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# Retrosigmoid approach for auditory brainstem implant

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**Abstract**

The present paper reports our experience with the surgical retrosigmoid-transmastoid (RS-TM) technique for implanting auditory brainstem implants (ABIs).

From April 1997 to August 1998, four patients with neurofibromatosis type 2 (NF2) were operated on for vestibular schwannoma removal with ABI implantation. The subjects (three men and one women) ranged in age from 22 to 31 years. Tumour size ranged from 12 to 30 mm.

A classical RS-TM approach was performed. After tumour excision, identification of landmarks (VIIth, VIIIth and IXth cranial nerves, choroid plexus) to the foramen of Luschka was carefully carried out. The choroid plexus was partially removed and the tela choroidea divided and deflected. The floor of the lateral recess of the fourth ventricle and the convolution of the dorsal cochlear nucleus became visible. The electrode array was then inserted into the lateral recess and placed in the correct position with the help of electrically-evoked auditory brain stem responses.

Auditory sensations were induced in all patients with various numbers of electrodes. Different pitch sensations could be identified with different electrode stimulation.

Details of the results are presented. In our series, the RS-TM approach represents the elective route for ABI insertion.

**Key words: Brain Stem, Prosthesis Implantation; Neurosurgical Procedures**

## Introduction

The multichannel auditory brainstem implant (ABI) electrically stimulates the auditory system at the level of the cochlear nuclei providing partial restoration of auditory function in patients with (NF2) who are deaf as a result of the disease or surgical removal of bilateral vestibular schwannoma (VS).[1–3]

These patients cannot be rehabilitated by a traditional cochlear implant because the auditory nerves are no longer intact. Additional theoretical indications for ABI are represented by total deafness in patients with head trauma or cochlear nerve aplasia.

In 1997 our group was asked to test the 'European' 21-channel ABI. Since then four subjects suffering from NF2 have received an ABI using the RS-TM approach. The present paper reports our experience with the surgical RS-TM technique in implanting ABI.

## Materials and methods

One-hundred and fifty-eight patients have been operated on in our Department, from January 1990 to December 1998, by AN surgery via a RS-TM approach. Their ages ranged from 18 to 88 years (average 54 years). Tumour size ranged from 4 mm to 50 mm. Among them, 13 patients were chosen for ABI implantation: eight subjects suffering from NF2 and five with the VS in the only-hearing ear were candidates for ABI.

All subjects with solitary VS preserved hearing and did not need ABI. None of the NF2 patients preserved hearing. Four of them refused ABI and four accepted implantation. Table I shows the characteristics of the four implanted patients. The Nucleus 21-channel ABI was used in all patients.

TABLE I
AUDITORY BRAINSTEM IMPLANT SERIES 1997–98: PATIENT DEMOGRAPHICS

| Patient | Sex | Aetiology | Op. date | Age at implantation (years) | Implant side | Tumour size (cm) |
|---|---|---|---|---|---|---|
| 1 MS | F | NF2 | 11/05/97 | 27 | R 1st s. | 3 |
| 2 BA | M | NF2 | 11/04/97 | 31 | L 1st s. | 1.2 |
| 3 CR | M | NF2 | 08/13/98 | 22 | R 2nd s. | 1.5×3 |
| 4 CP | M | NF2 | 08/12/98 | 25 | L 2nd s. | 3 |

Op. = operation; M = male; F = female; NF2 = neurofibromatosis type 2; R = right; L = left.

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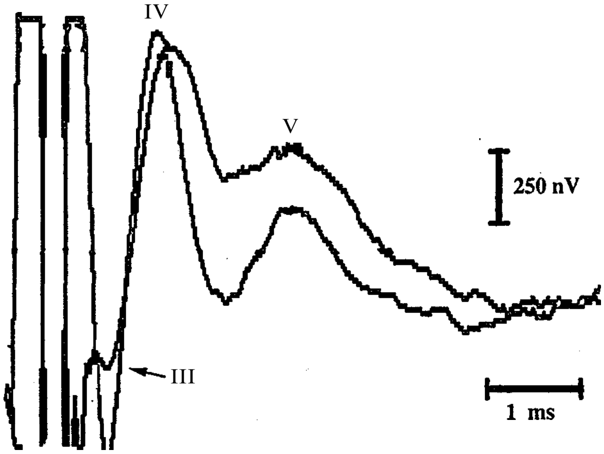


Fig. 1

Electrically-evoked auditory brainstem responses recorded intra-operatively in a patient with an auditory brainstem implant.

A classical RS-TM approach was performed until tumour excision was completed. After tumour excision, identification of landmarks to the foramen of Luschka was carefully carried out. The VIIth, VIIIth and IXth cranial nerves were used as main landmarks. The choroid plexus, which covers the foramen of Luschka, was identified in the triangle formed by the VIIIth and IXth cranial nerves and the lip of the foramen of Luschka. The VIIth and IXth cranial nerves could also be followed to the lateral recess with the help of electromyography (EMG).

The flocculus and the choroid plexus were retracted mediorostrally and the arachnoid membrane and its trabecule cut. After the choroid plexus was partially removed and the tela choroidea divided and deflected, the floor of the lateral recess of the fourth ventricle and the convolution of the dorsal cochlear nucleus became visible. The entrance of the lateral recess was confirmed by observing the outflow of spinal fluid with a Valsalva manouvre. The electrode array was then inserted into the lateral recess and placed in the correct position with the help of EABRs.

Electrodes for recording EABRs and for monitoring the facial and glossopharyngeal cranial nerves were put in position before surgery. An MK15 or MK12 system was used in combination with the diagnostic programming system from the Cochlear Corporation for measuring EABRs. The status of the cranial nerves VII and IX were monitored using a continuous electromyographic (EMG) recording system (NL1, Grass Instrument or MK12, Amplaid). Recording electrodes for EABR were positioned at the vertex (Cz) and over C7 on the neck, with a ground electrode between them on the neck near the hairline. This configuration permitted reduction in the stimulus artefacts.

After ABI insertion, the cochlear nuclei were stimulated (21 stimuli per second) using biphasic electric stimuli of 50 microseconds per phase. Signals were filtered using a 10 to 2500 Hz bandpass. Bipolar stimulations between sample electrodes of the different portion of the array were performed to confirm the correct position of the ABI.

A CT scan was taken post-operatively to evaluate the position of the electrode before discharge.

Activation of the ABI occurred four to six weeks post-operatively. Because of possible risks incurred by stimulating brainstem structures, it was undertaken in the intensive care unit under the monitoring of an electrocardiogram and with the assistance of an anaesthetist.

## Results

In the five subjects with a solitary VS, hearing was preserved. In particular two patients retained class A hearing according to the AAO 1995 rules, one patient showed a class B result and two a class C. ABI implantation was thus not necessary.

The cochlear nerve was severed in all subjects with NF2 and an ABI was applied in four patients. It was refused by the other four. The EABRs were recorded intra-operatively in all implanted patients during ABI application. Figure 1 provides an example of the evoked auditory response from one of the patients. Typical auditory responses with three peaks were obtained and the waveform of these

TABLE II

AUDITORY BRAINSTEM IMPLANT SERIES 1997–1998: RESULTS

| Patient | Elecs. in map + mode (cod.str.) | Current status | Results: Functional benefit | Results: Non-auditory effects (electrodes) |
|---|---|---|---|---|
| 1 | 12 – MP (SPEAK) | Good user | Good environmental awareness<br>Good rhythm and word discrimination<br>Lip-reading enhancement | Electrical sensation throughout homolateral arm$^{2,3,4,5}$ or hemisome$^{11,14,17,19,20}$ |
| 2 | 13 – MP (SPEAK) | Daily user | Good environmental awareness<br>Lip-reading enhancement | Warm sensation throughout homolateral arm$^{15,16,18,21}$ eyes winking$^{17,19,20,22}$ |
| 3 | 11 – MP (SPEAK) | Good user | Good environmental awareness<br>Good rhythm and word discrimination<br>Lip-reading enhancement | Itching sensation at the hemipharynx and larynx$^{2,5,8}$ itching sensation at the homolateral ear$^{11,14,17}$ vertigo$^{19,20,21,22}$ |
| 4 | 10 – MP (SPEAK) | Poor user* | Good environmental awareness | Electrical sensation throughout homolateral arm$^{2,4,5,8,11}$ vertigo$^{17,18,19,20,21,22}$ |

*Poor user because of other problems related to neurofibromatosis type 2 syndrome.

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peaks was not changed by inverting the polarity of stimulus, whereas stimulus artifact reversed in polarity.

Post-operative CT scanning showed that the ABI electrodes were in the proper position and there was no displacement.

Auditory sensations were induced in all patients with various numbers of electrodes. Different pitch sensations could be identified with the stimulation of different electrodes. Those electrodes that induced non-auditory effects or intolerable sound were deactivated. Table II shows the functional post-operative benefits of ABI as well as the non-auditory effects.

## Discussion

A number of surgical approaches to the posterior fossa and the IAC are available for removing a VS, i.e. translabyrinthine, transcochlear, middle fossa, retrolabyrinthine, retrosigmoid. The choice of the approach depends upon a number of factors, such as surgeon preference, size of the tumour, hearing level, etc.

Growing interest in functional preservation of the cranial nerves has focused surgeons' attention to the retrosigmoid and middle fossa routes. We prefer the RS-TM approach in any VS since we feel that it offers a series of advantages such as adequate control of bleeding, dissection of the entire tumour under direct view, easy identification of the facial nerve at its root entry zone and at the distal end in the IAC.[4,5]

A particular feature of this approach is the unique possibility of performing real-time intra-operative monitoring by means of direct recording of cochlear nerve and facial action potentials (CNAPs and FNAPs).[6,7] Instantaneous information on the function of the cochlear nerve, cochlea and facial nerve are obtained with these techniques, and insights into the mechanisms of hearing and facial nerve impairment are therefore available during surgery. Information yielded by intra-operative monitoring has thus contributed to the refinement of surgical techniques directed to preservation of cranial nerve function.

Decompression of the intrameatal portion of the vestibular schwannoma and planned partial resection with hearing preservation are also possible. In addition, even if the auditory function is lost, this technique permits sparing the cochlear nerve which may thus be suitable for electrical stimulation using a cochlear implant.

Our preliminary experience with ABI has shown that implantation may be avoided using the RS-TM approach with the aid of intra-operative CNAP monitoring. In all five subjects with solitary VS in the only-hearing ear, hearing was preserved and ABI avoided. Preservation of hearing in NF2 patients is much more difficult. Unfortunately, our patients with NF2, did not retain hearing and therefore the application of an ABI was decided.

The translabyrinthine approach for ABI placement was originally advocated by House and Hitselberger[8] and is considered by some authors to provide the most direct access to the foramen of Luschka. Despite considerable anatomical-surgical studies of the cerebellopontine angle and fourth ventricle regions, the anatomical relationship of the cochlear nerve and nucleii around the foramen of Luschka is not completely understood.

A recent anatomical paper by Kuroki and Moller[9] on cadaveric specimens showed that the translabyrinthine approach to the cerebellopontine angle offers a limited view so that it is necessary to retract the sigmoid sinus medially to obtain a medial view of the root entry zone of the cochlear nerve. In addition, exposure of the lateral recess may be difficult to secure when the jugular bulb is located in a high position. Care must be taken not to injure the jugular bulb in cases in which the jugular foramen has to be drilled when a translabyrinthine approach is used.

In an anatomical investigation Friedland and Wackym[10] found that the RS approach provided excellent visualization of the lateral recess of the fourth ventricle when using a 30° endoscope with a more direct appreciation of the implant site compared to the translabyrinthine approach.

In our hands the RS-TM approach represents the elective route for ABI insertion. It enables hearing preservation, that may be facilitated by intra-operative direct recording of CNAPs.

Our experience with multichannel ABI has demonstrated that patients were able to achieve environmental and speech sound recognition. This would help the patients in improving verbal discussion and reducing social isolation. Furthermore the functional benefits obtained in our patients in terms of lip-reading enhancement, good rhythm and speech discrimination are explainable with the direct view of the site of electrode positioning offered by the RS-TM approach and with the use of intra-operative electrical monitoring that can help for the proper placement of the electrode.

The EABRs were important in confirming the accurate placement of the ABI electrode and in determining the absence of non-auditory side-effects.

Our functional results seem to be substantially comparable to the other reports.[2,3] Therefore in our opinion the ABI implant is a successful tool for the treatment of these patients.

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