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ORIGINAL ARTICLE

Auditory steady-state response in cochlear implant patients

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KEYWORDS
Auditory steady state response;
Cochlear implant;
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Abstract
Introduction and objective: Auditory steady state responses to continuous amplitude modulated tones at rates between 70 and 110 Hz, have been proposed as a feasible alternative to objective frequency specific audiometry in cochlear implant subjects. The aim of the present study is to obtain physiological thresholds by means of auditory steady-state response in cochlear implant patients (Clarion HiRes 90K), with acoustic stimulation, on free field conditions and to verify its biological origin.
Methods: 11 subjects comprised the sample. Four amplitude modulated tones of 500, 1000, 2000 and 4000 Hz were used as stimuli, using the multiple frequency technique. The recording of auditory steady-state response was also recorded at 0 dB HL of intensity, non-specific stimulus and using a masking technique.
Results: The study enabled the electrophysiological thresholds to be obtained for each subject of the explored sample. There were no auditory steady-state responses at either 0 dB or non-specific stimulus recordings. It was possible to obtain the masking thresholds. A difference was identified between behavioral and electrophysiological thresholds of -6 ± 16, -2 ± 13, 0 ± 22 and -8 ± 18 dB at frequencies of 500, 1000, 2000 and 4000 Hz respectively.
Conclusions: The auditory steady state response seems to be a suitable technique to evaluate the hearing threshold in cochlear implant subjects.

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PALABRAS CLAVE
Potenciales evocados auditivos de estado estable;
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Campo libre;
Enmascaramiento;
Medidas objetivas

Potenciales evocados auditivos de estado estable en pacientes con implante coclear

Resumen
Introducción y objetivos: Los potenciales evocados auditivos de estado estable (PEAEE) por estimulación con tonos modulados en amplitud entre 70 y 110 Hz han sido propuestos como una alternativa factible para realizar una audiometría objetiva en pacientes con implante coclear. El objetivo del presente estudio es verificar el origen biológico de los umbrales auditivos obtenidos mediante PEAEE por estimulación acústica y en condiciones de campo libre, en pacientes con implante coclear (Clarion HiRes 90K).
Métodos: La muestra constó de 11 pacientes. Cuatro tonos modulados en amplitud con frecuencias portadoras de 500, 1.000, 2.000 y 4.000 Hz y presentados simultáneamente fueron empleados como estímulo. Se registraron series de intensidad hasta alcanzar el umbral auditivo, así como registros a 0 dB HL, con estímulos no específicos y empleando técnicas de enmascaramiento.
Resultados: El estudio permitió obtener los umbrales electrofisiológicos par cada paciente de la muestra explorada. No hubo respuesta de estado estable ni a 0 dB ni al emplear estímulos no específicos. Fue posible obtener los umbrales de enmascaramiento. Se identificó una diferencia entre los umbrales conductuales y electrofisiológicos de -6 ± 16 dB, -2 ± 13 dB, 0 ± 22 dB y -8 ± 18 dB a las frecuencias de 500, 1.000, 2.000 y 4.000 Hz, respectivamente.
Conclusiones: Los PEAEE pueden constituir una técnica apropiada para evaluar el umbral auditivo en sujetos con implante coclear.

Introduction

Audiology specialists often use cochlear implants as a treatment for patients with severe to profound hearing loss. Common techniques used to set map parameters for individual electrodes are Neural Response Telemetry (NRT)[1–3] and electrical auditory brainstem response.[4–6] Once the cochlear implant is set, behavioral audiometry in free-field conditions reveals information about how the device is working at conversational speech levels. The success of cochlear implantation in very young children (less than 2 years[7–10]) highlights the need of objective measures to assess hearing sensitivity.

Auditory steady state responses (ASSR) to continuous tones modulated in amplitude may be an approach that allowing for automated objective evaluation of audition. To evoke the ASSR stimulation can be trough by air conduction (headphones or insert earphones or loudspeaker), bone conduction (bone vibrator), or electrical (in cochlear implant subjects). ASSRs generated using headphones have extensively studied and it provides reasonably reliable estimates of hearing thresholds, e.g. in hearing impaired subjects to within 12–15 dB HL of the behavioral thresholds.[11–17] ASSRs to multiple continuous amplitude modulated (AM)-tones have previously been recorded in sound-field conditions in subjects with hearing aids[18–20] and young candidates for cochlear implant.[21,22] ASSR to multiple frequencies tones under free-sound-field conditions can provide valid hearing thresholds information and an objective indication of a patient's response to sound similar to speech. These measurements allow demonstrating the utility of the cochlear implant as part of the rehabilitation/information giving process and an outcome measure for discussion with parents of cochlear implant children.

A major barrier to using any auditory evoked potentials to evaluate cochlear implant subjects with electrical stimulation is the frequent occurrence of electromagnetic artifacts. Researchers have reported frequent electromagnetic contamination during ASSR recordings.[23–25] Several techniques are available to remove the cochlear implant artifact,[26–29] but they have not proven to be entirely satisfactory.[30] That is why any methods used to evaluate cochlear implants must consider these kinds of artifact.

The aim at recording ASSRs in cochlear implant patients using acoustic stimulation in sound-field conditions it is to determine if such artifacts are capable of contaminating the recordings. Validating the use of ASSRs in these conditions, also provide more data that will highlight the significance of introducing ASSR into routine clinical examinations and practice. Moreover, ASSR recordings in sound-field conditions can help to demonstrate that any available commercial device might assess the auditory sensitivity in cochlear implant patients.

Methods

Subjects

Eleven subjects (4 of which were females), took part in this study with chronological ages ranging between 10 and 19 years (14 ± 3). Their auditory ages (time since the cochlear implants were activated) were between 3 and 8 years. All subjects used Clarion HiRes 90K (Advanced Bionics Corp) cochlear implants, unilaterally. In all cases, behavioral