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Functional and surgical outcomes in subtotal petrosectomy and Cochlear implants in patients with chronic otitis media

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Objective: To evaluate the functional and surgical outcomes of cochlear implantation (CI) following subtotal petrosectomy (SP) in chronic otitis media (COM) and compare them with standard CI recipients.

Methods: A retrospective case-control study included 34 adults with postlingual deafness: 17 with COM undergoing SP and simultaneous CI (COM group) and 17 with no middle ear disease (CI group). Audiological performance was assessed by pure-tone audiometry (PTA₅), speech recognition in quiet and in noise (Oldenburg Sentence Test, OLSA), and the Speech, Spatial, and Qualities of Hearing Scale (SSQ).

Results: All surgeries were successful, with only two minor postoperative complications (one EAC closure breakdown, one abdominal hematoma). The analysis of hearing outcomes showed similar results between the two groups in terms of PTA₅ (36.6 vs. 35.6, $p = 0.09$), speech recognition in quiet (74.2 vs. 85.0, $p = 0.07$), speech-in-noise (2.7 vs. 0.7, $p = 0.58$). No significant intergroup differences were found in terms of self-perceived listening disability (SSQ) in the Speech (4.73 vs. 4.80, $p = 0.69$), Spatial (4.22 vs. 4.96, $p = 0.50$), or Qualities (5.17 vs. 5.25, $p = 0.87$) domains. There were no reported cases of disease recurrence, infection, or device extrusion during long-term follow-up (mean 36 months).

Conclusion: Cochlear implantation after SP provides hearing and quality-of-life outcomes comparable to standard CI, confirming its safety and efficacy in COM patients.

KEYWORDS

chronic ear, chronic otitis media, CI, Cochlear implantation, COM, hearing rehabilitation, subtotal petrosectomy

1 Introduction

Chronic otitis media (COM) is a long-standing inflammation of the middle ear, typically associated with tympanic perforation, chronic or recurrent otorrhea, and hearing loss. Two main forms are described: COM with cholesteatoma, characterized by the presence of keratinized squamous epithelium with an erosive behavior toward the surrounding bone structures, and COM without cholesteatoma (Aristegui et al., 2022; Vincenti et al., 2014). Symptoms can include conductive or mixed hearing loss, vertigo, and rarely facial paralysis (Aristegui et al., 2022; Lee et al., 2020). Potential complications can involve the temporal bone (mastoiditis, subperiosteal abscesses, petrositis), the

neck (cervical abscess), or even intracranial structures (meningitis, brain, or cerebellar abscesses, sigmoid sinus thrombophlebitis, hydrocephalus) (Rak et al., 2018).

Management of COM may be conservative, with regular ear toilette and topical medications, or through surgical intervention. In both cases, the primary objective is to achieve dry, and safe ear, and when feasible, a socially useful hearing (Vincenti et al., 2014; Pace et al., 2024). Surgical treatment includes different techniques and approaches, with or without removal of the posterior canal wall. Canal wall up (CWU), and canal wall down (CWD) procedures are selected based on the extent of the disease, the anatomical conditions, and the surgeon's experience. Among these procedures, subtotal petrosectomy (SP), introduced by Fisch and Mattox in the 80s (1988), has emerged as a more radical option reserved for complex or advanced disease. SP is indicated in cases of extensive cholesteatoma, recurrent disease after previous surgeries, or non-serviceable hearing. The technique consists of a complete exenteration of all pneumatic cells of the temporal bone, removal of the canal wall, and middle ear structures, closure of the external auditory canal (EAC), and Eustachian tube, and cavity obliteration, typically with abdominal fat, or other autologous materials (Prasad et al., 2017).

Once considered contraindicated in case of COM, cochlear implantation (CI) has been recently proposed as a valid option for hearing rehabilitation in chronic ears in association with SP, thus creating a closed, dry, and sterile environment, essential for the device protection and post-operative infections prevention (Aristegui et al., 2022; Incesulu et al., 2004). Several studies confirm its safety, low complication rates, and favorable functional outcomes (Canzi et al., 2023; Incesulu et al., 2004; Szymański et al., 2016; Vashishth et al., 2018; Vincenti et al., 2014). Ideal candidates for SP combined with CI include patients with recurrent cholesteatoma, chronic discharging CWD cavities, petrositis, massive labyrinthine fistulas, or refractory chronic infections unsuitable for a traditional approach (Bako et al., 2022; Issing et al., 1998).

When combining SP and CI, two key surgical questions arise timing and the management of the middle ear, and mastoid cavity. SP and CI can be performed simultaneously or as a staged procedure, with a two-stages approach generally recommended in cases of s of active infection, residual cholesteatoma, or diagnostic uncertainty (Incesulu et al., 2004; Jeong et al., 2021). The choice of whether to obliterate the middle ear and mastoid cavity is another critical consideration (Gray and Irving, 1995; Gray et al., 1999), as it may affect postoperative infection risk and access for revision surgery.

The present study aims to evaluate the functional and surgical outcomes of simultaneous cochlear implantation (CI) with subtotal petrosectomy (SP) in patients with chronic otitis media predominantly using a non-obliterative technique, and to compare these outcomes with those of standard CI recipients.

2 Materials and methods

2.1 Ethical consideration

This study adhered to the principles of the Declaration of Helsinki ("World Medical Association Declaration of Helsinki:

Ethical Principles for Medical Research Involving Human Subjects," 2013), and complied with national and institutional ethical guidelines for human research. Ethical approval was granted by the Institutional Review Board of the Policlinico Hospital Consortium in Bari, Italy (approval number 10336/2023CE). All participants provided written informed consent prior to inclusion.

2.2 Study design

A retrospective case-control study of 34 cochlear implantation (CI) adults (> 18 years) treated by the senior author between 2018 and 2022 was conducted. The review included age, gender, indications, audiological results, and post-operative complications.

2.3 Participants and group allocation

Participants were divided into two groups. The COM group included 17 consecutive subjects with chronic otitis media (COM) who underwent cochlear implantation simultaneously with SP for eradication of inflammatory disease. The CI group involved 17 age and sex matched patients without middle ear disease who underwent CI alone for severe to profound bilateral sensorineural hearing loss (SNHL). Diagnosis of COM was based on symptoms persisting for more than 3 months, otomicroscopy findings, and temporal bone computed tomography (CT). Patients with adhesive otitis media, atelectasis, chronic suppurative otitis media (COM), COM with cholesteatoma (CCOM) and those who had previously undergone canal wall-down (CWD) mastoidectomy were included. In the COM group, the middle ear inflammatory status was classified as follows:

- Active: presence of otorrhea and/or granulation tissue or polypoid middle ear/mastoid mucosa at the time of surgery or preoperatively, with ongoing middle ear discharge despite medical therapy.
- Quiescent: dry ear for at least 3 months before surgery, with intact or stable tympanic membrane perforation, no otorrhea and no macroscopic granulation tissue or polypoid change of the middle ear/mastoid mucosa.

Exclusion criteria included age under 18 years, incomplete medical, or audiological records, evidence of inner ear malformations, or retrocochlear pathology on preoperative imaging, and a postoperative follow-up period of less than 12 months.

2.4 Surgical techniques, Cochlear implantation protocol and audiological management

Cochlear implantation was indicated in all cases based on the current standard audiological criteria. Pre-surgery high-resolution computed tomography (CT) and magnetic resonance imaging (MRI) scans showed no evidence of inner ear malformations in all cases. In the CI group, electrode insertion was achieved through a classical transmastoid posterior tympanotomy approach. In the

COM group, cochlear implantation was performed in a single stage, along with subtotal petrosectomy, to create a safe, closed, and dry cavity before electrode insertion. In every case, it consisted of a complete exenteration of all pneumatic cells of the mastoid, removal of the canal wall and middle ear structures, and double-layer blind-sac closure of the EAC. The Eustachian tube was then subjected to a systematic inspection. In the absence of cerebrospinal fluid leakage, a perilymph gusher, or a significant perceived risk of ascending infection from the nasopharynx, the tube was left patent. In only two cases, obliteration with muscular grafts and connective tissue was performed selectively for the indications mentioned above, with the middle ear and mastoid cavity obliterated with abdominal fat. In the remaining 15 subjects, the middle ear and the mastoid cavity were not routinely obliterated, as would typically be expected. All subjects were implanted with a Nucleus multichannel device (Cochlear LTD, Sydney, Australia) using the extended round window (RW) approach and perimodiolar array. A complete array insertion into the cochlea was confirmed intraoperatively via neural response telemetry. In all cases, the round window niche was obliterated with autologous muscle to protect the cochlea and prevent perilymph leakage. An experienced cochlear implant (CI) audiologist programmed the speech processor and optimized the parameters after initial activation to ensure optimal speech understanding in everyday situations. All patients used a cochlear implant with the same Advanced Combination Encoder (ACE)-based strategy. None of the patients discontinued CI use with an average daily use of 15.4 ± 1.5 h.

2.5 Audiologic testing and questionnaires

Unaided and post-implantation pure-tone audiometry was performed in all subjects. The pure-tone average across five frequencies (PTA₅: 0.25, 0.5, 1, 2, and 4 kHz) was calculated to assess hearing thresholds, with all measurements expressed in decibels hearing level (dB HL). PTA₅ was selected for its broader representation of the speech-frequency range compared to PTA₄ (0.5, 1, 2, and 4 kHz), thereby providing a more comprehensive measure of auditory function in quiet conditions.

Speech recognition in quiet conditions was evaluated in a sound field using pre-recorded speech stimuli (60 disyllabic words) administered at 65 dB SPL at 0° azimuth. Scores were reported as the percentage of correctly repeated words.

Speech recognition in noise was measured under best-aided conditions in a sound field. Tests were conducted in a sound-treated chamber using a loudspeaker positioned one meter away from the subject's head (S₀N₀). Stimuli consisted of taped disyllabic words presented at 65 dB SPL with a fixed signal-to-noise ratio (SNR) of +5 dB (cocktail party noise at 60 dB SPL).

Two lists of 50 words (Turrini et al., 1993) were used and speech perception scores were calculated as the percentage of correctly identified words. The randomization of speech lists was implemented across all participants, with the exclusion of repetition within the same session.

Speech comprehension in noise was further examined using the Italian Oldenburg Sentence Test (OLSA) (Puglisi et al., 2015). The evaluation was conducted in an open field with speech and noise

presented from the front (S₀N₀). Background noise was set at 65 dB SPL, and the speech level was adaptively adjusted according to each participant's responses to determine the SNR corresponding to 50%-word recognition (critical SNR). Two lists of 30 sentences were used following one training list.

The Speech, Spatial, and Qualities of Hearing Scale (SSQ) (Gatehouse and Noble, 2004), was administered pre- and post-implantation to assess subjective hearing performance. The SSQ comprises three sections: 14 items assessing speech perception, 17 items evaluating spatial hearing, and 18 items concerning the quality of hearing. Each item is rated on a 0–10 scale, with 0 representing 'unable to hear' and 10 representing 'perfect hearing'. All participants were asked to consider their daily listening conditions in answering an expert physician's question.

2.6 Follow-up and outcome measures

All patients with COM underwent clinical follow-up at 1 week, 1 month, 3 months, 6 months after surgery, and then yearly. Patients at risk for cholesteatoma recurrence, specifically those with a previous history of cholesteatoma surgery or with intraoperative suspicion of residual disease, underwent annual CT follow-up.

Audiological and patient-reported outcome measures were analyzed at the last available follow-up visit after CI activation, with comparable follow-up duration between groups and a mean duration of approximately 36 months.

Local complications of CI were assessed using a score of 0–3 (0, no retraction; 1, retraction with subcutaneous protrusion of the receiver; 2, protrusion of the implant and array; and 3, extrusion of some part of the implant), as reported by Di Bari et al. (2024).

2.7 Statistical analysis

Statistical analysis was conducted using Microsoft Excel for Microsoft 365 MSO (Version 2306), MedCalc software version 22.009 by MedCalc Software Ltd, and the web application Statistics Kingdom 2017. Data distribution was assessed with the Shapiro–Wilk normality test. The mean and standard deviation (SD) were calculated for quantitative variables with a normal distribution. For variables without a normal distribution, the median and 95% confidence interval for the median were determined. The means or medians of independent samples were compared using the Student's *t*-test or the Mann-Whitney U test. The statistical significance was set at $p < 0.05$.

3 Results

3.1 Demographics and audiological presentation of included patients

Demographics and audiological characteristics of both groups are reported in Table 1.

Mean age at implantation was 62.36 years (± 14.91) in the CI group and 63.28 years (± 15.65) in the COM group. Mean follow-up time was 36 months in both groups (SD ± 0.52 in the CI

TABLE 1 Demographic and clinical characteristics of the study cohorts.

	CI group	Com group
Subject number	17	17
Sex	6 (F) 11 (M)	5 (f) 12 (m)
Mean duration of Hearing Loss (Years)	12.9 (SD ± 3.5)	12.7 (SD ± 4.6)
Mean age at CI surgery (years)	62.36 (SD ± 14.91)	63.28 (SD ± 15.65)
Mean follow-up time (months)	36 (SD ± 0.52)	36(SD ± 0.81)
Unaided PTA ₅ (dB HL)		
- CI ear	107.5 (SD ± 8.6)	111.83 (SD ± 7.5)
- Contralateral ear	92.9 (SD ± 8.1)	92.6 (SD ± 7.3)
Speech in quiet at 65 dB	10.2% (SD ± 8.7)	12.5%(SD ± 7.7)
Speech in noise (OLSA test) SRT	15.6 dB SNR (SD ± 3.2)	16.7dB SNR (SD ± 4.8)
Speech, spatial, and qualities of hearing scale (SSQ)		
- Speech	2.3 (SD ± 1.5)	2.2 (SD ± 1.7)
- Spatial	2.2 (SD ± 1.7)	2.7 (SD ± 1.4)
- Qualiteis	2.5 (SD ± 1.4)	2.8 (SD ± 1.8)

No statistically significant differences were observed between the COM and CI groups for any baseline variable (all $p > 0.05$). Cochlear Implantation (CI); Chronic otitis media (COM); Female (F); Male (M); Pure-Tone Average across five frequencies (PTA₅: 0.25, 0.5, 1, 2, and 4kHz).

group and ± 0.81 in the COM group). In all patients of the COM group, hearing loss in the implanted ear was progressive. In the CI group, hearing loss was progressive in 16 patients (94.2%) and sudden in one (5.8%), with variable etiologies, including Ménière's disease ($n = 1$), otosclerosis ($n = 4$), and idiopathic cases ($n = 11$). The unaided PTA₅ in the implanted ear was 107.5 ± 8.6 dB HL in the CI group and 111.83 ± 7.5 dB HL in the COM group. The PTA₅ in the better ear was 92.9 ± 8.1 dB HL in the CI group and 92.6 ± 7.3 dB HL in the COM group. The mean duration of hearing loss (HL), calculated from the patient-reported onset of subjective hearing impairment, was 12.7 years (SD ± 4.6) in the COM group, and 12.9 years (SD ± 3.5) in the CI group.

Overall, no statistically significant differences were observed between the COM and CI groups in terms of age at implantation, duration of hearing loss, unaided PTA₅ in the implanted and contralateral ears, or follow-up duration (all $p > 0.05$), confirming baseline comparability between the two cohorts.

3.2 Surgical results and post-operative complications

The characteristics of the COM group are summarized in Table 2.

Nine patients were initially affected by COM without cholesteatoma and 8 patients by CCOM. Two patients had not undergone previous surgery, while the remaining 15 had been previously treated with CWUT in 10 cases and CWDT in the other 5. During the surgical procedure, the middle ear mucosa appeared quiescent in the majority of cases while an active middle ear disease was identified in three patients. All patients underwent subtotal petrosectomy (SP) with blind sac closure of the EAC, followed by cochlear implantation as a single-stage procedure. The mastoid cavity was obliterated with abdominal fat and the Eustachian tube sealed with muscular grafts and connective tissue in only two cases (Table 2).

One patient, operated on during an active stage of COM without cholesteatoma, experienced a postoperative local complication characterized by cavity infection and failure of the EAC closure 3 months after surgery. The condition was managed with revision surgery and broad-spectrum antibiotic therapy, without the need for CI removal. Additionally, one case of abdominal subcutaneous hematomas was drained under local anesthesia 2 days after surgery. At the last follow-up, only one patient had a grade 1 post-auricular retraction (Di Bari et al., 2024). No recurrences of COM, and CCOM were observed on periodic CT-scan.

3.3 Audiological outcomes

Audiological outcomes were assessed at the last follow-up post-CI activation.

Overall, auditory performance with CI improved in both groups. The aided PTA₅ was 36.6 dB (± 2.5) in the COM group and 35.6 (± 1.05) in the CI group with no significant difference ($p = 0.09$).

The results of speech in quiet at 65 dB (Figure 1) were not different between the two groups (p -value = 0.07): the COM patients recognized 74, 17% (± 20.65) and CI group 85% (± 13.22) of disyllabic words.

Speech comprehension in noise (Figure 2), measured through the OLSA test, was similar between groups, with no significant differences ($p = 0.57$). The COM group reached 50% of the speech recognition threshold (SRT) at an SNR of 2.73 dB (± 2.33), while the CI group had an SNR of 0.73 dB (± 0.83).

Figure 3 shows the comparative analysis between the post-implantation ratings for the two groups across the three domains of the Speech, Spatial, and Qualities of Hearing Scale (SSQ). In the Speech section, the COM group obtained a mean score of 4.73 (± 2.7), vs. 4.80 (± 2.7) of the control group, with no statistically significant difference observed ($p = 0.69$). In the Spatial section, the COM group showed a mean score of 4.96 (± 2.5) compared to the control group's mean score of 4.22 (± 2.3), again with no statistically significant difference ($p = 0.50$). In the Qualities Section, the COM group attained a mean score of 5, 17 ($\pm 2, 3$), while the control group had a mean score of 5,25 (± 1.9), once more without statistical significance ($p = 0.87$).

TABLE 2 Characteristics of COM group undergoing subtotal petrosectomy and cochlear implant surgery.

Subject #	Chronic middle ear disorder	Middle ear inflammatory status at surgery	Previous middle ear surgery	Cavity and ET obliteration	Post-operative complications
1	COM	Active	NA	yes	
2	CCOM	Quiescent	CWD (4)	no	
3	CSOM	Quiescent	CWD (4)	no	
4	COM	Quiescent	rCDW	no	
5	CCOM	Active	CWU (2)	no	
6	CSOM	Active	CWU	no	EAC closure breakdown, cavity infection
7	COM	Quiescent	CWU	no	
8	COM	Quiescent	CWU (2)	no	
9	COM	Quiescent	CWU	no	
10	CCOM	Quiescent	CWD (2)	no	
11	COM	Quiescent	CWU	no	
12	CCOM	Quiescent	NA	yes	
13	COM	Quiescent	CWU	no	
14	COM	Quiescent	CWU	no	
15	COM	Quiescent	CWU	no	
16	CCOM	Quiescent	CWU (2)	no	
17	COM	Quiescent	CWD	no	

COM, simple Chronic Otitis Media; CCOM, Chronic Otitis Media with Cholesteatoma; CSOM, Chronic Suppurative Otitis Media; EAC, External auditory canal; CWD, Canal Wall Down mastoidectomy; rCWD, radical Canal Wall Down mastoidectomy; CWU, Canal Wall Up mastoidectomy; NA, not available; ET, Eustachian Tube; EAC, External Auditory Canal.

4 Discussion

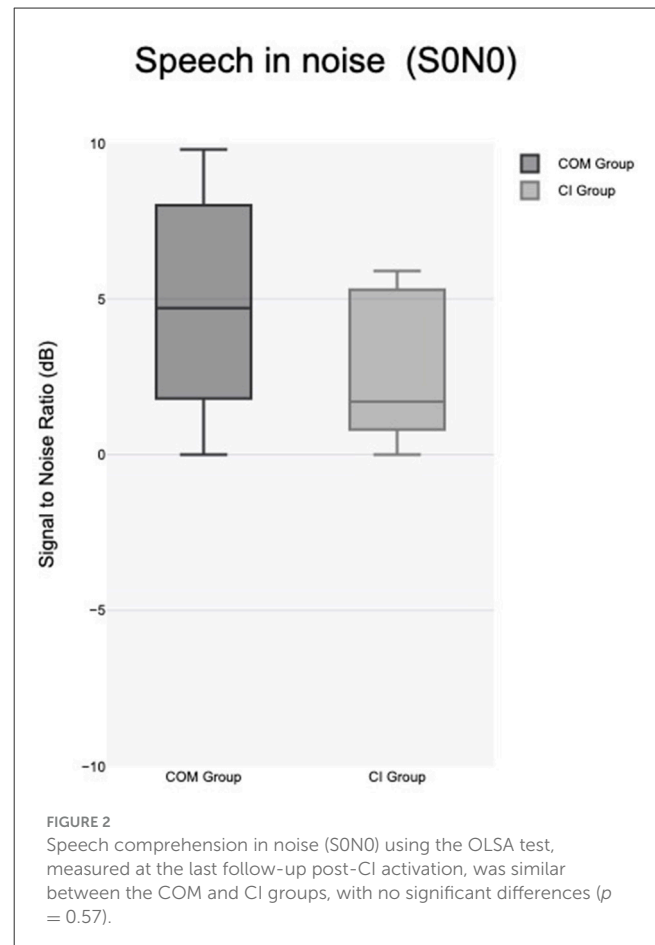
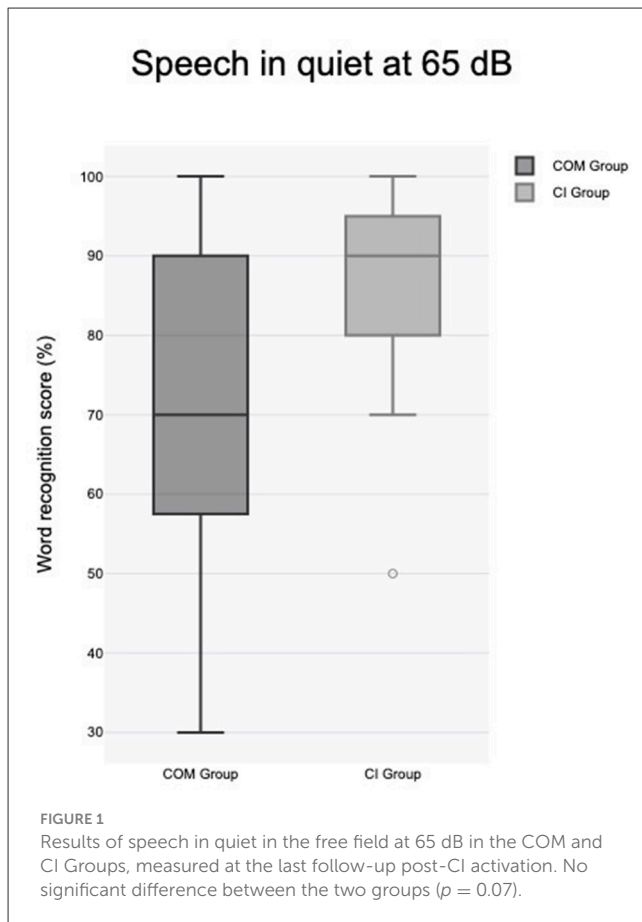
This study confirms and extends previous evidence supporting the safety and functional effectiveness of cochlear implantation following or associated with subtotal petrosectomy in patients with chronic otitis media. In accordance with prior reports (Szymański et al., 2016; Vincenti et al., 2014; Yan et al., 2020), our results demonstrate that the presence of middle ear disease does not preclude successful auditory rehabilitation when an appropriate surgical strategy is employed.

4.1 Surgical strategy: cavity, EAC and Eustachian tube management

From a surgical standpoint, the low complication rate in the COM cohort is encouraging and aligns with current evidence supporting the safety of cochlear implantation following subtotal petrosectomy, with low overall complication rates, most of which are minor (e.g., wound dehiscence, seroma, or hematoma) (Canzi et al., 2023; D'Angelo et al., 2020; Morelli et al., 2025; Szymański et al., 2016; Yan et al., 2020). In this context, a pivotal technical issue concerns the management of the mastoid cavity, and Eustachian tube, which remain a topic of ongoing debate (Bannister et al., 2020). Traditionally, cavity obliteration combined with secure external auditory canal closure (EAC) has been advocated to achieve a sealed and

sterile environment, thereby reducing the risk of postoperative infection and cholesteatoma recurrence (Aristegui et al., 2022). Indeed, Vincenti et al. (2014) reported a 66% (2/3) extrusion rate in cases of cochlear implantation in radical cavity vs. 5.9% (1/17) in subjects with SP and cavity obliteration, confirming the need for SP in patients with SNHL and a canal wall down mastoidectomy.

However, alternative strategies have been proposed (El-Kashlan et al., 2002, 2003) questioned the routine need for middle ear and mastoid cavity obliteration, highlighting potential advantages of a non-obliterative approach, including improved postoperative radiological surveillance for cholesteatoma recurrence and easier access in case of revision surgery. In our series, 15 of 17 patients underwent SP without mastoid obliteration and Eustachian tube closure and no cases of device extrusion or recurrent cholesteatoma were observed during follow-up. These findings in line with previous reports (Hernández et al., 2020; Yaşar et al., 2021), suggest that when meticulous disease eradication and robust multilayered EAC closure are achieved, cochlear implantation can remain safe and effective even without routine obliteration. The only case of cavity infection and EAC closure failure was observed in a chronic suppurative ear in active phase of disease, highlighting the importance of proper eradication of the disease and staging the procedure (Szymański et al., 2016). The absence of COM or cholesteatoma recurrence on long-term imaging supports the efficacy of SP in establishing a stable, dry ear, which is a fundamental prerequisite for successful



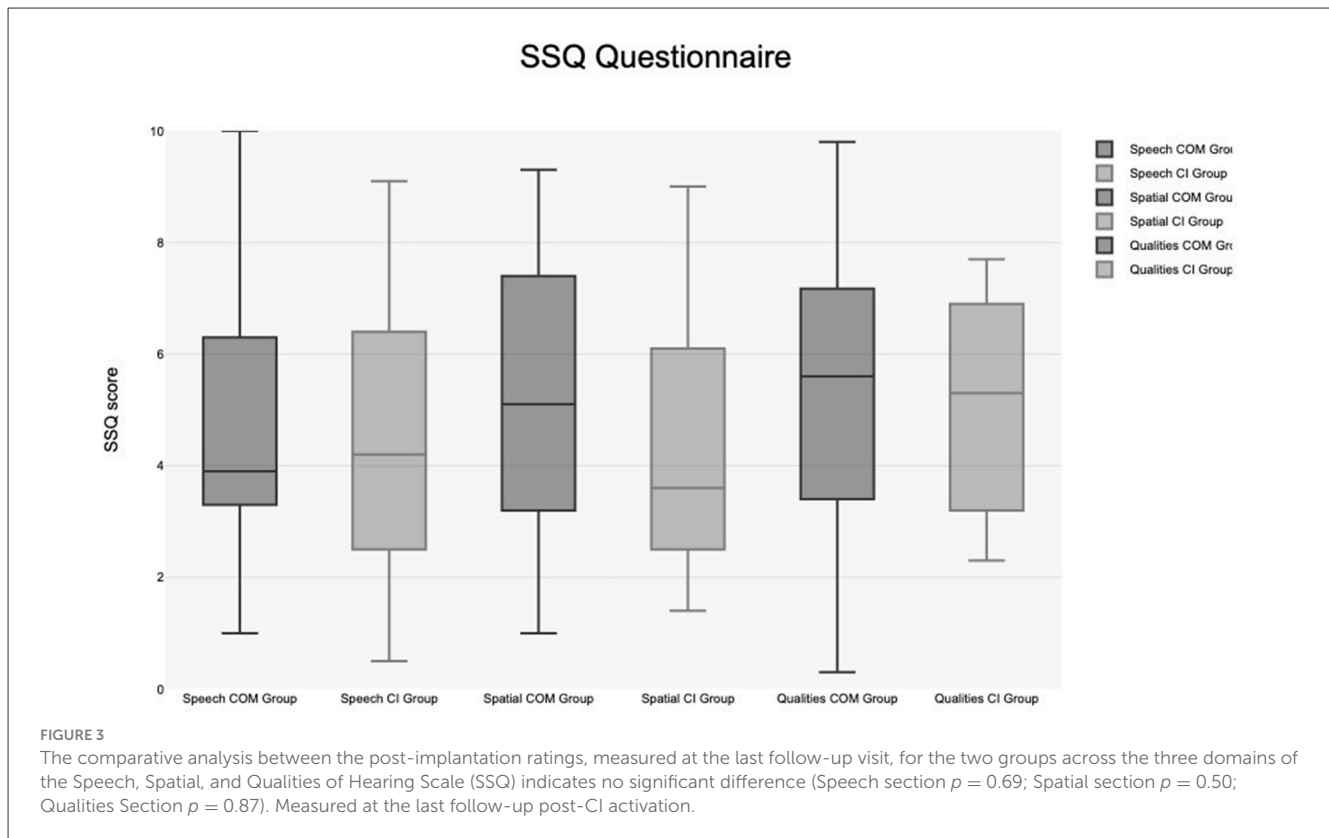
CI in this population (Zhang et al., 2021). Similar results are reported by Grinblat et al. (2020) with recurrence rates of 0%.

4.2 Simultaneous vs staged procedures and role of disease activity

The 17 patients of the COM group received a simultaneous procedure of SP and CI. As reported by Lee et al. (2020), the primary advantage of a simultaneous procedure is that it eliminates the need for multiple surgeries to treat one disease. This significantly reduces the financial cost of multiple surgeries and hospitalizations. Simultaneous procedures also allow for earlier auditory rehabilitation, leading to an earlier improvement in quality of life (QOL). However, when chronic ear disease is active, several authors have highlighted a higher risk of postoperative complications if cochlear implantation is performed in a single stage. The selection of an optimal surgical technique for cochlear implantation in the context of mastoid cavity disease remains a subject of ongoing debate. Although there is no definitive consensus, a two-stage procedure is generally regarded as appropriate in the presence of active infection (Issing et al., 1996; Donnelly et al., 1995; Postelmans et al., 2009). Issing et al. (1998) recommended a two-stage approach to mitigate postoperative complications in cases with existing inflammatory conditions

within the surgical cavity. Their findings noted that two of fourteen cases experienced complications, specifically retroauricular fistula, following a single-stage procedure on infected mastoid cavities. Similarly, Leung and Briggs (2007) documented two cases of active infection necessitating revision of the obliteration prior to cochlear implantation in a cohort of 10 patients who underwent staged surgery. In line with these observations, in the present series 1 of 3 patients who underwent single-stage implantation in the setting of active disease developed a postoperative complication, whereas no such events occurred in ears implanted after disease quiescence. Although the small sample size precludes formal statistical testing, the convergence between our findings and the previously published data supports a cautious recommendation in favor of staged surgery in cases of active disease.

The controversy persists concerning the management of patients with inactive middle ear disease, with some advocating for a single-stage approach. Proponents such as Hamzavi et al. (2001) reported satisfactory outcomes with no complications in seven patients who underwent subtotal petrosectomy combined with cochlear implantation in clinically stable mastoid cavities. However, a significant risk associated with single-stage procedures is the development of implantation cholesteatoma, which may remain asymptomatic and undetected postoperatively. Moreover, several reports of patients who have undergone single-stage surgery for inactive disease indicate occurrences of device extrusion, often



necessitating revision surgery. In conclusion, the choice between single- and two-stage surgical strategies should be individualized, considering the inflammatory status of the cavity. While staged procedures are favored in ears with active or infected middle ear disease to reduce postoperative complications, single-stage surgery may be appropriate in cases of inactive, clinically quiescent disease, provided that vigilant postoperative monitoring is maintained to detect potential complications such as cholesteatoma formation or device extrusion.

4.3 Audiological and patient-reported outcomes

Postoperative audiological outcomes revealed a significant and statistically comparable improvement in hearing thresholds post-implantation in both groups. The near-identical aided PTA₅ results (COM: 36.6 dB vs. Control: 35.6 dB, $p = 0.09$) underscore the capacity of electrical stimulation to restore auditory input, regardless of middle ear status. The speech perception outcomes further confirmed that the two groups performed comparably in terms of auditory ability. Both in quiet and in noise, results showed no significant differences in disyllabic word recognition or in the signal-to-noise ratios (SNRs) required to achieve 50% intelligibility on the Oldenburg Sentence Test (OLSA) in both groups. Since speech-in-noise perception is a key indicator of real-world listening efficacy and a persistent challenge for

the hearing-impaired (Wilson and Dorman, 2008), these findings suggest that the central auditory plasticity engendered by CI activation effectively compensates for pre-existing peripheral deficits (Fallon et al., 2008; Glick and Sharma, 2017), enabling a level of auditory rehabilitation comparable to standard candidates.

Our results align with evidence from large series showing that SP combined with CI grants significant hearing gains. Velasco et al. (2025) reported a mean improvement in pure-tone thresholds from 98.7 ± 9.2 dB HL preoperatively to 39.3 ± 9.3 dB HL postoperatively and open-set sentence recognition from 6.8% to 78.4% ($p < 0.001$) in patient who underwent simultaneous STP and CI. Likewise, Zhang et al. (2021) demonstrated postoperative benefit after SP and CI, with speech recognition thresholds improving from 80 ± 21 dB to 31 ± 9 dB ($p < 0.001$). AzBio sentence scores improved from 11% to 43% ($p = 0.002$), while Consonant–Nucleus–Consonant (CNC) word scores increased from 6% to 47% ($p < 0.001$) and from 15% to 66%, respectively. Similarly, (Morelli et al., 2025) reported significant postoperative improvements in 348 patients undergoing CI with SP, with mean PTA decreasing from 114 ± 11 dB HL to 48 ± 8 dB HL ($p = 0.004$) and speech discrimination score increasing from $12 \pm 4\%$ to $54 \pm 14\%$ ($p = 0.008$) 6 months after activation. Notably, consistent with our findings, these improvements were considerable and comparable to those achieved with standard cochlear implantation in patients without middle ear disease.

The Speech, Spatial, and Qualities of Hearing Scale (SSQ) results further revealed comparable overall satisfaction and listening performance between the two groups. No significant

differences were observed across any SSQ subscale post-implantation, suggesting that CI provides comparable subjective benefit in patients with chronic otitis media and in standard CI recipients. These findings align with the meta-analysis by [McRackan et al. \(2018\)](#), which showed significant improvements in hearing and CI-specific quality of life after implantation, regardless of patient variability or speech outcomes, reflecting the strong psychosocial impact of hearing restoration.

Collectively, these findings underscore that optimal outcomes depend on careful patient selection, complete disease eradication, and secure EAC closure, which together minimize postoperative morbidity and guarantee long-term implant viability.

4.4 Study limitations

The current research had several limitations, that should be taken into account when interpreting the findings. As a retrospective case-control analysis, it is subject to potential biases associated with non-randomized designs, including selection bias and the influence of unmeasured confounders. The relatively modest sample size, while adequate for detecting clinically relevant differences in primary audiological outcomes, may limit the generalizability of results and preclude definitive statistical conclusions regarding rarer surgical complications. The mean follow-up duration of 36 months, though substantial, may be insufficient to capture very late complications or disease recurrence in this chronic condition. The validation of these findings and the refinement of patient selection criteria and surgical strategies will be enabled by future multicentre studies with larger cohorts, standardized surgical protocols, and extended longitudinal follow-up.

5 Conclusion

In conclusion, integrating SP with CI provides a definitive therapeutic approach for patients who have been historically challenging to treat, effectively transforming chronically diseased ears into stable, functional ones. The current findings reinforce the consensus that CI with SP is a highly successful intervention for patients with COM, provided that the middle ear pathology is definitively addressed. Successful outcomes depend on meticulous surgical technique, complete eradication of the disease and secure EAC closure. However, while our findings are promising, they should be interpreted with caution due to the retrospective design and small sample size. Further prospective studies with larger cohorts are needed to confirm these results and refine surgical indications.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Review Board of the Policlinico Hospital Consortium in Bari, Italy (approval number 10336/2023CE). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AM: Data curation, Formal analysis, Resources, Writing – review & editing. AP: Writing – original draft. VP: Writing – review & editing. AS: Writing – original draft. NQ: Supervision, Writing – review & editing.

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