INTRODUCTION

Hearing loss is the most common sensory deficit in children. Loss can be broadly split into those that have lost hearing before speech development (pre-lingual) and those after it (post-lingual). Hearing loss occurs in 1-3 in 1000 live births per year, half of these are considered as profound with a deficit more than 90 dBHL, these children are all pre-lingually deaf (1).

The overwhelming majority of hearing impairment is as a direct result of loss or developmental failure of the hair cells of the cochlea. With absent or dysfunctional hair cells, sound is not transformed into neural stimuli for transmission to the higher auditory centers for processing. Hair cell loss occurs because of a number of conditions and insults (2).

Traditional acoustic hearing aids may improve hearing function but are diminishingly ineffective for many people with severe to profound sensorineural loss of hearing (3).

Until the advent of cochlear implants, little could be done for these children other than development of communication skills with sign-language and lip-reading. Profoundly deaf children often failed to develop intelligible speech, with subsequent reduction educational and professional prospects. With the development of cochlear implantation, prospects for these children have greatly improved (4).

A cochlear implant is an electronic prosthetic device that acts to convert external physical sounds to electrical impulses in place of the deficient hair cells (5).

Parallel to cochlear implant development, different alternative surgical techniques were invented and described in the last years. The surgical procedure including mastoidectomy and posterior tympanotomy, introduced in 1979, is known as classic standard approach (6).

In 2000, Kronenberg et al. presented the suprameatal approach (SMA) as alternative method for cochlear implantation. Using the suprameatal approach, the active electrode is inserted without mastoidectomy and posterior tympanotomy (6).

Patients and methods

Selection of patients

This study was conducted on 30 patients that underwent cochlear implantation surgery in Zagazig University Hospital, in the period from October 2010 to April 2014. The patients were 19 males and 11 females, their age ranged from 2 to 7 years. Patients were divided to 2 groups: one group was implanted by the supra mental approach (6 patients) and the other one was implanted by posterior tympanotomy approach (24 patients).

Results: There was a significant difference between the 2 groups as regard the total duration of surgery in favor of 1st group A (SMA). There was no significant difference between the 2 groups as regard the total number of major or minor complications. But there was one case of facial nerve paralysis in a child implanted by the classic approach.

Conclusion: SMA may be clearly a good alternative to the classical surgery technique for CI in terms of reducing the duration of surgery and reducing the incidence of facial and chorda tympani nerve injury.

Keywords: Cochlear implantation, Supra mental approach, Posterior tympanotomy approach, Mastoidectomy.
In this study, postlingual adults, children with congenital anomalies, and children with chronic suppurative otitis media were excluded. The written medical consent was taken from the parents after a clear explanation for the advantage and disadvantage of each approach and for the possible surgical complications.

Preoperative evaluation

All patients in the study had done basic preoperative assessment, which include the following:

- **Thorough general examination and ENT examination**
- **Audiological assessment**
  - Tympanometry.
  - Aided and non-aided audiometry by either play audiometry or visual reinforcement audiology.
  - Auditory brainstem response
  - Otoacoustic Emission
  - Language assessment
  - Intelligence Quotient (IQ) assessment
  - Electronecephalogram (EEG)
  - Imaging
    - Computerized tomography (CT scan) of the temporal bone
    - Magnetic resonance imaging (MRI) of the cochlea, auditory nerve and brain

Surgical techniques

**The classic approach**

1. **Incision**: 2 types of incisions were used (in the 24 case):
   - Post auricular inverted J shaped incision: was used in 4 cases
   - Extended endaural incision: was used in 20 case

2. **Elevation of the flap 2 layer**
   2 flaps layers are elevated
   1. The superficial layers include skin and S.C tissue.
   2. The deep layer:
      - Anterior based Palva flap
      - Upper flap is elevated in a subperiosteal plane to create device seat.
3. **Mastoidectomy and Posterior tympanotomy**
   The facial recess opening is Lowered down and the bone anterior to FN is removed till good exposure to round wind niche is achieved.

4. **Cochleostomy or RW approach**
   o First we used to do cochleostomy by opening cochlea in the promontory antro inferior to round window niche with 1mm diamond bur.
   o Now we used to open the RW membrane in all cases, except if difficult exposure, by good removing of entire RW niche till good exposure of RW membrane.

5. **Creation of the receiver/stimulator seat**
6. **Electrode insertion**
7. **Muscle Plug**
8. **Fixation**
   o We depend in fixation on sewing the periosteum together over the implant.
9. **Intraoperative X-ray (C-arm)**

10. **Suturing**
11. **Intraoperative device function assessment**
12. **Dressing**

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**B: Suprameatal technique**
1- Incision: extended endaural
2- Elevation of the outer flaps
3- Creation of the seat
4- Elevation of tympanomeatal flap and Anterior tympanotomy.
5- Creation of the groove
   o A groove is made in in postero superior wall of EAC starting from inside to outside. The groove is 1mm width and 3 mm in depth. It started from the scutum lateral to the long process of incus and just above the level of the pyramid, the chorda tympani should be identified before making the groove and reflected anteriorly away from the groove.
   o The groove is continued in outer direction till it reach the site of the seat without doing the blind tunnel as in classic SMA.

6- Exposure of RW
   o In all these cases the RW membrane was good exposed after removing of entire RW niche.

7- Electrode insertion

8- Fixation of electrode and obliteration of the groove.
   By either
   • Cartilage and cement like material (glass ionomer or calcium hydroxide).
   • Bone Patte and bioactive glass powder
9- Grafting and Packing with gelfoam
   o Securing of the TM by temporalis fascia
     graft, even if intact TM, which is
     supported by gelfoam in M.E
   o Then Tympanomeatal flap is returned
     and supported by gelfoam and one aural
     pack to be removed after 2 weeks.
10- Intraoperative X-ray (C- arm)
11- Intraoperative device function assessment
12- Dressing
Postoperative care:
   • 1st 24 hour we concern on the following:
     Facial nerve function, Vomiting, Vertigo,
     Temperature and Dressing is soaked or not
   • After 24 hour, we evaluate the presence or
     absence of hemotoma. If hematoma is present, it
     should be evacuated by aspiration under complete
     aseptic condition. Then we do digital x ray, Stenver
     view, for documentation, then we discharge the patient
     on oral antibiotic
   • After 1 week, we stop the antibiotics and
     remove the dressings, steristrips and cutaneous
     sutures, if present.
   • After 4 weeks, we start external device
     programing and recording any twitches, significant
     pain, then we start speech rehabilitation sessions.
   • Routine follow-up is done after 2 month
     and is repeated every 2 months. This follow up is
     for assessment of the surgical complications,
     audiological state, and language development.

The following parameters were recorded for comparison
A: Intraoperative parameters
   • Total duration of the surgery
   • Intraoperative difficulties:
     a. Exposed FN
     b. Chorda tympani n. injury
     c. Difficult RW exposure
     d. Difficult insertion of electrode
     e. Injury of the TM or TM annulus
B: Postoperative complications
Early complications
   • Fever
   • Vomiting
   • FN paralysis
   • Hematoma
Late complications
   • Wound infection
   • Number of working electrodes
   • Migration
   • Extrusion
   • EAC stenosis, granulation
   • Residual TM perforation, cholesteatoma
     formation
Results
A: Intraoperative Parameter:
   • Total Duration of the Surgery: table 1.
     There was a significant difference between
     the duration of the surgery in both groups.
     The mean duration of surgery was significantly shorter ($P < 0.05$) in the SMA
     (167.5 minutes) than in the MPTA (253.3
     minutes) group.
   • Intraoperative difficulties/insults: table 2.
     There was no significant difference between
     the 2 groups as regard the total
     intraoperative difficulties/insults.
B: Postoperative complications:
   • Early complications: table 3.
     There was no significant difference between
     the 2 groups as regard the total early
     postoperative complications.
   • Late complications: table 4.
     There was no significant difference between
     the 2 groups as regard the total early
     postoperative complications.
Table (1): The 2 groups as regarding the total duration of surgery (in minutes)

<table>
<thead>
<tr>
<th></th>
<th>A (SMA)</th>
<th>B (PTA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>130-200</td>
<td>180-300</td>
</tr>
<tr>
<td>Mean</td>
<td>167</td>
<td>253.33</td>
</tr>
<tr>
<td>S.D</td>
<td>28.9395</td>
<td>38.1833</td>
</tr>
</tbody>
</table>

\[ t \text{ test} = T-\text{Value} \ 6.0679 \]
\[ P-\text{Value} = 0.0002 \ (\text{highly significant}) \]

Table (2): The 2 groups as regarding the intraoperative difficulties

<table>
<thead>
<tr>
<th></th>
<th>A (SMA)</th>
<th>B (PTA)</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed dura</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>20.8%</td>
</tr>
<tr>
<td>Chorda tympani nerve Injury</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>25%</td>
</tr>
<tr>
<td>Exposed facial nerve</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4.1%</td>
</tr>
<tr>
<td>Difficult exposure of RW niche</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>20.8%</td>
</tr>
<tr>
<td>Difficult electrode insertion</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>12.5%</td>
</tr>
<tr>
<td>Injury of the EAC skin, or T.M annulus</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>8.3%</td>
</tr>
<tr>
<td>Total cases with one or more difficulties</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>54.1%</td>
</tr>
</tbody>
</table>

Chi-square = 0.833
p-value = 0.3614 (not significant)

Table (3): The 2 groups as regarding the early postoperative complications

<table>
<thead>
<tr>
<th></th>
<th>A (SMA)</th>
<th>B (PTA)</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>16.6%</td>
</tr>
<tr>
<td>Vomiting</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>20.8%</td>
</tr>
<tr>
<td>Vertigo</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>12.5%</td>
</tr>
<tr>
<td>FN paralysis</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4.1%</td>
</tr>
<tr>
<td>Hematoma</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>16.6%</td>
</tr>
<tr>
<td>Total cases with one or more early complication</td>
<td>2</td>
<td>10</td>
<td>12</td>
<td>41%</td>
</tr>
</tbody>
</table>

Chi-square = 0.139
p-value = 0.7092 (non significant)

Table (4): The 2 groups as regarding the late postoperative complications

<table>
<thead>
<tr>
<th></th>
<th>A (SMA)</th>
<th>B (PTA)</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>8.3%</td>
</tr>
<tr>
<td>EAC stenosis</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>12.5%</td>
</tr>
<tr>
<td>Device migration</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Device malfunction (due to accidental trauma)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>12.5%</td>
</tr>
<tr>
<td>Total cases with one or more late complication</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>20.8%</td>
</tr>
</tbody>
</table>

Chi-square = 2.088
p-value = 0.14846 (non significant)
Fig (9) Diagram representing the difference between the 2 groups (in percentage) as regard the intraoperative difficulties, early and late postoperative complications.

DISCUSSION

Cochlear implants are the first true bionic sense organs. The human cochlea is an electromechanical transducer. Cochlear implants, like other human hair cell, receive mechanical sound energy and convert it into a series of electrical impulses (7).

The classic surgery involves mastoidectomy, posterior tympanotomy, cochleostomy, and insertion of array of electrodes through the basal coil of the cochlea. The body of the implant is inserted into a seat drilled in the skull behind the ear (8).

In 2000, Kronenberg et al. presented the suprameatal approach (SMA) as alternative, safe and effective method for cochlear implantation. Using the suprameatal approach, the active electrode is inserted without mastoidectomy and posterior tympanotomy (6).

We have done a modification for this approach by doing endaural incision, then after elevation of the tympanomeatal flap, the grove is done in the posterosuperior wall of EAC starting from inside to outside. The grove is 1mm width and 3 mm in depth. It started from the scutum lateral to the long process of incus and just above the level of the pyramid. The groove is continued in the outer direction till it reaches the site of the seat without doing the blind tunnel as in classic SMA. Also we have inserted the electrode in all these cases by RW approach not by cochleostomy as in classic SMA.

Then obliteration of the groove is done by either cartilage or cement like material (glass ionomer or calcium hydroxide) or by bone patte and bioactive glass powder.

The debatable points of this approach are:

1- Injury of the scutum.

In all cases of SMA, and its modification by endomeatal approach, there are a small parts of the scutum (1mm width) should be drilled to make the groove for the electrode array.

But by reviewing the results of this scutum injury, there was no retraction pocket formation or cholesteatoma formation in many literatures (9; 10; 11; 12; 13).

This also was confirmed in all our cases done by SMA, the duration of follow up was ranging from 2 month up to 2 years.

2- External auditory canal affection

As a matter of fact, cochlear implantation with electrode insertion via the EAC was tried in the early stages of cochlear implantation by several surgeons. At that time, glass ionomer cement was not available and electrodes were rigidly positioned directly under the skin, so that extrusions occurred (14 & 15).

In half of our cases (50%) we used small strip of cartilage to avoid the skin reaction made by glass ionomer, however, this causes EAC narrowing in one case that was improved after removal of this cartilage.
In the other 50% of cases we used bioactive glass and bone pâté in obliteration of the groove and there were excellent results with no skin reaction or granulations.

3- Tympanic membrane affection

Taibah K, reported 5 cases out of 134 case of tympanic membrane perforation that was healed spontaneously with conservative measures (9).

In the present work there were no T.M perforations and we used to graft the T.M routinely, even if there is no perforation, by temporalis fascia.

4- Extrusion

Some surgeons exclude small children as a candidate for CI by SMA, as they concern that lengthwise growth of the EAC might create problems for an electrode fixed to EAC and may cause electrode extrusion from the cochlea (10).

However there were no reported cases of electrode extrusion or damage in many literatures (9; 11; 12; 13).

In our cases there were no extrusion and the follow up periods were ranging from 2 month up to 2 years

The advantages of this approach are:

1- Duration of surgery

In the present study the mean duration of surgery was significantly shorter (P < 0.05) in SMA (167.5 minutes) than in PTA (253.3 minutes) group.

Postelman et al., stated that the mean duration of surgery was significantly shorter (P < 0.05) in SMA (111.7 minutes) than in the MPTA (132.2 minutes) group (16). Also the short duration of SMA was confirmed by many surgeons (9; 10; 11; 12; 13).

In the present study, the total duration of surgery in both approaches was longer than reported in the literature. The cause is that we added the duration of C arm and neural response telemetry to the total duration of surgery.

2- Facial nerve injury

There were no reported cases of FN paralysis during the SMA or its modifications in many literatures (9; 10; 11; 12; 13; 16).

In the present study only one case of facial nerve paralysis happened with posterior tympanotomy approach with incidence of 4.1%.

3- Chorda tympani injury

Damage to the chorda tympani nerve in the classic approach was described in 5.2% to 20% of cases (17; 18; 19)

There were no reported cases of chorda tympani nerve injury by the SMA or its modifications in many literatures (10; 11; 12; 16).

In the present study only one case of chorda tympani nerve injury by SMA, with incidence of 16.6%, in contrast to 6 cases of chorda tympani nerve injury by the posterior tympanotomy approach, with incidence of 25%.

Generally, in the present study there was no significant difference in the total incidence of the major and minor complications in both groups

This was confiding with the metanalysis done in 2014 by Xu BC et al., for cochlear implantation, and he found that there is no statistically significant difference in major and minor complications between the two approaches, SMA and PTA, except for facial nerve and chorda tympani injuries (20).

CONCLUSION

Supra meatal approach is shorter in duration and safer as regard facial and chorda tympani nerve injury, but it has nearly the same incidence of complications like the classic approach.

Whatever the technique, the most important is to know how to do it well.

REFERENCES


دراسة مقارنة بين طريق الصلاخي العلوي وطريق بضع الطبلة الخلفي في زراعة قوقعة الأذن

زراعة قوقعة الأذن الصناعية تعتبر وسيلة امتصّة وفعالة ل إعادة تأهيل مرضى الصمم الحاد. وهناك طرق جراحية عديدة لزراعة قوقعة الأذن، فهناك الطريقة التقليدية عن طريق استئصال النتوء العملي وصولاً إلى بضع الطبلة الخلفي. وهناك طرق بديلة أُهمٌّهم طريق الصلاخي العلوي.

المضاعفات المحتملة حدوثها لمرضى زراعة قوقعة الأذن يمكن تصنيفها إلى مضاعفات كبيرة (والتي تحتاج إلى اجراء عملية أخرى أو الى دخول المستشفى) ومضاعفات صغيرة (والتي لا تحتاج الى علاج أو إلى علاج خارج المستشفى).

أجرت هذه الدراسة على 30 حالة اجراء عملية زراعة قوقعة الأذن الصناعية بمستشفيات جامعة الزقازيق في الفترة من شهر أكتوبر 2010 إلى شهر أبريل 2014. و تم تقسيمهم الى مجموعتين:

1- المجموعة الأولى أجريت زراعة قوقعة الأذن عن طريق الصلاخي العلوي.
2- المجموعة الثانية أجريت زراعة قوقعة الأذن عن طريق بضع الطبلة الخلفي.

تم استعداد حالات ضعف السمع بعد تركين اللعنة وحالات العيون الخلفية في الأذن. و تم تسجيل المدة الكلية والصعوبات والمضاعفات الصغرى والكبرى للعملية وذلك لكل حالة في المجموعتين.

ووجد فرق وفجوات بين المجموعتين من حيث المدة الكلية للعملية لصالح المجموعة الأولى. ولا يوجد فرق واضح بين المجموعتين من حيث الصعوبات أثناء العملية. ولكن لوحظ أن ادخال اقطع السرير الكهربائي للجهاز عن طريق النافذة الدائرية كان ممكنا أكثر في المجموعة الأولى.

ووجد عدم وجود فرق واضحة بين المجموعتين من حيث المضاعفات الصغرى للعملية. وان كانت نسبة اصابة عصب الجبل الطبي العالي في المجموعة الثانية.

ووجد عدم وجود فرق واضحة بين المجموعتين من حيث المضاعفات الكبرى للعملية. وان كانت نسبة اصابة العصب الوجي العالي في المجموعة الثانية ونسبة خروج الطبل السرير الكهربائي للجهاز من الفوقعة أعلى في المجموعة الأولى.

مقارنة هذه الدراسة بنتائج الدراسات الأخرى السابقة هي مقارنة غير عادلة وذلك لقلة عدد الحالات في المجموعتين. ونحن نأمل في الدراسات النتائية أن يكون لنا مشاركة أفضل من حيث عدد الحالات على مستوى البحث العلمي في المستقبل.

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