OTOLOGY

Cochlear implantation in chronic otitis media and previous middle ear surgery: 20 years of experience

L'impianto cocleare nell'otite media cronica e negli esiti di chirurgia dell'orecchio medio: esperienza di 20 anni

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SUMMARY

Cochlear implantation in the setting of chronic otitis media or previous middle ear surgery poses several problems for the surgeon: possible spread of infection to the cochlea and the subarachnoid spaces with consequent meningitis, risk of electrode array extrusion and possible recurrence of the original disease. Several surgical strategies have been proposed to overcome these problems. In the present study, clinical and functional results of cochlear implantation in 26 patients with chronic otitis media (8 cases) or previous middle ear surgery (18 cases) in the ear most suitable for implantation were retrospectively reviewed. Among the 8 patients with chronic otitis media, in 7 cases a subtotal petrosectomy associated with external auditory canal closure and mastoid and Eustachian tube obliteration was performed, while in the remaining patient cochlear implantation was done 6 months after a myringoplasty. The only complication observed was a reperforation of the tympanic membrane in this latter patient. Among the 18 patients with previous middle ear surgery, 2 had undergone intact canal wall tympanomastoidectomy and were implanted utilising the previous surgical approach. In the remaining 16 patients who had a radical cavity, an open technique was maintained in 3 cases; a cavity revision associated to external auditory canal closure, Eustachian tube and mastoid obliteration was performed in 12 patients, while in one case a middle cranial fossa approach was utilised. Two of the 3 patients in whom an open technique was maintained have experienced electrode array extrusion. The only complication observed in the remaining patients was the breakdown of the external auditory canal closure in one case. No problems were noted in patients who had undergone intact canal wall tympanomastoidectomy as well as in the subject implanted via the middle cranial fossa approach. All patients achieved and maintained good hearing performance over time. Subtotal petrosectomy associated with external auditory canal closure, Eustachian tube occlusion and mastoid obliteration is an effective procedure to facilitate cochlear implantation in presence of chronic otitis media. The open cavity technique offers the advantage of a close clinical examination, but may expose the patient to the risk of electrode array extrusion, mainly in the long-term period.

KEY WORDS: Chronic otitis media • Cholesteatoma • Sensorineural hearing loss • Cochlear implantation

RIASSUNTO

La chirurgia dell'impianto cocleare in presenza di otite cronica o precedente chirurgia dell'orecchio medio pone il chirurgo di fronte a diversi problemi: eventuale propagazione dell'infezione verso la coclea e gli spazi subaracnoidei con possibile meningite, rischio di estrusione dell'array elettrodico, possibile recidiva della patologia originaria. Varie sono le strategie chirurgiche proposte in letteratura al fine di ovviare a tali problemi. Nel presente studio è stata condotta un'analisi retrospettiva sui risultati e sulle complicanze dell'impianto cocleare in 26 pazienti che presentavano un'otite cronica (8 casi) o esiti di precedente chirurgia otologica (18 casi). Nel gruppo degli 8 pazienti con otite cronica, la tecnica chirurgica utilizzata è stata una petrosectomia subtotale con chiusura del condotto uditivo esterno e obliterazione della mastoide e della tuba di Eustachio in 7 casi, mentre il restante paziente è stato impiantato 6 mesi dopo una miringoplastica. L'unica complicanza riscontrata è stata la riperforazione della membrana timpanica in quest'ultimo paziente. Nel gruppo dei 18 pazienti già operati, 2 presentavano esiti stabilizzati di una timpanoplastica chiusa e sono stati impiantati utilizzando il precedente accesso chirurgico. Nei rimanenti 16 pazienti, che presentavano una cavità di radicale, in 3 casi è stata mantenuta una tecnica aperta, in 12 è stata eseguita una revisione della cavità con chiusura del condotto uditivo esterno e obliterazione della cavità e della tuba di Eustachio e in un caso l'impianto è stato inserito utilizzando la via della fossa cranica media. In 2 dei 3 pazienti in cui era stata mantenuta una tecnica aperta si è verificata l'estrusione dell'array elettrodico. Nel gruppo di pazienti trattati con la chiusura del condotto uditivo esterno si è verificata una deiscenza della chiusura del condotto. Nessuna complicanza è stata riscontrata nei soggetti con esiti di timpanoplastica chiusa e nel paziente impiantato per via della fossa cranica media. Tutti i pazienti hanno raggiunto e mantenuto nel tempo buone performance uditive. La petrosectomia subtotale, associata alla chiusura del condotto uditivo esterno e all'obliterazione della tuba di Eustachio e della mastoide è una tecnica affidabile e sicura nel trattamento dei pazienti da sottoporre ad impianto cocleare in presenza di otite cronica. Il mantenimento di una tecnica aperta offre il vantaggio di un più agevole follow-up, ma espone ad un più alto rischio di estrusione dell'array elettrodico, soprattutto nel lungo periodo.

PAROLE CHIAVE: *Otite media cronica • Colesteatoma • Ipoacusia neurosensoriale • Impianto cocleare*

Introduction

In presence of normal temporal bone anatomy, cochlear implantation is a safe and relatively simple procedure performed via the well-standardiaed transmastoid approach or, alternatively, via a transcanal approach. In some patients, profound hearing loss can be the result of chronic otitis media (COM) as well as surgery performed to treat middle ear disease. Under these circumstances, the surgeon may be faced with different clinical situations, such as inactive or active COM, cholesteatoma or previous middle ear surgery. In the past, cochlear implantation was contraindicated in the setting of COM due to a variety of problems. First of all, infection can spread from the middle ear to the labyrinth and intracranial spaces via the implant. Furthermore, in the presence of cholesteatoma, recurrence of disease is always possible with potentially serious consequences. Another problem is the heightened risk of electrode array extrusion in mastoid cavities because of the lack of protection by the tympanic membrane and the posterior wall of the external auditory canal (EAC). Schlondorff and Parnes [1 2] firstly reported on patients with COM who underwent cochlear implantation. Over the following years, several surgical options have been proposed to facilitate cochlear implantation in patients with a history of COM. Some authors have proposed treatment of COM by either tympanoplasty or tympanomastoidectomy as a first-stage procedure followed by cochlear implantation after 3-6 months [3], while others have suggested a single stage surgery [4]. Many authors [5-7] agree to manage COM more aggressively by performing a subtotal petrosectomy with closure of the EAC; sources of debate among proponents of this technique are whether or not obliterate the cavity and the Eustachian tube (ET), the material of choice for cavity obliteration and whether or not to stage the procedure in presence of cholesteatoma or active infection. If cochlear implantation is contemplated in an ear with a mastoid cavity, some surgeons have proposed to maintain an open technique [8], while others have suggested anatomic rehabilitation of the cavity by reconstructing the posterior canal wall with bone plates and obliterating the mastoid bowl with bone chips [9]. Finally, it has also been suggested to place the CI via a middle cranial fossa (MCF) approach, thereby avoiding septic fields [10]. In this article, we describe our 20-year experience in cochlear implantation of patients with a history of chronic ear disease.

Materials and methods

From December 1991 to October 2011, 26 patients with a history of COM in the ear most suitable for cochlear implantation were implanted at our department were included. All patients were adults with postlingual onset of deafness. There were 14 male and 12 female subjects with a mean age of 48.5 years (range 20-67 years). They consisted of five patients with simple COM (4 in inactive status and 1 with active infection), three patients with middle ear cholesteatoma, two patients with an intact canal wall tympanomastoidectomy and 16 patients with a pre-existing mastoid cavity. One of these 16 patients was a 33-year-old woman who underwent re-implantation because of electrode array extrusion after previous cochlear implantation at another hospital. Medium-term results of six of the 26 patients were discussed in a previous publication [11].
Patients details are summarised in Tables I and II. Clinical records were retrospectively analysed for patient demographics, physical findings at presentation, surgical issues, functional results and incidence and management of complications. All patients who underwent EAC closure were followed-up by high-resolution computed tomography (HRCT). Speech performances were evaluated in terms of bisyllabic word recognition (BWR), sentence recognition (SR) and common phrase comprehension (CPC). The speech materials were presented in auditory-only condition using monitored live voice through the sound field at a level of 70 dB.

Results

Among the eight patients with COM, one patient had a simple tympanic perforation and underwent cochlear implanta-

Table I. Clinical details of patients with COM

Case	Sex	Age	Implanted ear	Contralateral ear	Surgical technique	Stages	Complications/Notes
1	F	51	Inactive COM	Inactive COM	Cochlear implantation after myringoplasty	two	Tympanic membrane re-perforation
2	M	49	Inactive COM	Inactive COM	STP, EAC closure, obliteration	one	
3	M	52	Inactive COM	Inactive COM	STP, EAC closure, obliteration	one	
4	M	43	Inactive COM	CHL	STP, EAC closure, obliteration	one	
5	F	37	Active COM	Active COM	STP, EAC closure, obliteration	two	
6	M	61	Cholesteatoma	Cholesteatoma	STP, EAC closure, obliteration	two	
7	F	35	Cholesteatoma	Cholesteatoma	STP, EAC closure, obliteration	two	Residual cholesteatoma
8	M	53	Cholesteatoma	Atresia auris	STP, EAC closure, obliteration	two	

COM: chronic otitis media; STP: subtotal petrosectomy; EAC: external auditory canal; CHL: congenital hearing loss.

Table II. Clinical details of patients with previous middle ear surgery.

Case	Sex	Age	Implanted ear	contralateral ear	Surgical technique	Stages	Complications/Notes
1	F	57	ICWT	ICWT	ICWT	one	
2	M	49	ICWT	ICWT	ICWT	one	
3	F	67	Infected MC	CHL	EAC closure, obliteration	two	
4	M	62	Stable MC	TOM	EAC closure, obliteration	one	
5	M	54	Stable MC	Stable MC	EAC closure, obliteration	one	
6	F	39	Stable MC	TOM	EAC closure, obliteration	one	
7	M	62	Stable MC	Stable MC	EAC closure, obliteration	one	
8	F	55	Stable MC	Stable MC	EAC closure, obliteration	one	
9	F	20	Stable MC	Stable MC	EAC closure, obliteration	one	Scala vestibuli implantation
10	F	36	Stable MC	CHL	EAC closure, obliteration	one	EAC closure breakdown
11	M	56	Stable MC	Stable MC	EAC closure, obliteration	one	
12	F	33	Array extruded in MC	Stable MC	EAC closure, obliteration	one	RW hided by bone patè
13	M	55	Stable MC	Stable MC	EAC closure, obliteration	one	
14	M	61	Stable MC	Stable MC	EAC closure, obliteration	one	Scala vestibuli implantation
15	F	47	Stable MC	Stable MC	open technique	one	
16	M	48	Stable MC	Stable MC	open technique	one	
17	M	35	Stable MC	Stable MC	open technique	one	
18	F	46	Stable MC	CHL	MCF approach	one	

ICWT: intact canal wall tympanomastoidectomy; CHL: congenital hearing loss; MC: mastoid cavity; TOM: tuberculous otitis media; EAC: external auditory canal; RW: round window.

tion six months after myringoplasty. Four subjects underwent subtotal petrosectomy (STP), initially as a two-stage procedure because of the presence of cholesteatoma (n = 3) or COM in active status (n = 1). In the first stage, EAC blind sac closure and mastoid obliteration were performed; a silastic sheet was placed between promontory and fat to facilitate dissection during the second stage. Cochlear implantation was performed six months after the first stage. The remaining three patients with simple COM in inactive status underwent STP, cavity obliteration and cochlear implantation as a single-stage procedure. A standard cochlear implantation was performed in the two cases who had undergone an intact canal wall tympanoplasty as primary surgery. Among the 16 patients with a mastoid cavity, 11 underwent cochlear implantation associated with cavity obliteration and EAC closure as a single-stage procedure; in one patient with persistent infection despite medical therapy a two-stage procedure was done. In three patients who had a modified radical mastoidectomy with a small middle ear cavity, an open technique was maintained and the electrode array was protected with a pedicled temporalis muscle flap. Finally, in the remaining patient, cochlear implantation was performed via a MCF approach because the facial nerve was uncovered by its bony canal and strictly epidermisated in its entire tympanic portion.

No complications were observed in the short-term period; cochlear implantation was uncomplicated with full active electrodes insertion into the cochlea in all subjects; in two patients, the electrode array was inserted into the scala vestibuli using the Steenerson procedure [12] because of the scala tympani was found to be ossified. The postoperative course was uneventful and all patients were discharged in good health within 3-5 days after surgery.

The patient who underwent cochlear implantation and myringoplasty experienced re-perforation of the tympanic membrane three months after cochlear implant surgery and refused any further treatment. This subject used his implant with satisfactory hearing results for seven years before dying of a heart attack. Among the 17 patients who underwent EAC closure to facilitate cochlear implantation, after a mean follow-up of 11 years (range 1-21 years), the only complication observed was the breakdown of the EAC closure in one patient, which was successfully treated by performing a rotation skin flap. In one patient (case 5), a residual cholesteatoma was found and removed from the round window niche during the second stage.

Among the three patients in whom an open technique was maintained, two experienced extrusion of the electrode array at 4 and 6 years after surgery, respectively. Both patients underwent re-implantation using an obliterative technique and, to date, after a follow-up of 7 and 9 years, no local or intracranial complications occurred. No problems were observed in the patients who had undergone an intact canal wall tympanoplasty as primary surgery or in the subject implanted via the MCF approach.

At 1-year follow-up, all patients had excellent hearing outcomes as demonstrated by open-set speech testing CPC scores ranging from 44% to 100% (mean 75.60% ± 21.60) in quiet and from 30% to 90% (mean 59.80% ± 21.64) with 10 dB signal-to-noise ratio. The

mean bysillabic word and sentence recognition score was 67.46% ± 23.90 (range 35-100%) and 78% ± 20.32 (range 50-100%), respectively. As revealed by 3- and 5-year follow-up, implant performances remained stable over an extended postoperative time period.

Discussion

The management of COM in profoundly deaf patients is a paradigmatic example of continual improvements in the field of cochlear implantation. In the mid-1980s COM was regarded as a contraindication; today, there are different management options to facilitate cochlear implantation in a chronically diseased ear.

In presence of inactive COM with a simple dry tympanic perforation, some authors have proposed insertion of the cochlear implant and tympanomastoidectomy either as a single or two-stage procedure [3 4]. Regrettably, as in the subject reported in this study, tympanic membrane perforation can reoccur exposing the patient to possible re-infection with potential serious endocranial complications. Thus, most surgeons have recommended a more aggressive approach by performing a subtotal petrosectomy associated with EAC closure [5-7]. The rationale behind this surgical strategy is to eradicate all sources of infection and to create a closed and sterile environment; subject of debate is whether or not to obliterate the resultant mastoid cavity. Since in EAC closure the main problem is the risk of the development of a cholesteatoma, some surgeons [13 14] prefer to not obliterate the cavity by performing a modified Rambo technique, originally designed to create an air-containing cavity in communication with the pharynx through a patent ET; this would allow a better chance to control the cavity by HRCT. In order to prevent possible ascending infections through the ET and to further protect the electrode array, other surgeons have recommended occlusion of the ET and obliteration of mastoid cavity. El-Kashlan et al. [15], in 2003, reported on 28 patients who underwent cochlear implantation with a modified Rambo technique. Cavity obliteration was performed in only two cases. The authors described the development of a cholesteatoma in two children, 8 months and 5 years after implantation, respectively. Interestingly, both patients underwent EAC closure because of abnormal temporal bone anatomy and not because of the presence of cholesteatoma. Probably, squamous epithelium left behind the EAC closure was the cause of the cholesteatoma.

El-Kashlan et al. [15] did not consider possible infection through a patent ET to be a notable clinical problem. Our experience is quite different since infection through a patent ET can be a significant clinical problem, as demonstrated by the patient who underwent re-implantation; this case merits an in depth presentation. As reported in her clinical chart, the previous surgical procedure consisted of a STP with EAC blind sac closure; the ET was left patent,

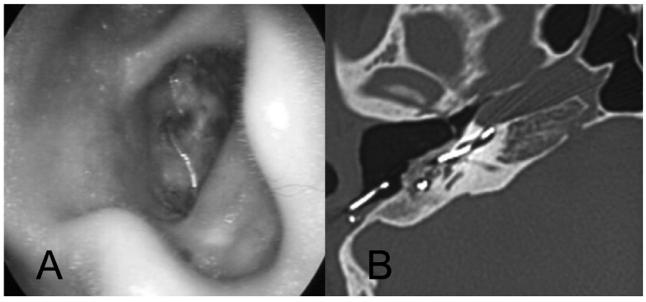

Fig. 1. Otoscopic (A) and axial HRCT (B) view of electrode array extrusion in case 12.

and the electrode array was covered with bone patè and temporalis fascia without mastoid cavity obliteration. Seven months after surgery, concomitant with an upper respiratory tract infection, the patient developed rhinorrhoea, fever, otalgia and purulent otorrhoea through breakdown of the EAC closure. Probably, a rhinopharyngeal infection reached the cavity through the patent ET leading to a purulent otitis media. During the following months, the patient experienced recurrent episodes of otorrhoea and progressive deterioration of hearing performance. When the patient came to our department, otoscopy and HRCT of the temporal bone revealed a completely reabsorbed EAC closure with the electrode array extruded in the cavity (Fig. 1). One year after the first cochlear implantation, a re-implantation was performed. At surgery, the cavity was found to be partially obliterated by ossified bone patè, which hid the round window region. Bone patè was drilled maintaining the array in situ to serve as a guide for the identification of the cochleostomy site. Once the round window was identified, the array was explanted and a new electrode was inserted into the scala tympani with subsequent EAC closure and mastoid obliteration with abdominal fat plus a superiorly pedicled temporalis muscle flap.

In addition to possible ascending infections from the rhinopharynx through a patent ET, another possible cause of cavity infection is the incomplete removal of the mucosa from the tympano-mastoid cleft. Leung and Briggs [7] implanted 16 patients affected by COM (8 with active chronic suppurative otitis media and 8 with existing mastoid cavities) by performing an obliterative technique with ET occlusion. Cochlear implantation and mastoid obliteration were performed as a two-stage procedure in 10 patients and as a single-stage procedure in six. No clinical signs of cholesteatoma were observed with a mean follow-up of 7 years. Two patients underwent obliteration revision. In one patient, middle ear effusion occurred after mastoid obliteration and EAC closure requiring a revision procedure before cochlear implantation because of the possible risk of infection. In the second patient, revision surgery was required by breakdown of EAC closure. Imperfect occlusion of the ET in combination with incomplete removal of mucosa were considered to be the causes of the

above-mentioned problems. For these reasons, the authors highlighted the importance of some steps of the surgical technique, such as meticulous mucosal removal, occlusion of the ET and secure soft tissue closure of the EAC, in obtaining a successful obliterative technique.

Another crucial question is whether to perform a single- or a two-stage procedure. Many authors have recommended staging the procedure in the presence of active infection or middle ear cholesteatoma [16 17], while others [18 19] have sustained that a single-stage procedure is sufficient in the presence of cholesteatoma. Basavaraj et al. [19], in their experience on four patients implanted by performing a single stage technique, reported the occurrence of a cholesteatoma in one patient nine years after cochlear implantation. The authors stated that staging of the procedure should not offer any advantage since cholesteatoma can reoccur at any time following EAC closure. In our opinion, a two-stage procedure is more suitable in the presence of a cholesteatoma if there is any doubt about complete removal of squamous epithelium. As in one patient of this series, the second stage can allow the detection of residual squamous epithelium that, if left behind the EAC closure, would lead to an enlarging cholesteatoma with possible serious consequences. Autologous abdominal fat and temporalis muscle flap are considered the most suitable obliterative materials [3 7]. Bone patè, hydroxyapatite and tricalcium phosphate have also been proposed, but it is preferable to not utilise these materials as they may turn into solid bone and thus complicate eventual revision surgery [6]. This was also our experience in the patient who underwent re-implantation. We usually utilise abdominal fat because of its easy availability, low metabolic rate and resistance to necrosis; in addition, fat has been reported to have intrinsic immunoreactive features that may overcome infection [20]. Regarding the problem of radiological assessment, undoubtedly the presence of fat makes interpretation of HRCT scans more difficult, but detection of soft tissue expansion or temporal bone erosion revealing the development of cholesteatoma is possible.

In the presence of pre-existing mastoid cavities several surgical strategies have been proposed [21 22]. Curiously, as for the treatment of middle ear cholesteatoma, in the literature there is debate among surgeons who prefer to maintain an "open technique" and others who advocate "closed techniques". Proponents of the open procedure have suggested to drill the bed for the receiver-stimulator more posteriorly than in a standard technique as well as to shape the canal for the electrode in a wave-like form in order to prevent looping of the array and, thus, to reduce the risk of necrosis of the covering skin [8 23 24]. Once the electrode array is positioned, its canal can be closed with bone patè resulting in a flat surface; subsequently, vascularised flaps [8] and/or free soft tissue grafts [23] are used to further protect the array before repositioning the epithelial lining of the cavity. Maintaining an open cavity offers the advantages of a single-stage, not time-consuming procedure and easier postoperative clinical surveillance; on the other hand, this technique requires lifelong care with periodical cleaning of the ear and exposes to the risk of electrode extrusion, especially in the long-term period [3 16 18]. This has also been our experience in two of three patients implanted by maintaining an open cavity and covering the electrode array with bone patè and a temporalis muscle flap. Both patients experienced electrode array extrusion in the long-term period (4 and 6 years after surgery, respectively) and were re-implanted using an obliterative technique with EAC blind sac closure. Since results with the open technique have been disappointing, currently our approach to mastoid cavities includes elevation and removal of the entire epithelial layer possibly without disrupting it (for this purpose we have found Mesna [25] to be useful, a mucolytic compound that facilitates surgical dissection), along with removal of all mucosal lining, ET occlusion with free muscle graft and bone patè, EAC closure with a "blind sac" technique, cochlear implantation and cavity obliteration with abdominal fat. A two-stage procedure is performed in the presence of active infection. Japanese authors [9 26] have suggested the anatomic rehabilitation of the cavity with reconstruction of the bony posterior wall and tympanic membrane. However, this technique is time consuming, quite difficult, even in experienced hands, and requires a two-stage operation; in addition, electrode migration in the cavity, inclusion of epithelial debris and necrosis of the cutaneous layer can occur [17]. As such, it cannot be considered an appealing alternative.

A completely different strategy has been proposed by Colletti et al. [10], who have utilised the MCF approach to avoid a septic field through the middle ear. We have performed this approach in a 46-year-old woman who had, in the ear most suitable for cochlear implantation, an infection-free and stable radical cavity with the facial nerve completely exposed and strictly epidermisated in its entire tympanic portion. Removal of the epidermal layer was judged to be hazardous for the integrity of the facial nerve and thus, after extensive counselling with the patient, cochlear implantation was performed via a MCF approach. This patient uses regularly her device with good functional results; to date, with a follow-up of 12 years, no complications have occurred. Despite this positive experience, in our opinion, this technique, which involves the risk of craniotomy and does not correct the underlying problem, leaving a focus of infection very close to the implant, should be reserved only for very special cases.

Conclusions

Cochlear implant candidates with COM in the ear most suitable for implantation are doubly handicapped by a combination of profound deafness and chronic discharging ears; in these patients, surgery must have the goal to resolve both problems. Since COM may present with dif-

ferent clinical pictures and all the surgical techniques proposed in the literature have pros and cons, each patient's management should be tailored to clinical findings; another factor to consider is the expertise of the surgeon with various techniques. Regardless of the preferred technique, two rules must be respected in this specific population of patients: securing an infection-free ear before implantation and creating a strong and healthy protective layer to cover the implant. On the basis of our experience, we conclude that STP associated with EAC closure, Eustachian tube occlusion and mastoid obliteration is an effective procedure to block the potential entry routes for infection and adequately protect the electrode array. In addition, life-long care of the ear and water restriction are not required. In order to make this technique successful, meticulous removal of all mucosal lining and skin, effective mastoid and ET obliteration and a two-staged procedure in presence of cholesteatoma or active infection are of paramount importance. Maintaining an open cavity offers the advantage of close clinical examination, but may expose to the risk of electrode array extrusion, mainly in the long-term period. The MCF approach should be reserved for very special cases.

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