Comparison of Complications by Technique Used in Cochlear Implants

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Abstract
Introduction: Complications are very sensitive indicators of the usefulness of a surgical technique. In cochlear implant surgery, there are 3 principal approaches: the classic approach uses the facial recess (FR), the suprameatal approach (SMA) does not require mastoidectomy and uses the creation of a tunnel over the facial nerve to enter the middle ear, and the endomeatal approach (EMA) is based on the completion of a groove in the posterior wall of external auditory canal.

Material and methods: A multicentre review of 208 patients with cochlear implants was performed for comparing the different techniques. The complications were classified into major and minor.

Results: Among the 208 implanted patients, 10.5% (22 of 208) had complications. Of these, 2.88% (6 of 208) were major complications and 7.69% (16 of 208) were minor complications. Comparing the results obtained by the different approaches, the FR technique had the lowest rate of major complications (1.1%), followed by the EMA technique with 2.38% and SMA with 3.75%. As for minor complications, operations in the SMA group had the lowest rate (6.25%), followed by the EMA group (7.14%) and the group operated on using the FR technique presented the highest (10%).

Conclusions: The 3 techniques described show very similar rates of complications. Consequently, we can conclude that they are safe and are alternatives.

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KEYWORDS
Complications; Cochlear implant surgery; Endomeatal approach; Facial recess approach; Suprameatal approach

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**Palabras clave**

Implante coclear; Complicaciones; Técnica suprameatal; Técnica endomeatal; Técnica receso facial

**Comparación de complicaciones según la técnica utilizada en los implantes cocleares**

**Resumen**

*Introducción*: Las complicaciones son un indicador muy sensible de la utilidad de una técnica quirúrgica. En cirugía de implante coclear se pueden utilizar 3 abordajes: el abordaje clásico utiliza el receso facial para el paso del electrodo; el abordaje suprameatal (SMA) no requiere mastoidectomía y utiliza la creación de un túnel que pasa por encima del nervio facial para entrar a la caja del timpano desde atrás, y el abordaje endomeatal (EMA) que se basa en la realización de un conducto en el conducto auditivo externo. *Material y métodos*: Estudio multicéntrico de revisión de 208 pacientes, comparando las diferentes técnicas de abordaje descritas. Se clasificaron las complicaciones en mayores y menores.

*Resultados*: Entre los 208 pacientes implantados el 10,5% (22 de 208) presentó complicaciones, de estas el 2,88% (6 de 208) fueron complicaciones mayores que llevaron a la reimplantación y el 7,69% (16 de 208) fueron complicaciones menores. Comparando los resultados obtenidos por los diferentes grupos, podemos decir que la técnica del RF es la que menos porcentaje de complicaciones mayores tuvo, 1,1% seguida de la técnica EMA con un 2,3% y la SMA con un 3,75%. En cuanto a las complicaciones menores, el grupo operado por SMA tuvo el menor porcentaje presentando el 6,25%, seguido del grupo operado por EMA con el 7,14% y el grupo operado por el RF presentó el 10%.

*Conclusiones*: Las 3 técnicas quirúrgicas descritas muestran un porcentaje de complicaciones muy similar. Por lo tanto, podemos concluir, que las 3 técnicas son seguras y alternativas unas con otras.

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**Introducción**

Complications are a very sensitive indicator of the usefulness of a particular surgical technique. Thus, there are many techniques and surgical approaches which, though excellent, are scarcely used or not used at all due to their high rate of complications.

Regarding cochlear implants, a number of approaches were considered from the very beginning. The classical approach, the most widely used and accepted one, uses the facial recess for passage of electrodes from the mastoidectomy into the middle ear. This technique requires a simple mastoidectomy and a posterior tympanotomy. Access to the middle ear is narrow at this point and requires precision and experience on the part of the surgeon, since the presence of the facial nerve requires certain risks to be assumed. Critics of the technique emphasise this point, arguing that this access can be bypassed, thus avoiding the proximity of the facial nerve and its possible complications.

For this reason, alternative routes have been designed over the history of cochlear implant surgery. The suprameatal approach (SMA) does not require an initial mastoidectomy and instead creates a tunnel that passes over the facial nerve to enter the tympanic cavity from behind. This tunnel is drilled from the cribiform area, in parallel to the posterior wall of the external auditory canal, directly towards the long apophysis of the incus, where the drill emerges. Supporters of this technique highlight the fact that there is no risk of facial nerve lesion, since it is anatomically distant from the Fallopian canal.

Finally, the endomeatal approach (EMA) is another surgical option for performing a cochlear implant which employs the ear canal as a reference for the introduction of the electrode into the middle ear. This technique requires a meatotympanal flap to be obtained, similarly to a stapedectomy, and is based on creating a channel in the posterior wall of the external auditory canal, parallel to its axis, through which the electrode enters the middle ear. This channel is formed from an intermediate position between the malleus and incus towards the mastoid in a straight line, leading up to the cribiform area with a depth of approximately 2 mm. Once the electrode is positioned, it should be covered by bone paste and then the skin of the external auditory canal (EAC) covering it should be repositioned. This technique avoids the proximity of the facial nerve, is quick and requires no anthropo-mastoidectomy. In children, the sulcus is limited to the inner third of the EAC. In addition, a small mastoid cavity is also created, with a narrow groove that continues the sulcus to the cortical mastoid and communicates the cavity with the EAC. This is done to accommodate the electrode guide within the cavity rather than the sulcus, in order to avoid a possible displacement of the electrodes due to growth of the EAC.

In this work we will use the classification of complications described in the work of Hoffman and Cohen (1995), who divided them into:

(a) Intraoperative (Gusher).
(b) Immediate postoperative (cerebrospinal fluid [CSF] fistula).
(c) Late postoperative (extrusion).

This classification uses a division including major complications and minor complications. Major complications are those requiring surgical reoperation to be resolved (incorrect placement of electrodes, extrusion, migration
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of receiving coils, etc.) or hospitalisation of the patient (meningitis, CSF leak), while minor complications are those requiring conservative treatment (infection of the flap, facial nerve stimulation, vertigo, etc.).

Objective

The aim of this work is to compare the incidence of complications, in general and in particular, between 3 different surgical approach routes used to perform cochlear implants. In this respect, there are very few references establishing a direct comparison between techniques, which is the primary objective of this work.

Material and Methods

We present a multicentre review of 208 patients, out of which 104 were females and 104 were males. The age range of patients was between 1 and 80 years. The 3 techniques described were used on 3 different groups of participants. Of the total 208 implanted patients, 41 patients were implanted using the endomeatal approach (EMA) (group A), of which 19 were males and 22 were females. Group B consisted of 80 patients implanted by the SMA technique (30 females and 50 males). This group included a subgroup of 56 patients in whom a variant of the SMA was employed. In this variant, access took place through a small atticotomy. Finally, group C included 87 patients who were implanted using the facial recess technique (FR) by posterior tympanotomy (35 males and 52 females).

Results

Among the 208 implanted patients, 10.5% (22 of 208) presented complications. Of these, 2.88% (6 of 208) were major complications which led to reimplantation, and 7.69% (16 of 208) were minor complications.

Group A, operated with the EMA technique, presented 4 complications, 1 major and 3 minor. The major complication was extrusion of the receiver–stimulator by flap infection. Minor complications corresponded to 1 haematoma at the surgical site, 1 serous otitis and 1 surgical wound infection. All 3 were resolved with medical treatment. Therefore, there was a 9.5% complication rate, with 1 being major (2.38%) and 3 being minor (7.14%) (Fig. 1). We should clarify

that the major complication was not specifically caused by the EMA technique, since placement of the receiver requires a similar incision in all 3 surgical approaches.

Patients in group B, who were operated by the SMA technique and atticotomy, suffered 8 complications. Of these, 3 were major, including 2 due to intraoperative problems leading to implantation in the contralateral ear and 1 displacement of the prostheses which required surgical repositioning. This group also presented 5 minor complications, including 1 case of skin ulceration, 1 of prolonged vertigo, 1 short tympanomeatal flap which had to be closed with a fascia graft, 1 case of prolonged vomiting and, finally, 1 case of intraoperative Gusher. Therefore, group B presented a 10% complication rate, of which 3.73% were major complications and 6.25% were minor.

Finally, group C, which included patients operated with the FR technique, presented 10 complications. Of these, 2 were major complications, including 1 meningeal artery haemorrhage and 1 prosthesis displacement, and 8 were minor complications, including 3 cases of intraoperative Gusher, 2 patients with facial nerve stimulation, 1 case of haematoma in the retroauricular and neck areas, 1 patient who developed a seroma, and 1 case of prolonged vertigo with difficult clinical management. Therefore, group C suffered 11.6% complication rate, of which 1.1% were major complications and 10.5% were minor (Table 1). The analysis of these data did not show statistically significant differences between the 3 techniques (P> .76).

Comparing the results obtained in the different groups, we could say that the FR technique had the lowest rate of major complications (1.1%), followed by the EMA (2.38%) and the SMA (3.75%) techniques. As for minor complications, the group operated with the SMA technique showed the lowest rate (6.25%), followed by the EMA group (7.14%) and the FR group (10%). We should clarify that minor problems with the facial nerve were not related to the technique employed, but rather were due to facial stimulation by proximity of the otic capsule to the intracranial portion in a patient with marked pericochlear bone resorption due to advanced otosclerosis (Fig. 2).

The percentages obtained were within the values described in the literature. Therefore, the 3 techniques were considered to be safe when performed by experienced surgeons.

Complications according to surgical technique

<table>
<thead>
<tr>
<th></th>
<th>Major</th>
<th>Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>9.52%</td>
<td></td>
</tr>
<tr>
<td>EMA</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td>11.6%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 Total complications according to the surgical approach employed. EMA, endomeatal approach; FR, facial recess approach; SMA, suprameatal approach.

<table>
<thead>
<tr>
<th></th>
<th>Major</th>
<th>Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>3.73</td>
<td>1.1</td>
</tr>
<tr>
<td>EMA</td>
<td>6.25</td>
<td>2.38</td>
</tr>
<tr>
<td>FR</td>
<td>7.14</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 Percentage of major and minor complications in each approach. EMA, endomeatal approach; FR, facial recess approach; SMA, suprameatal approach.
Table 1: Number and Type of Complications According to Surgical Technique Employed.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Type of Complications</th>
<th>Major Complications</th>
<th>Minor Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>n=41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endoneural Approach</td>
<td></td>
<td>1 stimulator receptor</td>
<td>1 haematoma</td>
<td>1 infection by skin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>infection</td>
<td></td>
<td>wound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 serious otitis</td>
</tr>
<tr>
<td>Group B</td>
<td>n=80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suprameatal Approach</td>
<td></td>
<td>2 electrode placements</td>
<td>1 prosthesis failure</td>
<td>1 vertigo with clinical management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 prosthesis</td>
<td>1 vertigo with difficult clinical management</td>
<td>1 vertigo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 placement failures</td>
<td>1 vertigo with difficult clinical management</td>
<td>1 vertigo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 haematoma</td>
<td></td>
<td>1 vertigo</td>
</tr>
<tr>
<td>Group C</td>
<td>n=87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial recess Approach</td>
<td></td>
<td>3 Gusher</td>
<td>2 facial nerve stimulations</td>
<td>1 haematoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 external processor failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 vertigo</td>
</tr>
</tbody>
</table>

Discussion

Firstly, we must compare the overall complication rate. It has been clearly established that the number of complications depends on many factors, one of the most important being the point of the learning curve at which interventions took place. The surgeons involved in this work had at least 10 years prior experience in all types of otological surgery. In our work, we found a complication rate of 10.5%. Of these, 7.69% were minor, while 2.88% were major complications. These figures are comparable to the percentages reported in the literature. Thus, we found that Kandogan et al. reported a 6.6% rate of minor complications and 12.33% of major complications, while Postelmans et al. reported a 3.7% rate of major complications. One of the first published studies referring to surgical complications related to cochlear implantation corresponds to Thielemier et al. This author studied the results obtained in 269 implantations and detected 4 cases of flap necrosis.

Based on a classification of complications into major and minor depending on their severity and whether or not there was a need to perform reoperation, Cohen et al. pointed out that major complications obtained in their work ranged between 2.5% and 15%, with those related to flap infections obtaining the highest percentages. Minor complications (transient facial paresis, changes in taste sensitivity, instability, tympanic perforation, tinnitus, seromas, and haematomas) varied between 6.2% and 25%. All were transient and were resolved with topical cures or processor reprogramming in cases of facial nerve stimulation.

Other works, such as that by Mondain et al., reported complications in 16% of patients, with 5.6% being minor complications. Within the major complications, 7.2% corresponded to reimplantations and 3.2% to major complications requiring repositioning of the prosthesis without reimplantation (skin infections, trauma).

Hospital Universitario in Valencia, Spain, had published a report on 246 implanted patients who suffered a total of 28 complications, corresponding to 11.38% of all implants. Of these, 7 were minor complications and 21 were major complications, of which 6.5% corresponded to failures in the implanted prostheses.

A study by the University of Maastricht had described the SMA technique as safe for the performance of cochlear implants (CI). This study reported on 107 patients who were implanted with this technique, of which 23.4% (25 of 107) suffered minor complications, whereas only 3.7% (4 of 107) suffered major complications. The latter included 2 extrusions due to skin infections, 1 failure in electrode placement, and 1 implant failure.

Comparing the results obtained by different groups, we can say that the FR technique had the lowest rate of major complications (1.1%), followed by the EMA (2.38%) and the SMA (3.75%) techniques. Regarding minor complications, the group undergoing operation by SMA presented the lowest percentage (6.25%), followed by the group operated by EMA (7.14%) and the group operated by FR (10%). Finally, we must insist on the concept that both the EMA and SMA approaches increase the distance with the facial nerve. Some of the general complications described would have occurred using any of the 3 surgical techniques. A good example is intraoperative Gusher, which represented 1 minor complication.
in group B and 3 minor complications in group C, and which does not depend on the approach used, but rather on the anatomical conditions of each patient. We must also clarify that facial nerve stimulation occurs after implant programming and sometimes requires the electrodes to be disconnected. In general, this complication is unrelated to the proximity of the implant to the Fallopian canal. Instead, it is linked with the proximity of the otic capsule to the intracranial facial nerve (a very common occurrence among patients whose otic capsules are in the spongiosis or “spongy bone” phase of otosclerosis).

Conclusions

The 3 surgical techniques described showed very similar rates of major complications (SMA 3.75%, EMA 2.38%, and FR 1.1%). Therefore, we may conclude that the 3 techniques are safe and alternatives to one another.

Conflict of Interests

The authors have no conflict of interests to declare.

References