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Extracochlear eight-channel electrode system

by

P. Banfai, G. Hortmann, S. Kubik, A. Karczag, P. Lüers and W. Sürth
(Düren, West Germany)

Summary

The Cologne-Düren research group has developed a new extracochlear eight-channel electrode system. The first observations on six cases have shown encouraging psychoacoustic results.

The Cologne-Düren research group has carried out 52 cochlear implants since 1979. In 46 cases, eight single electrodes have been implanted evenly into boreholes in the medial wall of the tympanic cavity corresponding to the projection of the cochlea, so that the inner ear cavities were not opened. This intracochlear extrascalar method has the following advantages:

1. By avoiding opening of the scalae, further damage of the ganglion cells or the auditory nerve fibers is avoided.
2. By the different placing of the electrodes, a frequency analysis is made possible in accordance with the 'location' principle of the cochlea.

Although the electrical measurements as well as the psychoacoustic results have been encouraging, and a granulating otitis media has been observed in only two cases so far as a local reaction in the tympanum, we have attempted to achieve further improvements in the field of surgical technique. We intend to alter the surgical technique in accordance with the following criteria:

1. Simplification of the tedious and time-consuming anchoring of the eight single electrodes.
2. If possible, reduction of the later danger of infection, local reaction in the tympanum. This danger arises in that:
   - 2.1 the single electrodes largely fill the middle-ear cavities,
   - 2.2 tubal ventilation can be restricted,
   - 2.3 granulation tissue can form from the boreholes, favouring further infections,
   - 2.4 the repositioning of the tympanic membrane is made more difficult in some cases because of the space required by the electrodes.

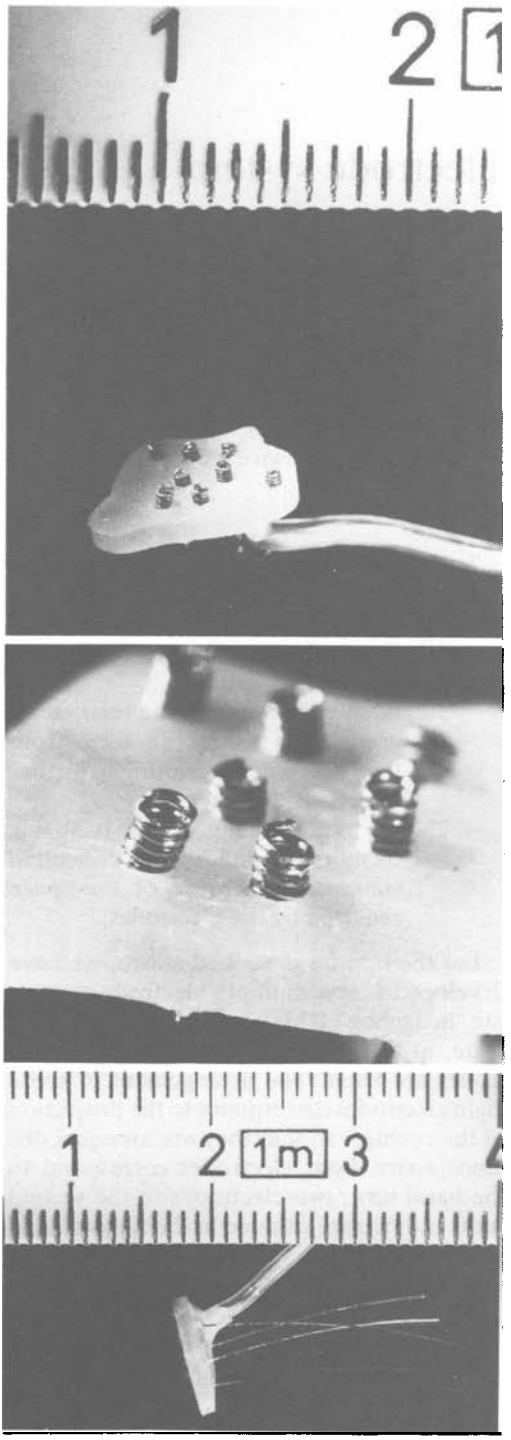
For the reasons described above, we have developed a new multiple electrode system, the 'hedgehog'. This electrode consists of a plate, at the distal end of which eight electrodes are fixed. The arrangement of these eight electrodes corresponds to the projection of the cochlea, so that they are an equal distance apart. Four electrodes correspond to the basal turn, two electrodes to the second turn, and two are situated in the helicotremal region (Fig. 1).

The electrodes end spirally, in order to balance out the unevenness of the promontory wall (Fig. 2).

Fixation of the contact plate in the tympanic

Department of Otorhinolaryngology and Special Department for the Deaf (Head Physician: Prof. Paul Banfai, MD), St. Marien-Hospital, Düren, affiliated with the Department of Otorhinolaryngology, University of Cologne (Cologne-Düren Cochlear Implant Research Group)

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FIGS. 1, 2 and 3
Contact plate with the eight fixed active electrodes.

cavity is ensured by a beak-like projection at the end of the plate and by spring wire attached to the proximal surface of the plate (Fig. 3).

Corresponding to the windows, there are recesses at the posterior edge of the plate.

Surgical technique

A retroauricular incision is made, and this is followed by mobilization of the auditory canal skin together with the tympanic membrane. The bony auditory canal is widened:

1. backwards, so that both windows can be overlooked,
2. forwards, 3–4 mm into the tube,
3. upwards, the lateral attic wall being ablated to the extent that the malleus and incus can be removed.

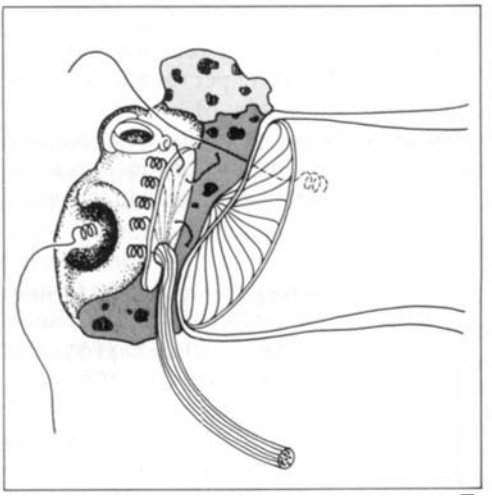
The semicanal for the tensor tympanic muscle is opened, the muscle is severed and beginning from the cochleariform process, a section of the muscle 3–4 mm is removed. The unevenness of the promontory is reduced with a diamond drill, after mobilization of the mucosa, and the mucosa is later replaced. The electrode plate is now placed and fixed in the tube by means of the beak-shaped promontory, and also with the spring wires in the hypotympanum and attic (Figs. 4, 5 and 6). Any unevenness of the medial wall of the tympanic cavity still present is balanced by the spring effect of the spiral electrodes. The two inactive electrodes could be placed either: (a) into the attic and into the antrum; or (b) into the round window niche and into the tube. After repositioning of the tympanic membrane and auditory canal, the retroauricular incision is closed layer by layer. The percutaneous plug which is still applied at present is fixed into a bone fossa formed retroauricularly with wires (as it was applied with the eight single electrodes). Up to the end of September 1983, we have carried out six cochlear implants with the new 'hedgehog' electrode system.

Electrical measurements

Experience so far has shown that the electrical measurements determined even a few

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FIGS. 4 and 5

Schematic representation of the positioning of the contact plate with the fixed electrodes (hedgehog). The unevenness of the medial wall of the tympanic cavity is compensated by the spring properties of the spiral electrodes.

days after the operation are highly informative with regard to the chances of success of the cochlear implant. Five days after the operation, the electrical impedances and the stimulus thresholds are first determined. The

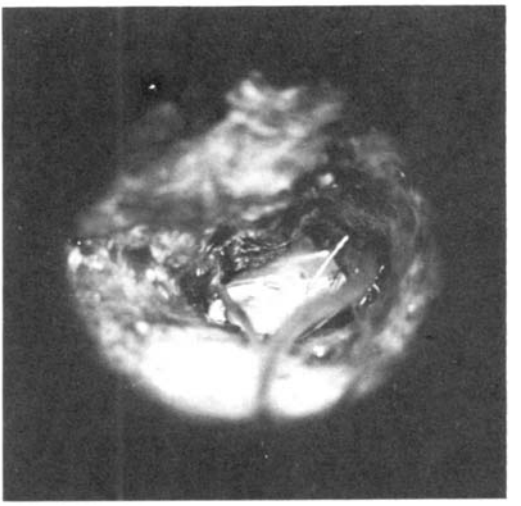


FIG. 6

Operative photograph of the placing of the contact plate in the tympanic cavity.

impedances and stimulus thresholds recorded with the new electrode system have revealed the same values as the eight single electrodes.

The average values of the impedances are 4.3 kOhm and the electrical stimulation thresholds is at 26.5 μA. The values are stabilized after about 30 days.

Psychoacoustics

Although the final evaluation of the psychoacoustic values has not been possible in the short time so far available, we can already make certain inferences from the corresponding test batteries:

1. Recognition of background noises. Whereas 88 per cent of our 35 patients in whom the rehabilitation program was concluded were able to recognize background noises, a value of 80 per cent has already been reached in the six patients roughly three weeks after implantation of the hedgehog system.
2. The recognition of three different human voices has been recorded in 75 per cent with the new system, as compared to 80 per cent with the eight single electrodes.

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3. Recognition of the number of syllables was observed in 87 per cent as compared to 97 per cent.
4. Differences in pitch (tone) in the octave range was discerned in 85 per cent with the hedgehog, as compared to 84 per cent with the eight single electrodes.
5. Lip-reading improved from 34 per cent for monosyllabic words and 55 per cent for sentences to 69 per cent and 92 per cent respectively. After application of the single electrodes, the values were raised from 34 per cent and 54 per cent to 71 per cent and 79 per cent respectively.
6. Testing of closed language showed 65 per cent for monosyllables and 82 per cent for sentences, as compared to 66 per cent and 97 per cent respectively. It should be emphasized that the values obtained with the new system were already determined three weeks after the operation, whereas the comparison values with the single electrodes were obtained after conclusion of the rehabilitation program (after 6–9 months).
7. On average, the vowels were correctly recognized in 78 per cent of the cases with the speech processor alone (Fig. 7).

Response →

Stimulus ↓	a	e	i	o	u
a	90	4		6	
e		80	20		
i			73		17
o				78	22
u			12	17	71

FIG. 7

Averaged responses of 6 patients 3 weeks after operation.

8. The test with the 'five consonants' (DNZST) revealed the following values: Lip-reading alone was correctly recognized in 68 per cent, with the language processor (without lip-reading) in 79 per cent. Confusion of voiced and unvoiced consonants was 33 per cent with lip-reading alone and only 15 per cent in use of the stimulator alone (Fig. 8).
9. The test battery with the logatome showed that the 'place distinction' in lipreading was better (100 per cent) than in the use of

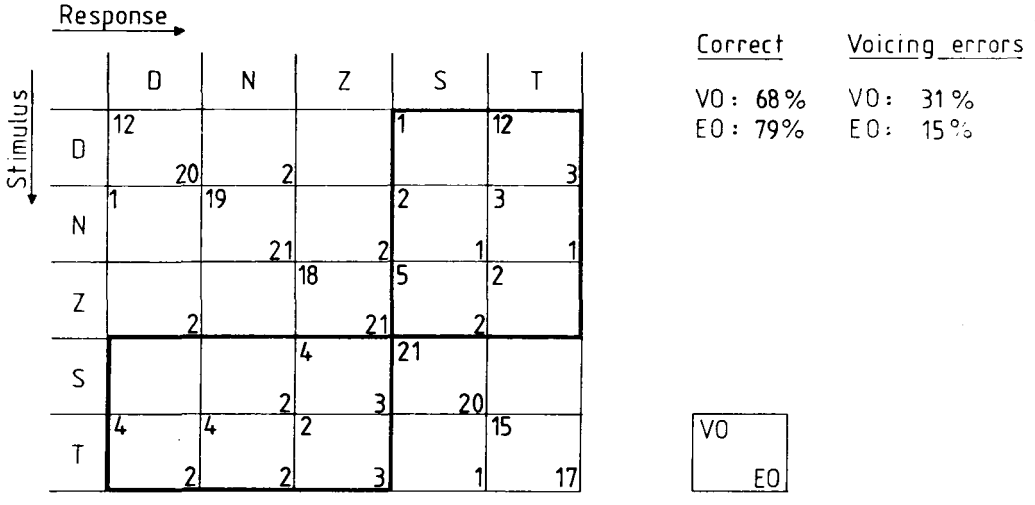


FIG. 8

Consonant discrimination test in vowel-consonant-vowel context (nonsense syllable) where the vowel is a
EO = Electrical Stimulus only
VO = Vision only
Averaged responses of 6 patients 3 weeks after operation.

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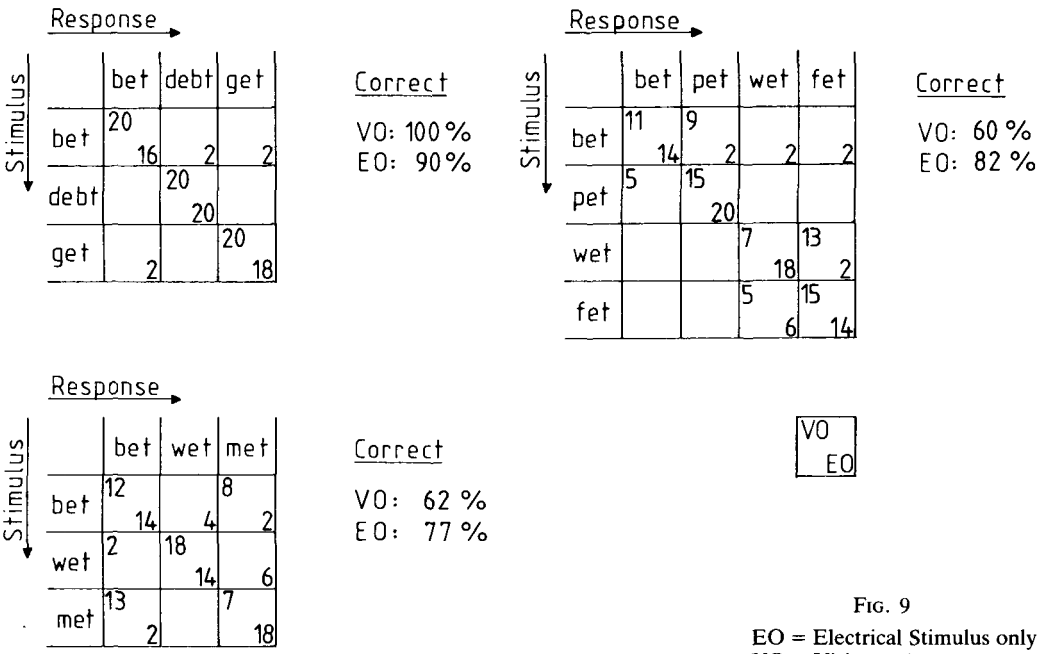


FIG. 9

EO = Electrical Stimulus only
VO = Vision only
Averaged responses of 6 patients 3 weeks after operation.

the instrument alone. On the other hand, the 'manner distinction' with the instrument provided better results (77 per cent) than lip-reading alone (62 per cent). Furthermore, the 'voicing distinction' also showed a better result with the instrument alone (82 per cent) than with lip-reading alone (60 per cent) (Fig. 9).

Conclusion

According to experience available so far, our new extracochlear electrode system has yielded electrical measurements and psychoacoustic values which were almost equivalent to those of the previous extrascalar (intramural) intracochlear eight single-channel system.

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Address for correspondence:
Professor Dr P. Banfai
HNO
St. Marien-Hospital
Hospitalstrasse 44
D-5160 Düren 4 (Birkesdorf)
West Germany

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