | 34 | 44.1 |
| Pulsar CI 100 Opus 2 (device 2) | 17 | 22.1 |
| AB device | | |
| HiRes 90K Auria (device 3) | 10 | 13.0 |
| HiRes 90K Harmony (device 4) | 16 | 20.8 |

shown to be significant lower than at three months, and at 12 months was significant lower than at six months ($p < 0.05$) (Table 2). There was no interactive effect between the time-intervals and groups of deaf patient on the mean scores of AR.

***The scores of AR on different cochlear implant devices***

The mean scores of AR between patients operated with different cochlear implant devices were also analyzed and found that at least two types of device worn showed significantly difference ($p < 0.01$). At 12 months, patients operated with Device 4 was found to have lower mean scores of AR than those with Device 1 and patients operated with Device 3 and 4 had lower mean scores of AR than those with Device 2, which were both statistically significant ($p < 0.05$) (Table 3).

When compared the mean scores of AR between the time-intervals at 3, 6, and 12 months among patients operated with different cochlear implant devices, it revealed that at least two time-intervals had statistical difference ($p < 0.001$). The mean scores of AR at six and 12 months were significant lower than at three month and at 12 months was significantly lower than at six month ($p < 0.05$) (Table 3). There was no interactive effect between the time-intervals and groups of patients operated with different cochlear implant devices on the mean scores of AR.

***The results of CAP***

***The scores of CAP on different groups of deafness***

At 12 months, the mean scores of CAP between five groups of deaf patients revealed that at least two groups had statistical difference ($p < 0.01$). Patients in group 5 had mean scores of CAP significantly higher than group 1, 2 and 4 ($p < 0.05$) and patients in group 3 had mean scores of CAP significantly higher than group 4 ($p < 0.05$) (Table 2).

When compared between the time-intervals among five groups of deaf patients at three, six, and 12 months, it revealed that at least two time-intervals had statistical difference ($p < 0.001$). It was shown that the mean scores of CAP at six and12 months were significantly higher than at three months and at 12 months was significantly higher than at six months ($p < 0.05$) (Table 2). There was no interactive effect between the time-intervals and groups of deaf patients on the mean scores of CAP.

***The scores of CAP on different cochlear implant devices***

The mean scores of CAP between patients operated with different cochlear implant devices showed that at least two types of device worn had mean scores of CAP significantly different ($p < 0.01$). It revealed that patients operated with cochlear implant Device 2, 3, and 4 had mean scores of CAP significantly higher than those using Device 1 ($p < 0.05$) (Table 3).

**Table 2.** Mean and standard deviation scores of AR at 3, 6 and 12 months between groups of deaf patients

| Groups of patients (n) | Scores of AR | | | Scores of CAP | | |
|---|---|---|---|---|---|---|
| | 3 mts | 6 mts | 12 mts | 3 mts | 6 mts | 12 mts |
| Gr. 1: pre-lingual deaf patients 0-3 years (17) | 32.65 ± 3.121 | 30.00 ± 5.303 | 28.53 ± 6.559 | 1.94 ± 1.298 | 2.59 ± 1.770 | 3.59 ± 1.770 |
| Gr. 2: pre-lingual deaf patients with aural/oral communication 4-7 years (16) | 30.31 ± 3.400 | 27.19 ± 4.820 | 26.88 ± 6.801 | 1.88 ± 1.500 | 2.75 ± 2.017 | 4.00 ± 2.191 |
| Gr. 3: pre-lingual deaf patients with aural/oral communication ≥ 8 years (8) | 33.75 ± 5.175 | 28.75 ± 4.432 | 28.13 ± 5.303 | 2.50 ± 1.069 | 3.63 ± 1.506 | 4.75 ± 1.669 |
| Gr. 4: pre-lingual deaf patients without aural/oral communication (23) | 31.09 ± 3.679 | 27.17 ± 3.639 | 24.57 ± 4.980 | 1.35 ± 0.714 | 2.04 ± 1.107 | 3.13 ± 1.359 |
| Gr. 5: post-lingual deaf patients (13) | 32.69 ± 5.633 | 29.23 ± 7.316 | 26.92 ± 5.604 | 3.15 ± 1.819 | 4.54 ± 1.984 | 5.46 ± 1.664 |
| Total | 31.82 ± 4.129 | 28.31 ± 5.105 | 26.69 ± 5.939 | 2.01 ± 1.400 | 2.90 ± 1.847 | 3.97 ± 1.878 |

p = 0.003 (Gr. 1 vs Total)
p = 0.009 (Gr. 2 vs Total)
p = 0.021 (Gr. 3 vs Total)
p = 0.000 (Gr. 4 vs Total)

p = 0.000 (3 mts vs 6 mts)
p = 0.014 (6 mts vs 12 mts)
p = 0.000 (3 mts vs 12 mts)
p = 0.000 (3 mts vs 6 mts)
p = 0.000 (6 mts vs 12 mts)
p = 0.000 (3 mts vs 12 mts)

**Table 3.** Mean and standard deviation scores of AR at 3, 6 and 12 months between groups of patients operated with different cochlear implant devices

| Cochlear implant devices | Scores of AR | | | Scores of CAP | | |
|---|---|---|---|---|---|---|
| | 3 mts | 6 mts | 12 mts | 3 mts | 6 mts | 12 mts |
| Combi 40+ Tempo+ (34) | 32.94 ± 3.915 | 29.26 ± 4.627 | 27.65 ± 6.768 | 1.65 ± 1.098 | 2.06 ± 1.455 | 3.03 ± 1.547 |
| Pulsar CI100 Opus 2 (17) | 32.65 ± 3.587 | 30.88 ± 4.755 | 28.24 ± 5.286 | 2.47 ± 1.736 | 3.35 ± 2.178 | 4.35 ± 2.149 |
| HiRes 90K Auria (10) | 31.00 ± 3.944 | 27.00 ± 5.869 | 23.50 ± 4.743 | 2.70 ± 1.567 | 4.20 ± 1.398 | 5.70 ± 0.949 |
| HiRes 90K Harmony (16) | 29.06 ± 4.171 | 24.38 ± 3.594 | 25.00 ± 4.472 | 1.88 ± 1.310 | 3.38 ± 1.784 | 4.50 ± 1.633 |
| Total (77) | 31.82 ± 4.129 | 28.31 ± 5.105 | 26.69 ± 5.939 | 2.01 ± 1.400 | 2.90 ± 1.847 | 3.97 ± 1.878 |

p = 0.002 (Combi 40+ Tempo+ vs HiRes 90K Harmony)
p = 0.032 (Pulsar CI100 Opus 2 vs HiRes 90K Harmony)
p = 0.002 (HiRes 90K Auria vs HiRes 90K Harmony)

p = 0.014 (Combi 40+ Tempo+ vs HiRes 90K Harmony)
p = 0.001 (Pulsar CI100 Opus 2 vs HiRes 90K Harmony)
p = 0.033 (HiRes 90K Auria vs HiRes 90K Harmony)

p = 0.000 (3 mts vs 6 mts)
p = 0.000 (6 mts vs 12 mts)
p = 0.000 (3 mts vs 12 mts)
p = 0.000 (3 mts vs 6 mts)
p = 0.000 (6 mts vs 12 mts)
p = 0.003 (3 mts vs 12 mts)

The mean scores of CAP between the time-intervals at three, six, and 12 months among patients operated with different cochlear implant devices revealed that at least two time-intervals had statistical difference ($p < 0.001$). The mean scores of CAP were significant higher at six and 12 months than at three months and at 12 months was significant higher than at six months ($p < 0.05$) (Table 3). Additionally, it was shown to have an interactive effect between the time-intervals and groups of patients operated with different cochlear implant devices on the mean scores of CAP ($p < 0.001$).

**Discussion**

Patients from the present study had a wide range of age from children to adult, the median being 11 years old. Each had different level of linguistic ability prior to surgery. Most small children of pre-lingual deaf were speechless while older age groups with aural rehabilitation or post-lingual deaf adults were able to speak and understand of some degree. Therefore, to select the appropriate evaluation tests for every patient under different status was difficult since it depended on the age and level of linguistic ability prior to the surgery. There was a variety of methods in evaluation of audiological benefits after cochlear implantation. Both AR and CAP were the most appropriate tests for this study. While AR evaluated the hearing sensitivity threshold, CAP would evaluate the auditory performance ability. At the time of fitting the sound processor which was the first time to hear with cochlear implant, AR would allow the abrupt improvement of hearing threshold while CAP need longer time period of practice listening to reach maximum performance. Therefore, the evaluation by CAP had to follow the progression along a continuum certain period.

The hearing threshold with cochlear implant had shown an improvement in every group of deafness without statistical significance. For the auditory ability assessment, patients with post-lingual deaf had apparently shown significant higher scores of CAP at all time periods than those who were pre-lingual deaf. This revealed that those who had linguistic prior to surgery would be more beneficial from cochlear implant. Those with aurally educated prior to surgery also showed the higher scores of CAP than those without. This could be anticipated that those who were using aural communication with hearing aids prior to surgery would be more understandable with speech after fitting with the cochlear implant sound processor and may have the superior result than those without.

The improvement of both means scores of AR and CAP at six and12 months had confirmed the importance of the aural rehabilitation program after cochlear implantation.

From the present study, the comparison of audiological outcomes between different cochlear implant devices revealed that there were improvements of hearing threshold in users with HiRes 90K Harmony than with Combi 40+ Tempo+, and with HiRes 90K Auria and HiRes 90K Harmony than with Pulsar CI 100 Opus 2. In terms of auditory ability performance, cochlear implant users with Pulsar CI 100 Opus 2, HiRes 90K Auria and HiRes 90 K Harmony, which were the three newer models, achieved better performance than with Combi 40+ Tempo+. Since Combi 40+ Tempo+ was the older model, therefore, the newer ones appeared to be more beneficial.

The present study of mean scores of AR showed no interactive effect between the time-intervals and groups of deaf patients, or between the time-intervals and different cochlear implant devices. The present study of mean scores of CAP showed different results. Although there was no interactive effect between the time-intervals and groups of deaf patients, there was an interactive effect between the time-intervals and different cochlear implant devices. It revealed that at the first 3-month period of rehabilitation, the mean scores of CAP were highest in order from patients who were using HiRes 90K Auria, Pulsar CI 100 Opus 2, HiRes 90K Harmony and Combi 40+ Tempo+, respectively. At 6-month period of rehabilitation, the pattern of mean scores of CAP had changed and were found to be highest in order from patients who were using HiRes 90K Auria, HiRes 90K Harmony, Pulsar CI 100 Opus 2 and Combi 40+ Tempo+, respectively, and resumed the same at 12 months. This interactive effect documented the significantly developing ability of HiRes 90K Harmony users at the second and third periods of evaluation. As mention before, CAP, which evaluated patient's auditory ability, need longer time period of practice listening to reach the maximum performance. The scores of CAP evaluated at the early post-operative period appeared to be similar to the ability prior to the surgery and the more reliable outcomes would be at the 6-month and 12-month evaluations.

The functional success of cochlear implant surgery depends on both the recipient status and technology used of each cochlear implant system. The

technology alone did not guarantee the given benefit because there were many biological factors that could affect how well the patient can hear and understand sound. This hearing potential depended on patient's individual basic biological factor, such as the anatomy of cochlea, age of hearing loss, the duration of deafness, amount of previous hearing prior to surgery, and hearing nerve survival. Therefore, to enable the best benefits of cochlear implant both good candidate, good surgery and good technology were joined together.

## Conclusion

The actual benefit of cochlear implant users was the ability to understand speech not only the hearing of sound. Post-lingual deaf patients achieved better performance than those with pre-lingual deafness. Pre-lingual deaf patients with aural communication prior to surgery achieved better performance than those who were not using aural communication. All models of cochlear implant resulted in improved ability to hear sound, however the users of Pulsar CI 100 Opus 2, HiRes 90K Auria and HiRes 90 K Harmony showed better auditory ability performance than the Combi 40+ Tempo+ users. HiRes 90K Harmony users showed a significantly developing ability performance at the second and third trimester periods of evaluations. The good outcome can be anticipated from the good candidate, good technology, and enough length of rehabilitation.

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## Potential conflicts of interest

None.

## References

1. Eisenberg LS, Johnson KC, Martinez AS, Cokely CG, Tobey EA, Quittner AL, et al. Speech recognition at 1-year follow-up in the childhood development after cochlear implantation study: Methods and preliminary findings. Audiol Neurootol 2006; 11: 259-68.
2. Connor CM, Hieber S, Arts HA, Zwolan TA. Speech, vocabulary, and the education of children using cochlear implants: oral or total communication? J Speech Lang Hear Res 2000; 43: 1185-204.
3. Kasemsuwan L, Cheewaruangroj W, Tungkeerati-chai J, Bhongmakapat T, Thawin C, Lertsukprasert K, et al. Fourteen-years experience with cochlear implantation in Ramathibodi Hospital. J Med Assoc Thai 2010; 93: 1399-405.
4. Archbold S, Lutman ME, Marshall DH. Categories of Auditory Performance. Ann Otol Rhinol Laryngol Suppl 1995; 166: 312-4.
5. Thawin C, Kanchanalarp C, Lertsukprasert K, Cheewaruangroj W, Khantapasuantara K, Ruencharoen S. Auditory performance of cochlear implant children aged 2-5 years. J Med Assoc Thai 2006; 89: 1923-7.
6. Ho R. Handbook of univariate and multivariate data analysis and interpretation with SPSS. New York: Chapman&Hall; 2006.

# การศึกษาผลการได้ยินในผู้ป่วยที่ผ่าตัดใส่อุปกรณ์รับเสียงฝังหูชั้นใน (cochlear implant) ในโรงพยาบาลรามาธิบดี

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***วัตถุประสงค์:*** *เพื่อศึกษาผลการได้ยิน ติดตามผลในเวลา 1 ปี ภายหลังการผ่าตัดใส่อุปกรณ์รับเสียงฝังหูชั้นใน (cochlear implant) ในโรงพยาบาลรามาธิบดี*

***วัสดุและวิธีการ:*** *เป็นการศึกษาย้อนหลังผลการได้ยินทุก 3, 6 และ12 เดือน ใน143 หู ที่ได้รับการผ่าตัดอุปกรณ์รับเสียงฝังหูชั้นใน ตั้งแต่ปี พ.ศ. 2538 ถึงปี พ.ศ. 2552 มีจำนวน 77 หู ที่สามารถเก็บข้อมูลได้ครบ และมากพอที่จะทำการศึกษา แบ่งผู้ป่วยออกเป็น 5 กลุ่ม ตามการสูญเสียการได้ยิน อุปกรณ์รับเสียงฝังหูชั้นในที่ได้รับการผ่าตัดมีทั้งหมด 4 รุ่น ในการศึกษานี้ศึกษาจากการวิเคราะห์ค่า aided response of hearing (AR) ซึ่งวัดระดับการได้ยินเสียงและค่า Categories of Auditory Performance (CAP) ซึ่งเป็นการประเมินความสามารถปฏิบัติจากการได้ยิน*

***ผลการศึกษา:*** *ผลการศึกษาพบอัตราส่วนชาย:หญิง เท่ากับ 4:3 อายุตั้งแต่ 2 ถึง 68 ปี ผลการศึกษาพบว่าระดับการได้ยินดีขึ้นในผู้ป่วยทุกกลุ่ม ผลการประเมินความสามารถปฏิบัติจากการได้ยินมีค่าสูงกว่าอย่างมีนัยสำคัญทางสถิติในผู้ป่วยกลุ่มที่สูญเสียการได้ยินภายหลังมีภาษาแล้วเมื่อเปรียบเทียบกับกลุ่มที่สูญเสียการได้ยินก่อนมีภาษาและในกลุ่มที่สูญเสียการได้ยินก่อนมีภาษาที่ได้รับการฝึกด้วยการพูดและฟังมากก่อนเปรียบเทียบกับกลุ่มที่สูญเสียการได้ยินก่อนมีภาษาแต่ไม่ได้รับการฝึกการพูดและฟัง สำหรับในผู้ป่วยที่ได้รับการผ่าตัดใส่อุปกรณ์รับเสียงฝังหูชั้นในรุ่นต่าง ๆ พบว่าผลการประเมินความสามารถปฏิบัติจากการได้ยิน มีค่าสูงอย่างมีนัยสำคัญทางสถิติในผู้ป่วยที่ใช้ Pulsar CI 100 Opus 2, HiRes 90K Auria, and HiRes 90 K Harmony มากกว่าผู้ที่ใช้ Combi 40+ Tempo+ ค่าคะแนนทั้ง AR และ CAP สูงขึ้นในการติดตามผลที่ 6 และ 12 เดือน กว่าช่วงระยะ 3 เดือนแรก และ ที่ 12 เดือน มีค่าคะแนนสูงกว่าที่ 6 เดือน อย่างมีนัยสำคัญทางสถิติ*

***สรุป:*** *การผ่าตัดใส่ประสาทหูเทียมให้ผลการได้ยินเสียงที่ดีขึ้น แต่การที่จะเข้าใจคำพูดจำเป็นต้องใช้เวลาการบำบัดการพูดและการฟังภายหลังการผ่าตัดมีความสำคัญเป็นอย่างยิ่ง ยิ่งนานวันยิ่งทำให้การพูดและฟังดีขึ้น*