# Implantação coclear bilateral em adultos: abordagem sequencial ou simultânea?

Artigo Original


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## Resumo

Introdução: Os benefícios da implantação coclear (IC) bilateral encontram-se bem estabelecidos na literatura. No entanto, não existe um consenso sobre qual o melhor timing de implantação nos adultos, se simultaneamente ou de forma sequencial.
Materiais e métodos: Estudo retrospetivo que incluiu doentes submetidos a implantação bilateral de implantes cocleares de 2020 a julho 2024. Os doentes foram divididos em dois grupos, consoante a implantação bilateral fosse sequencial (SeqCI) ou simultânea (SimCI).
Resultados: A duração média total da cirurgia para o grupo SimCI foi 10,4 minutos mais curta do que a duração combinada para o grupo SeqCI. Os doentes do grupo SimCI tiveram um internamento hospitalar 1,74 dias mais curto e necessitaram de menos 15,34 consultas de seguimento do que os doentes do grupo SeqCI ($p<0,05$). Não foram detetadas diferenças significativas nos resultados auditivos entre os grupos, exceto na inteligibilidade máxima do discurso, que foi significativamente superior no grupo SimCI ($p<0,05$).
Conclusão: No nosso estudo a implantação coclear bilateral simultânea demonstrou reduzir significativamente o tempo de internamento hospitalar e o número de consultas pós-operatórias em comparação com a implantação sequencial, sem aumento do número de complicações.


Palavras-chave: implantação coclear; surdez; implantação bilateral; cirurgia; adultos


## Introduction

Cochlear implantation (CI) is a well-established intervention for adults with severe to profound hearing loss. Bilateral CI has shown significant benefits over unilateral CI by improving binaural hearing abilities, sound localization and speech perception, particularly in noisy environments[1,2,3]. These advantages are related to psychoacoustic effects such as head shadow, binaural summation, and squelch effect[4]. Despite these advantages, there is still no consensus on the optimal approach for bilateral implantation

in adults, whether it should be performed simultaneously or sequentially. Simultaneous bilateral cochlear implantation (SimCI) has already been shown to be safe and efficient in pediatric populations. This approach reduces surgical and anesthetic risk, the duration of bilateral auditory deprivation and optimizes resources without compromising audiometric outcomes[5,6]. In contrast, sequential bilateral cochlear implantation (SeqCI) has traditionally been more widely performed in adults, often due to a combination of clinical, logistical, and financial considerations. In adults with profound bilateral hearing loss, sequential implantation has been preferred to prioritize rehabilitation of the worst-performing ear first and perform an outcome assessment before proceeding to the second implant. Additionally, some patients may experience adequate functional hearing with a unilateral CI combined with a contralateral hearing aid, delaying or negating the perceived need for a second implant[7]. Finally, financial and healthcare system constraints also contribute significantly to the preference for SeqCI in adults [8]. By analyzing key factors like surgical duration, hospital stay, follow-up consultations, and postoperative hearing outcomes, the objective of this study is to evaluate the safety, audiometric outcomes, and procedural efficiency of simultaneous versus sequential bilateral cochlear implantation in adults.

## Materials and Methods

This retrospective controlled study was approved by the research ethics committee of a tertiary referral medical center. The study was conducted according to the Declaration of Helsinki. All participants voluntarily signed an informed consent. This retrospective study included adult patients who underwent bilateral cochlear implantation at a cochlear implant reference center between January 2020 and July 2024. Patients were divided into two groups based on whether they received sequential bilateral implantation (SeqCI) or simultaneous bilateral implantation (SimCI). The exclusion criteria were patients who had undergone CI outside the study period, those with insufficient clinical data, or those under 18 years of age at the time of implantation. Insufficient clinical data were defined as incomplete medical records, particularly missing or incomplete operative reports and key perioperative documentation required for outcome analysis. The choice between sequential and simultaneous bilateral implantation was not randomized and was based on a shared decision-making process. This decision resulted from a multidisciplinary team evaluation, considering clinical suitability and candidacy for SimCI, together with patient preference and informed consent regarding the proposed implantation strategy.

Data for this study were collected through a detailed review of patient medical records. Key variables recorded included demographic data, surgical duration, hospitalization time, the number of follow-up consultations, associated complications, and audiological outcomes. The surgical duration was classified into total procedure time (TPT) and surgical time (ST). TPT was defined as the time from anesthesia induction to the end of anesthesia, measured in minutes. ST was defined as the time from surgical incision to the completion of the surgery. The number of follow-up consultations was recorded, including both medical consultations and non-medical consultations, such as those with audiologists, speech therapists, and psychologists, within the cochlear implant reference center context. Audiological outcomes were evaluated through tonal and vocal audiograms. The pure tone average (PTA) was calculated based on the hearing loss in dB at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. In addition, speech intelligibility in quiet was measured from a loudspeaker positioned in front of the patient, using the standard Portuguese disyllabic word test. Statistical analysis was conducted using the Statistical Package for the Social Sciences 21.0® (IBM SPSS Statistics; Armonk, NY, USA). Fisher's exact test was used to evaluate categorical variables, and a p-value of $\leq 0.05$ was considered statistically significant.

The distribution of continuous variables was tested for normality using the Shapiro-Wilk test. For normally distributed data, the Welch's t-test was applied to compare means between the congenital and acquired cholesteatoma groups. For non-normally distributed data, the Mann-Whitney U test was used to compare medians between the two groups.

## Results

The **SimCI** group had a smaller sample size, consisting of 4 patients who received 8 cochlear implants. The **SeqCI** group, with 31 patients, underwent a total of 62 implantations. In terms of gender distribution, the **SimCI** group was evenly split between men and women (50%), while the **SeqCI** group had a higher proportion of women (61.3%). The mean age for the **SimCI** group was slightly higher at 53.75 ± 7.68 years, compared to the **SeqCI** group, which had a mean age of 50.94 ± 16.14 years, but not statistically significant ($p > 0.05$). The patient characteristics are described in Table 1.

### Surgical Time

In the SeqCI group, the mean duration of the first cochlear implant procedure was 134.3 ± 47.2 minutes for the total procedure time (TPT) and 112.2 ± 45.21 minutes for the surgical time (ST). For the second cochlear implant in this group, the TPT averaged 118.65 ± 16.44 minutes, and the ST was 91.2 ± 19.40. The mean combined TPT for both cochlear implants was 252.9 ± 37.39 minutes, while the mean combined ST was 203.4 ± 45.20 minutes. In the SimCI **group,** the mean TPT was 242.5 ± 35.59 minutes, and the mean ST was 213.25 ± 38.26 minutes. Although the TPT for the SimCI group was, on average, 10.4 minutes shorter than the combined TPT for the SeqCI group, this difference was not statistically significant ($p > 0.05$), nor was there a significant difference in ST between the two groups.

### Hospital Stay and Follow-Up

The length of hospital stay was significantly shorter for patients in the SimCI group, with an average of 2,00 ± 0.95 days compared to 3.74 ± 0.82 days for the SeqCI group ($p < 0.05$). Regarding follow-up consultations, patients in the SeqCI group attended an average of 34.84 ± 12.86 consultations, while those in the SimCI group attended an average of 19.5 ± 5.26 consultations. This represented a statistically significant reduction of 15.3 consultations for the SimCI group compared to the SeqCI group ($p < 0.05$).

**Table 1**
Characteristics of participants in the study

| | SeqCI | SimCI |
|---|---|---|
| **Patients (n)** | 31 | 4 |
| **Female / Male** | 19/12 | 2/2 |
| **CI** | 62 | 8 |
| **Age at inclusion (years)** | 50.94 ± 16.14 | 53.75 ± 7.68 |
| **Pre-op PTA (dB)** | 102.67 ± 13.78 | 97.00 ± 19.82 |
| **Pre-op SRT (dB)** | 85.00 ± 7.07 | - |
| **Pre-op maximum intelligibility (%)** | 20.52 ± 32.55 | 3,33 ± 32.16 |
| **TPT (minutes)** | 252.9 ± 37.39 | 242.5 ± 35.59 |
| **ST (minutes)** | 203.4 ± 45.20 | 213.25 ± 38.26 |
| **Hospital Stay (days)** | 3.74 ± 0.82 | 2,00 ± 0.95 |

CI: cochlear implant; PTA: pure tone average; SRT: speech recognition threshold; TPT: total procedure time; ST: surgical time.

### Audiometric evaluation

#### Preoperative

Before implantation, the SeqCI group demonstrated a mean PTA threshold of 102.67 ± 13.78 dB in the implanted ears, compared to 97.00 ± 19.82 dB in the SimCI group. The SeqCI group also had a mean speech recognition threshold (SRT) of 85.00 ± 7.07 dB, while no measurable SRT was detected in the SimCI group. Regarding maximum intelligibility, the SeqCI group achieved a mean score of 20.52 ± 32.55%, compared to 3,33± 32.16% in the SimCI group. Additionally, the intensity at maximum intelligibility was higher in the SeqCI group (92.14 ± 5.67 dB) than in the SimCI group (26,66 ± 41,31 dB). Statistically significant differences were observed for maximum intelligibility, which was higher in the SeqCI group ($p < 0.05$).

#### Postoperative

After implantation, the SeqCI group achieved a mean PTA threshold of 35.5 ± 7.52 dB, a mean SRT of 30.61 ± 11.60 dB, and a mean maximum intelligibility score of 85.45± 25.58 %. The average intensity at maximum intelligibility in this group was 43.81 ± 13.22 dB. In the SimCI group, the mean PTA threshold was 36.17 ± 13.15 dB, the mean SRT was 33.75 ± 4.79 dB, and the mean maximum intelligibility score reached 100%. The intensity at maximum intelligibility averaged 45 ± 5.77 dB. No significant differences were detected between the groups except for maximum intelligibility, which was significantly higher in the SimCI group ($p < 0.05$). Table 2 shows the comparison of the audiometric outcomes between the two groups.

### Complications

No complications, surgical or non-surgical, were identified in the SeqCI and SimCI groups.

## Discussion

The aim of this study was to evaluate the safety, audiometric results, and efficiency of the SimCI versus SeqCI procedure in adults. The results highlight relevant differences between the two approaches, while revealing some common advantages. SimCI demonstrated clear procedural advantages, with shorter hospital stays and fewer follow-up consultations compared to SeqCI. The patients in the SimCI group had, on average, a 1.74-day shorter hospital stay and attended 15.3 fewer follow-up consultations compared to the SeqCI group. These results highlight SimCI's potential to significantly reduce the logistical and resource burden on both patients and healthcare systems. Although the total procedural time (TPT) for SimCI was marginally shorter than the combined times for SeqCI, the difference was not statistically significant. This efficiency aligns with prior research showing SimCI to be a time- and cost-effective approach in adult populations[9].

Both SimCI and SeqCI groups experienced significant improvements in audiometric outcomes post-implantation, confirming the efficacy of bilateral cochlear implantation in restoring functional hearing. Postoperative pure tone audiometry (PTA) thresholds and speech recognition thresholds (SRT) were similar between the groups, reflecting comparable overall benefits. However, the SimCI group demonstrated significantly

**Table 2**
Audiometric outcomes after cochlear implantation

| | SeqCI | SimCI |
|---|---|---|
| **Post-op PTA (dB)** | 35.5 ± 7.52 | 36.17 ± 13.15 |
| **Post-op SRT (dB)** | 30.61 ± 11.60 | 33.75 ± 4.79 |
| **Post-op maximum intelligibility (%)** | 85.45± 25.58 | 100 |

PTA: pure tone average; SRT: speech recognition threshold;

better postoperative maximum intelligibility scores, achieving 100% compared to 85.45% in the SeqCI group. While this difference may suggest an inherent advantage of SimCI it is important to interpret this result cautiously. This study was retrospective in design, lacking randomization, which introduces the possibility of selection bias. Patients chosen for SimCI may have been selected as optimal candidates for simultaneous implantation due to factors such as fewer comorbidities or higher motivation for rehabilitation. These factors could have contributed to the superior maximum intelligibility scores observed in the SimCI group. Future prospective, randomized studies are needed to confirm whether this advantage persists when selection bias is controlled. Both SimCI and SeqCI were found to be safe, with no significant differences in the frequency of surgical or non-surgical complications. This finding is reassuring, especially given prior concerns about the potential risks of longer surgical durations and anesthesia exposure in SimCI for adult patients with comorbidities.

SimCI has shown promise in improving procedural efficiency, although there is still limited evidence regarding its outcomes compared to sequential implantation in adults. Some studies indicate that simultaneous implantation has been shown to provide early and stable benefits, potentially avoiding the risks of auditory deprivation in the second ear and reducing surgical costs and hospitalization durations[9,10]. Furthermore, long-term studies suggest that SimCI results in stable or improved speech perception and sound localization over time[11]. Studies comparing the two approaches suggest that simultaneous implantation may result in better binaural integration and symmetric auditory outcomes, especially when the interval between sequential implants is prolonged. However, individual factors such as age, duration of hearing loss, and health status may influence the choice of approach. Patient preference and financial considerations also play a significant role in decision-making. Further research is necessary to evaluate the long-term auditory and quality-of-life outcomes associated with both strategies. The decision should involve a multidisciplinary team and a patient-centered approach to ensure optimal results tailored to individual needs and circumstances. Financial and healthcare system constraints also contribute significantly to the preference for SeqCI in adults. Sequential implantation allows for staged surgical and rehabilitation costs, which can be easier to justify in health systems where funding for a second cochlear implant in adults may not be universally available[8]. Additionally, there are concerns that simultaneous bilateral implantation might be associated with increased risks due to longer surgical durations and anesthesia times[9]. These risks, while not supported by all studies[9], are often considered for adults who may have comorbidities or advanced age, further justifying a sequential approach.

The retrospective nature of this study is a key limitation, as it inherently lacks randomization and introduces selection bias. Additionally, the sample size of the SimCI group was small compared to the SeqCI group, further limiting the generalizability of the findings. Moreover, this study did not include a systematic assessment of vestibular function or sound localization abilities, outcomes that are particularly relevant in bilateral cochlear implantation and could differ between simultaneous and sequential approaches. These aspects warrant further investigation in future prospective studies. All these factors highlight the need for caution when extrapolating these results to broader adult populations. Despite these limitations, the study's findings suggest that SimCI offers compelling advantages in procedural efficiency and speech intelligibility, making it an attractive option for appropriately selected candidates. However, SeqCI remains a valuable approach, particularly in cases where staged rehabilitation aligns better with patient-specific clinical, financial, or logistical considerations.

## Conclusions

This study highlights the safety and effectiveness of simultaneous and sequential bilateral cochlear implantation in adults, with notable distinctions in procedure efficiency and postoperative outcomes. SimCI offers superior benefits in reducing hospital stays, follow-up visits and achieving maximum speech intelligibility. These advantages make it an attractive option for adult patients. However, SeqCI continues to serve as an effective and adaptable approach, particularly in contexts where individual patient needs or healthcare system constraints require phased interventions. Future research should aim to further explore long-term outcomes, including patient satisfaction, cost-effectiveness, and quality of life metrics, to better inform clinical decision-making and optimize care pathways for adults undergoing bilateral cochlear implantation.

### Conflict of Interest

The authors declare that they have no conflicts of interest related to this article.

### Data Confidentiality

The authors affirm that all patient data were handled in accordance with institutional protocols regarding data confidentiality and publication.

### Protection of Human and Animal Subjects

The authors declare that all procedures were conducted in compliance with the regulations of the Institutional Ethics and Clinical Research Committee and in accordance with the principles of the Declaration of Helsinki of the World Medical Association.


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### Data Availability

There are no publicly available datasets associated with this work.

### Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to verify statistical inconsistencies and spelling errors. After using this tool, the authors reviewed and edited the content as necessary and take full responsibility for the final version of the manuscript.

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