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Common cavity and custom-made electrodes: Speech perception and audiological performance of children with common cavity implanted with a custom-made MED-EL electrode

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ABSTRACT

Objective: Few studies exist on children with common cavity, fewer still on their long-term audiological development after having received a cochlear implant. Our goal was to observe and report the long-term audiological progress of children with common cavity who were implanted with a custom-made electrode.
Methods: In this longitudinal, multi-center study, 19 children were implanted with a MED-EL custom-made electrode via either single slit cochleostomy or double posterior labyrinthotomy. We observed their audiological development with a test battery consisting of Categories of Auditory Performance (CAP), Speech Intelligibility Rating (SIR), and Ling 6-Sounds tests. We tested the children 1 month prior to the surgery; at first fitting; at 1, 3, 6, 12, and 18 months post first-fitting; at 2 years after first-fitting; and, whenever possible, at 3, 4, and 5 years after first-fitting.
Results: Children with common cavity tend to steadily and significantly improve their audiological skills over time. This development may, however, be highly individual; probably in part due to relatively high levels of additional needs. Parents should be counseled to establish realistic post-implantation expectations. Surgically, contrary to our expectations, we cannot confirm that double posterior labyrinthotomy reduces intracochlear electrode movement or that the MED-EL custom electrode leads to fewer incidences of intra- or post-implantation complications.
Conclusions: Cochlear implantation is a safe and effective treatment option in children with common cavity. The majority of children with CC derive significant audiological benefit from implantation. Intra- and post-surgical complications, while serious, and be dealt with effectively in most cases.

1. Introduction

Inner-ear malformations are a significant cause of hearing loss and are thought to be responsible for about 28.4% of congenital sensorineural hearing loss cases [1]. Our ability to distinguish and classify different malformations has progressed with technological advancements. In 1987, Jackler et al. [2] created a widely referenced classification system based on polytomography. This system was refined in 2002 with the use of computed tomography (CT) and magnetic resonance imaging (MRI), both of which produce images with much better resolution than had been possible [3]. Cochlear malformations can now be categorized in a descending scale of physiological severity: (1) Michel's deformity,

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(2) cochlear aplasia, (3) common cavity (CC) deformity, (4) cochlear hypoplasia, (5) incomplete partition type I, and (6) incomplete partition type II [3].

Common cavity (CC) can be characterized by ill-defined and rudimentary but nonetheless distinguishable cochlea, vestibule, and semicircular canals. The cochlea is round or ovoid and the internal auditory meatus (IAM) usually enters the cavity at its center. Auditory neural tissue and spiral ganglion cell equivalents are along the walls of the cavity, although in significantly lower numbers than in the fully formed inner-ear. The presence of spiral ganglion cells and neural tissue is particularly important for cochlear implantation as they make hearing physiologically possible [5].

Intraoperative cerebrospinal fluid (CSF) gushers and/or postoperative meningitis in CC subjects may present a challenge during CI surgery. Surgeons, however, have developed multiple techniques to deal with this [6–9] and cochlear implantation (CI) is a safe and effective approach for treating deafness due to inner-ear malformations, including CC [9–11].

The question remains: what long-term auditory and speech progress do people with CC make after implantation? The post-CI auditory speech progress results of patients with generally malformed cochleae have been well studied, e.g., Eisenman et al. [12]; van Wermeskerken et al. [13]; and Luntz et al. [14]. To our knowledge, however, only one other study has focused specifically on the follow-up audiological results of children with CC and a CI [15]. Using MAIS, CAP, SIR, and open set one-syllable, and two-syllable word tests administered in regular intervals in the 48 months after implantation, they reported that hearing ability increased with age, provided that the surgery was carefully planned and performed.

This study aims to document and assess the speech perception and production outcomes in children with a CC who have received a cochlear implant with a custom-made MED-EL electrode.

2. Methods

2.1. Subject inclusion criteria

To be included in the study, subjects had to

(1) have a common cavity (CC) confirmed by MRI,
(2) be implanted with a MED-EL COMBI 40+ implant system with a custom-designed electrode and wear either a TEMPO+ behind-the-ear speech processor or CIS PRO+ body-worn speech processor,
(3) meet the participating cochlear implant centers' implant candidacy criteria,
(4) have the same native language as that used in their test clinic, and have a parent give their informed consent.

2.2. Custom-made electrodes

All patients were implanted with a custom-made MED-EL common cavity electrode featuring a prolonged apical part ending with a small platinum ball [10]. The extension is made purely of inert silicone carrier containing platinum wire. In all other respects, the custom-made implants are identical to the regular MED-EL implant electrodes. The electrodes come in 3 sizes: standard, medium, and compressed. Each subject had a radiological examination before implantation to determine which of the 3 electrodes was correct for his/her cochlear cavity (Fig. 1).

2.3. Surgical techniques

Surgical teams inserted the electrode through either the double posterior labyrinthotomy or a single slit cochleostomy. The double posterior labyrinthotomy implantation technique was detailed by Beltrame [10]. In single slit cochleostomy, surgeons make a single postbox-like slit in the same position as the double posterior labyrinthotomy and insert an electrode loop. The single slit cochleostomy is the faster and easier to perform of the 2 techniques, however it may result in more CSF gushers and may have an increased potential for meningitis. Before surgery, the surgical team made sure all implantees had been vaccinated against meningitis.

2.4. Testing

To evaluate the subjects' audiological performance, we conducted a battery of tests 1 month prior to the surgery; at first fitting; at 1, 3, 6, 12, and 18 months post first-fitting; at 2 years after first-fitting; and, whenever possible, at 3, 4, and 5 years after first-fitting. The test battery consisted of Categories of Auditory Performance (CAP), Speech Intelligibility Rating (SIR), and Ling 6-Sounds test. We also completed a checklist detailing telemetry status, fitting thresholds, and maximum comfortable loudness (MCL) levels.

The CAP and SIR tests both evaluate and rate children during their spontaneous play. The CAP [16] rates children's everyday listening skills from 0 to 7 (7 is the best) while the SIR [17] rates children's speech intelligibility from 1 to 5 (5 is the best). CAP and SIR scores are assigned after the test session; either from other professionals and/or the family; or from a representative video sample. Ideally, the rating is based on observation in more than one context. If the child is on the borderline between 2 scores, the lower one is given.

The Ling 6-sounds test [18] evaluates children's ability to detect and discriminate 6 basic sounds (*a*, *e*, *m*, *u*, *sh*, *s*). Each sound is presented to the child in an auditory-only manner. The child must then identify – usually by pointing to a card with an easily recognizable pictorial representation of the sound – which sound he/she heard.

An audiologist completed the checklist of detailed telemetry status, fitting thresholds, and MCL using a DIB 2.0 interface box with the most recent STUDIO+ fitting software.

2.5. Statistical analyses

We used descriptive statistics to report demographic (e.g. age, gender) and baseline characteristics (e.g. etiology). Quantitative data are presented as mean, median, and range (minimum and

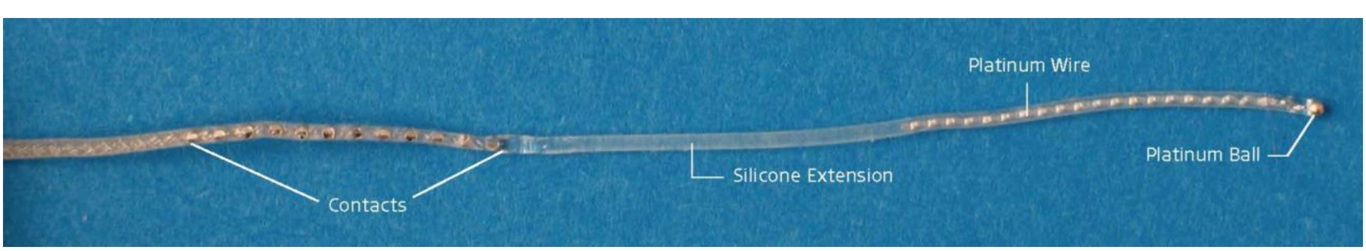

Fig. 1. A custom made common cavity electrode. The platinum ball at the nonactive terminal end of the silicon array allows surgeons to pull the implant end out of the inferior labyrinthotomy with a special designed hook.