COMPARATIVE STUDY BETWEEN SUPRAMEATAL APPROACH AND POSTERIOR TYMPANOTOMY APPROACH IN COCHLEAR IMPLANTATION

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ABSTRACT

Background: Cochlear implant is established as an effective and safe method of rehabilitation for profoundly deaf patients. There are two common surgical approaches for cochlear implantation. The first surgical approach, with mastoidectomy and posterior tympanotomy, is known as the classic approach or posterior tympanotomy approach. The second surgical approach, without mastoidectomy or posterior tympanotomy, is known as the suprameatal approach. Using the suprameatal approach, the active electrode is inserted and posterior tympanotomy. **Aim of the work:** To compare between suprameatal approach and posterior tympanotomy approach in cochlear implantation. **Patients and methods:** 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 meatal 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 meatal approach, Posterior tympanotomy approach, Mastoidectomy.

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:

1- 1st group (group A) was implanted by the supra meatal approach (SMA). This group includes 6 patients.
2- 2nd group (group B) was implanted by the classic approach or posterior tympanotomy approach (PTA). This group includes 24 patients.

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 audiometry.
  - Auditory brainstem response
  - Otoacoustic Emission
- **Language assessment**
- **Intelligence Quotient (IQ) assessment**
- **Electroncephalogram (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

Fig (1) post auricular inverted J shaped incision

Fig (2): extended endaural incision

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 elvated in a subperiosteal plane to create device seat.

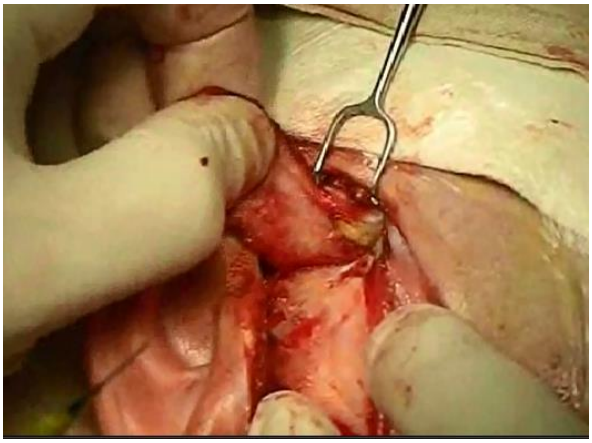

Fig (3) Palva flap

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**

- First we used to do cochleostomy by opening cochlea in the promontory antro inferior to round window nich with 1mm diamond bur.
- 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**
   - We depend in fixation on sewing the periosteum together over the implant.
9. **Intraoperative X-ray (C-arm)**

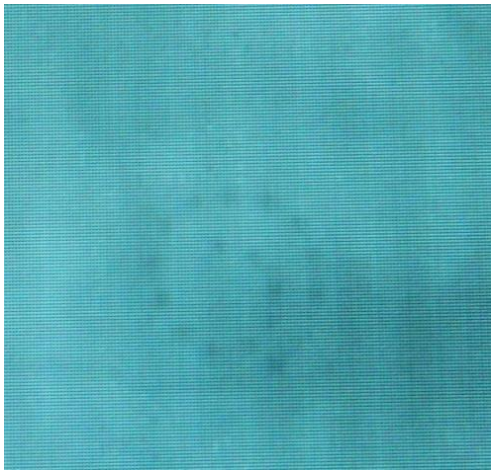

Fig (4) Intraoperative X-ray

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

B: Suprameatal technique

1- **Incision: extended endaural**
2- **Elevation of the outer flaps**

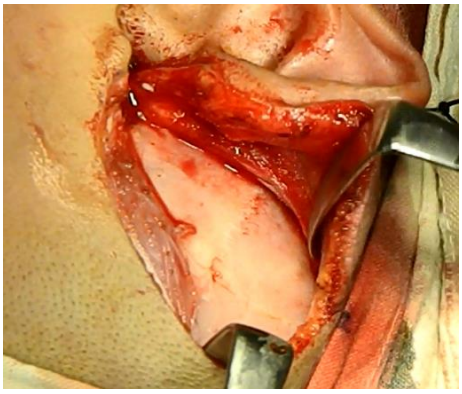

Fig (5) elevation of the outer flaps

3- Creation of the seat

4- Elevation of tympanomeatal flap and Anterior tympanotomy.

5- Creation of the groove

- 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.
- The groove is continued in outer direction till it reach the site of the seat without doing the blind tunnel as in classic SMA.

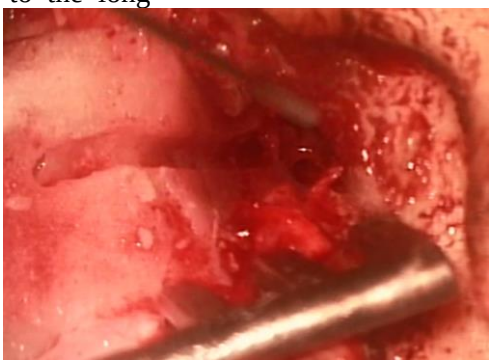

Fig (6) creation of the groove

6- Exposure of RW

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

7- Electrode insertion

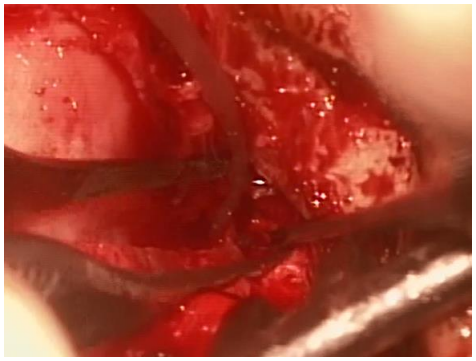

Fig (7): Electrode insertion

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

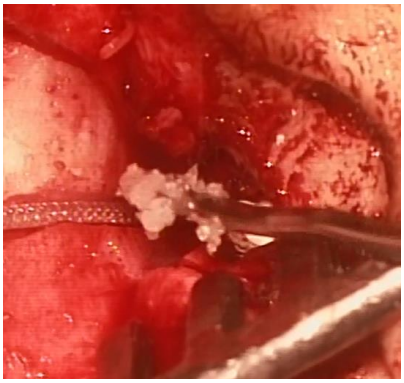

Fig (8): Electrode fixation using bioactive glass

9- Grafting and Packing with gelfoam

- Securing of the TM by temoralis fascia graft, even if intact TM, which is supported by gelfoam in M.E
- 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 hematoma, 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)

	A (SMA)	B (PTA)
Range	130-200	180-300
Mean	167	253.33
S.D	28.93959	38.18339

t test = T-Value 6.0679
P-Value = 0.0002 (highly significant)

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

	A (SMA)		B (PTA)	
	Total	Percent	Total	Percent
Exposed dura	0	0	5	20.8%
Chorda tympani nerve Injury	1	16.6%	6	25%
Exposed facial nerve	0	0	1	4.1%
Difficult exposure of RW niche	0	0	5	20.8%
Difficult electrode insertion	1	16.6%	3	12.5%
Injury of the EAC skin, or T.M annulus	0	0	2	8.3%
Total cases with one or more difficulties	2	33.3%	13	54.1%

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

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

	A (SMA)		B (PTA)	
	Total	Percent	Total	Percent
Fever	1	16.6%	4	16.6%
Vomiting	1	16.6%	5	20.8%
Vertigo	1	16.6%	3	12.5%
FN paralysis	0	0	1	4.1%
Hematoma	0	0	4	16.6%
Total cases with one or more early complication	2	33.3%	10	41%

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

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

	A (SMA)		B (PTA)	
	Total	Percent	Total	Percent
Wound infection	1	16.6%	2	8.3%
EAC stenosis	1	16.6%	0	
Device migration	0		3	12.5%
Device malfunction (due to accidental trauma))	1	16.6%	0	
Total cases with one or more late complication	3	50%	5	20.8%

Chi-square = 2.088
p-value = 0.14846 (non significant)

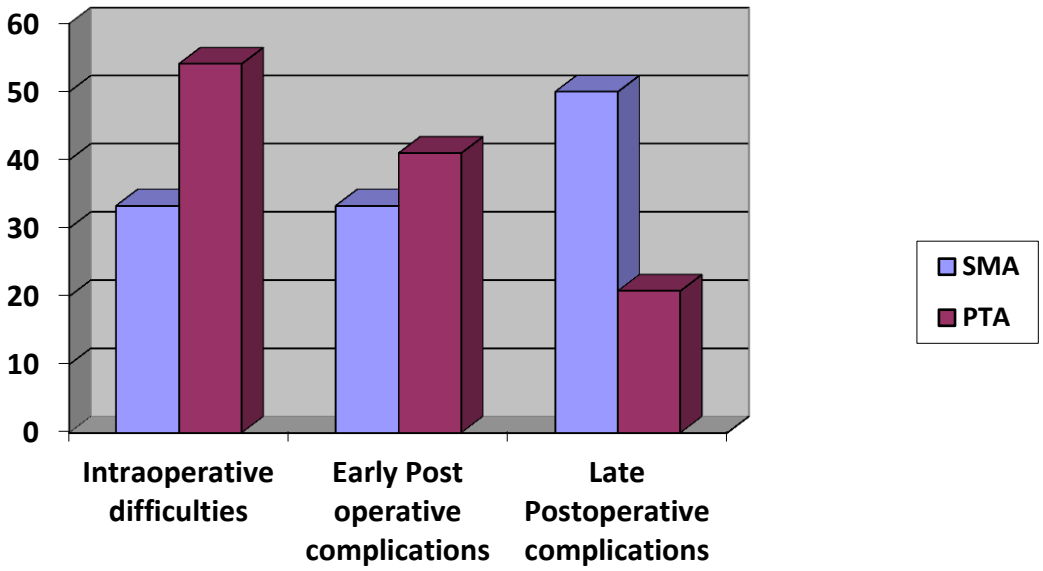

Fig (9) Diagram representing the difference between the 2 groups (in percentage) as regard the intraoperative difficulties, early and late postoperative complications.

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 grove 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 grove 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.

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

زراعة قوقعة الأذن الصناعية تعتبر وسيلة امنه وفعالة لاعادة تاهيل مرضى الصمم الحاد. وهناك طرق جراحية عديدة لزراعة قوقعة الأذن، فهناك الطريقة التقليدية عن طريق استئصال النتوء الحلمي وصولاً ببضع الطبلة الخلفى. وهناك طرق بديلة أهمهم الطريق الصلاخى العلوى بتعديلاته المختلفه.

المضاعفات المحتمل حدوثها لمرضى زراعة قوقعة الاذن يمكن تصنيفها الى مضاعفات كبرى (والتي تحتاج الى اجراء عملية اخرى او الى دخول المستشفى) و مضاعفات صغرى (والتي لا تحتاج الى علاج او الى علاج خارج المستشفى).

اجريت هذه الدراسة على 30 حالة اجروا عملية زراعة قوقعة الأذن الصناعية بمستشفيات جامعة الزقازيق في الفتره من شهر اكتوبر 2010 ال شهر ابريل 2014 . و تم تقسيمهم إلى مجموعتان :

1- المجموعة الاولى اجرت زراعة قوقعة الأذن عن طريق الصلاخى العلوى
2- المجموعة الثانيه اجرت زراعة قوقعة الأذن عن طريق بضع الطبلة الخلفى

تم استبعاد حالات ضعف السمع بعد تكوين اللغة وحالات العيوب الخلقية في الاذن. و تم تسجيل المدة الكلية والصعوبات و المضاعفات الصغرى والكبرى للعمليه وذلك لكل حالة في المجموعتين.

لوحظ وجود فرق واضح بين المجموعتين من حيث المدة الكلية للعمليه لصالح المجموعة الأولى. ولا يوجد فرق واضح بين المجموعتين من حيث الصعوبات اثناء العملية. ولكن لوحظ أن ادخال اقطاب المسرى الكهربي للجهاز عن طريق النافذه الدائرية كان ممكنا اكثر في المجموعة الاولى.

ولوحظ عدم وجود فرق واضح بين المجموعتين من حيث المضاعفات الصغرى للعملية. وان كانت نسبة اصابة عصب الحبل الطبلي اعلى في المجموعة الثانية.

ولوحظ عدم وجود فرق واضح بين المجموعتين من حيث المضاعفات الكبرى للعملية. وان كانت نسبة اصابة العصب الوجهي اعلى في المجموعة الثانية ونسبة خروج القطب المسرى الكهربي للجهاز من القوقعة اعلى في المجموعة الاولى.

مقارنة نتائج هذه الدراسة بنتائج الدراسات الاخرى السابقة هي مقارنة غير عادلة وذلك لقلة عدد الحالات قي المجموعتين. ونحن نأمل في الدراسات التاليه ان يكون لنا مشاركة افضل من حيث عدد الحالات على مستوى البحث العلمي في المستقبل.