Partial deafness cochlear implantation

Introduction

1. Adult hearing loss: high frequency sensorineural deficit, damage to hair cells in the basal end of the cochlea, inability to distinguish the higher-frequency sounds of speech
2. Noise exposure, presbycusis and administration of ototoxic medications
3. Apical hair cells still function normally, permitting the accurate perception of low-frequency sounds.
4. Traditional acoustic amplification is efficient for low frequencies, high-frequency range (>1,000 Hz, >70dB HL) hardly be compensated
5. Powerful hearing aid: possible induce hearing loss

![Frequency Chart]

Cochlear implant (CI)

1. Profound prelingually deafened children and profound postlingually deafened adults and children.
2. Provide high-frequency information up to 6,000 Hz, “mechanical” or “raspy”
3. Usable residual hearing capacity may be destroyed by intracochlear application of the electrode array
4. Leake: electrical stimulation of the auditory nerve can partially prevent the degeneration, but trauma to the basilar membrane, osseous spiral lamina or modiolar wall can offset this protective effect and cause subsequent local degeneration of neural elements(1)
5. The most successful implant: only realize perhaps 6 to 8 channels of distinct “place-frequency” information ➔ can’t understand speech in background noise; accurate perception and enjoyment of music.
6. Poorer performance in detecting pitch change (frequency difference limens), perception of direction of pitch change (higher or lower)
1999, Electric-Acoustic stimulation of the auditory system, (2) Prof. Christoph von Ilberg

Adult normal-hearing cats and pigmented guinea pigs (about 800 g)
1. Extracochlear electric stimulation at round window
2. Acoustic stimulation (short tone bursts), electric stimulations were combine
3. Most frequently the acoustically evoked pattern was prominent
4. Acute and chronic electric stimulation of the normal cochlea doesn’t substantially interfere with the normal acoustically evoked compound action potentials

First clinical patient experience
1. MedEL Combi-40+ CI in the right ear, insertion depth 20 mm

2. Sentence recognition increased from 0% with CI or HA alone to 58% under the EAS condition
3. Central auditory system: combine an acoustic stimulation of residual hearing with direct electric stimulation of the cochlear nerve without disturbing interference.

2003, short distance (10 mm) into the cochlea, Dr. Bruce J Gantz & Christopher Turner, Iowa/Nucleus Hybrid Cochlear Implant (3,4,5,6)
1. In an attempt to limit the intracochlear damage and to preserve residual low-frequency hearing
2. Criteria: postlingual hearing impairment CNC word understanding between 10% and 50% with an appropriately fitted hearing aid in the worse ear, and 60% or worse in the better hearing ear.
3. Short 10 x 0.4 x 0.2 mm electrode has been developed. Standard electrodes are about 1.2mm in diameter
4. Internal implant; ground; reserve electrode (16 channel); active electrode

5. Original 6 mm device produced an unpleasant high pitch percept.

6. The electrode was lengthened to 10 mm to place the electrode array at a more apical location, with the most apical electrode now at approximately 2,500 to 3,000 Hz (Greenwood place frequency map)

7. Cochleostomy and entering the scala tympani: like “drill-out” stapes for otosclerosis.

8. Inner ear is opened: bleeding must be controlled, and suction must be avoided

9. The cochleostomy is created anterior inferiorly to the round window.

10. Dacron collar to limit the intracochlear placement to 10 mm.

11. Prevent injury to the ascending basal turn of the cochlea and electrode from curling on itself

12. The tip of the 10 mm electrode curves into the ascending segment but does not extend to the upper basal turn of the cochlea.

13. The range of change was 0 dB to 30 dB.
14. Potential deterioration of residual low frequency hearing over time? In a review of our clinic’s records for adults with severe high-frequency HL, low frequency (less than 2,000 Hz) thresholds remain remarkably constant over many years (up to 20 years) and lose less than 0.75 dB/year on average.

15. Stability of low frequency residual hearing: there was an average of only 1.05 dB hearing deterioration per year in the low frequencies and that presbycusis accounted for approximately one third to one half of this decline.

16. Longer distance (17-20 mm) into the cochlea (e.g., Baumgartner; Kiefer, et al.; Skarzynski; Dye at al.) MED-EL Combi-40 electrode, Nucleus 24 Contour.(7,8,9,10)

17. Some subjects achieve between 60% and 70% CNC (consonant-Nucleus-Consonant) word recognition with a six channel 10 mm electrode using electrical speech processing only

18. Longer electrode may deliver more information? if individuals with significant residual hearing are to benefit from this technology, preservation of residual hearing is of paramount consideration.

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1. Dorman et al (11).: lowpass filtered at 500 Hz with a 90 dB/octave roll-off and
software version of a cochlear implant signal processor: A gap of 500 Hz allowed 90% correct sentence recognition for difficult sentence material. A gap of 3.2 kHz allowed only 45% sentence recognition.

2. The gap between acoustic and electric stimulation should be minimized.

3. Significant risk associated with a very shallow insertion: if hearing is lost, then speech understanding with electrical stimulation alone may be no better than the level of speech understanding achieved before the surgery.

4. 10 mm insertion leave a larger gap than a 20 mm insertion (near the 1 kHz place)

5. Lead to deterioration or even loss of residual hearing as a result of cochlear implantation:
   I. acoustic trauma due to drilling of the bone, especially at the bony shell of the cochlea
   II. Mechanical damage due to electrode insertion, e.g. fractures of the osseous spiral lamina, disruption of the basilar membrane and tearing of the lateral spiral ligament or the endothelial layer of the scala tympani
   III. Disturbance of homeostasis within the cochlear fluid spaces
   IV. Potential bacterial infection
   V. Fibrosis of the cochlea, due to a foreign body reaction to the silastic electrode carrier or the platinum iridium contacts of the electrodes or as a sequel to inflammatory reactions.

6. A “soft” surgery protocol: 1-1.2-mm cochleostomy hole anterior and inferior to the round window; Nucleus Contour Advance electrode array inserted using the “Advance-off-stylet” technique; insertion depth controlled by means of three square marker ribs left outside the cochleostomy hole.

7. Cochlear view X-ray images: the depth of insertion varied between 300 and 430°

8. Kiefer et al. (2005): 1 year following implantation, thresholds in 12 patients had decreased from preoperative levels by mean values of 20 dB at 125 Hz, 25dB at 250 Hz, 20 dB at 500 Hz, and 5 dB at 1000 Hz.

9. Chris James (2005), 12 pts: the median increases of 23, 27 and 33 dB presented here for frequencies of 125, 250 and 500 Hz, 2 was a complete loss of residual hearing due to problems encountered during surgery.

10. Insertion angles > 400° appeared to impact hearing preservation at frequencies of 250 - 500 Hz.

11. Skarzynski, 2006, 10 pts
Conclusion

1. Two surgical strategies: have been successful in preservation of low-frequency hearing

2. Combined electrical and acoustical speech processing improved word understanding as compared with their preoperative hearing with bilateral hearing aids

3. The improvement of speech in noise, melody recognition, enjoy listening to music, perception of emotion in speech, recognition of speaker gender and even the recognition of individual talkers.

4. Preservation of any residual hearing must be a goal of all future CI surgeries.

5. In both the long and short-electrode approaches, a few patients do lose all their acoustic hearing at some time following surgery.


