

## REFERENCES

- Advanced Bionics Corporation (8-21-2000). *Clarion system: Hifocus electrode* [online]. Available: [http://www.cochlearimplant.com/shortcut\\_hifocus.html](http://www.cochlearimplant.com/shortcut_hifocus.html).
- Allen, J. B. (1985). Cochlear modelling. *IEEE ASSP Magazine*, 3-29.
- ANSYS (1997). *ANSYS Modelling and Meshing Guide* USA: SAS IP, Inc.
- ANSYS (1999). *ANSYS Electromagnetic Field Analysis Guide (pp. 13-1-13-8)*. USA: SAS IP, Inc.
- Bertoluzza, A., Fagnano, C., Monti, P., Simoni, R., Tinti, A., Tosi, M. R., & Caramazza, R. (1992). Raman spectroscopy in the study of biocompatibility. *Clinical Materials*, 9, 49-68.
- Black, R. C., & Clark, G. M. (1980). Differential electrical stimulation and the auditory nerve. *Journal of the Acoustical Society of America*, 67.
- Black, R. C., Clark, G. M., & Patrick, J. F. (1981). Current distribution measurements within the human cochlea. *IEEE Transactions on Biomedical Engineering, BME-28*, 721-724.
- Briaire, J. J., & Frijns, J. H. M. (2000). 3D mesh generation to solve the electrical volume conduction problem in the implanted inner ear. *Simulation Practice and Theory*, 8, 57-73.
- Brown, C. J., Abbas, P. J., Bertschy, M., Tyler, R. S., Lowder, M., Takahashi, G., Purdy, S., & Gantz, B. J. (1995). Longitudinal assessment of physiological and psychophysical measures in cochlear implant users. *Ear and Hearing*, 16(5), 439-449.
- Brummer, S. B., & Turner, M. J. (1975). Electrical stimulation of the nervous system: The principle of safe charge injection with noble metal electrodes. *Bioelectrochemistry and Bioenergetics*, 2, 13-25.
- Brummer, S. B., & Turner, M. J. (1977). Electrical stimulation with Pt electrodes: II-Estimation of maximum surface redox (theoretical non-gassing) limits. *IEEE Transactions on Biomedical Engineering, BME-24*, 440-443.
- Busby, P. A., Whitford, L. A., Blamey, P. J., Richardson, L. M., & Clark, G. M. (1994).

- Pitch perception for different modes of stimulation using the Cochlear multiple-electrode prosthesis. *Journal of the Acoustical Society of America*, 95(5), 2658-2669.
- Clark, G. M. (1996). Electrical stimulation of the auditory nerve: the coding of frequency, the perception of pitch and the development of cochlear implant speech processing strategies for profoundly deaf people. *Clinical and Experimental Pharmacology and Physiology*, 23, 766-776.
- Clark, G. M., Shute, S. A., Shepherd, R. K., & Carter, T. D. (1995). Cochlear implantation: Osteoneogenesis, electrode-tissue impedance, and residual hearing. *Annals of Otology, Rhinology and Laryngology Supplement (United States)*, 166 , 40-42.
- Clark, G. M., Tong, Y. C., & Patrick, J. F. (1990). *Cochlear Prostheses* Great Britain: Churchill Livingston.
- De Sauvage, R. C., da Costa, D. L., Erre, J.-P., & Aran, J. M. (1997). Electrical and physiological changes during short-term and chronic electrical stimulation of the normal cochlea. *Hearing Research*, 110, 119-134.
- Donaldson, N. d. N., & Donaldson, P. E. K. (1986). When are actively balanced ('Lilly') stimulating pulses necessary in a neurological prosthesis? II pH changes; Noxious products; Electrode corrosion; Discussion. *Medical and Biological Engineering and Computing*, 24, 50-56.
- Dorman, M. F., Smith, L. M., Dankowski, K., McCandless, G., & Parkin, J. L. (1992). Long-term measures of electrode impedance and auditory thresholds for the Ineraid cochlear implant. *Journal of Speech and Hearing*, 35, 1126-1130.
- Eddington, D., Dobelle, W., Brackmann, D. E., Mladejousky, M., & Parkin, J. L. (1988). Auditory prosthesis research with multiple channel intracochlear stimulation in man. *Annals of Otology, Rhinology and Laryngology Supplement*, 87, 5-39.
- Finley, C. C., Wilson, B. S., & White, M. W. (1990). Models of neural responsiveness to electrical stimulation. In Miller, J. M. and Spelman, F. A., *Cochlear Implants* (pp. 55-96). New York: Springer-Verlag Inc.
- Frankenhaeuser, B., & Huxley, A. F. (1964). The action potential in the myelinated

- nerve fibre of *Xenopus Laevis* as computed on the basis of voltage clamp data. *Journal of Physiology*, 171, 302-315.
- Frijns, J. H. M. (1995). *Cochlear implants: A modelling approach*. Ph.D Thesis, Rijksuniversiteit, Leiden, The Netherlands.
- Frijns, J. H. M., Briaire, J. J., & Schoonhoven, R. (2000). Integrated use of volume conduction and neural models to simulate the response to cochlear implants. *Simulation Practice and Theory*, 8, 75-97.
- Frijns, J. H. M., de Snoo, S. L., & Schoonhoven, R. (1995). Potential distributions and neural excitation patterns in a rotationally symmetric model of the electrically stimulated cochlea. In Frijns, J. H. M., *Cochlear Implants. A Modelling Approach* (pp. 93-124). Den Haag: CIP-Data Koninklijke Bibliotheek.
- Fu, Q.-J., & Shannon, R. V. (1999a). Effects of electrode location and spacing on phoneme recognition with the nucleus-22 cochlear implant. *Ear and Hearing*, 20, 321-331.
- Fu, Q.-J., & Shannon, R. V. (1999b). Effects of electrode configuration and frequency allocation on vowel recognition with the nucleus-22 cochlear implant. *Ear and Hearing*, 20, 332-344.
- Fujita, S., & Ito, J. (1999). Ability of nucleus cochlear implantees to recognize music. *Annals of Otology, Rhinology and Laryngology*, 108, 634-640.
- Girzon, G. (1987). *Investigation of current flow in the inner ear during electrical stimulation of intracochlear electrodes*. MS Thesis in EE&CS, MIT, Cambridge, Massachusetts.
- Golden, B. (2-1-1997). *Cochlea* [online]. Available:  
[http://www.yavapai.cc.az.us/division/sci\\_math/biology/golden/a&p/AP112-22.HTM](http://www.yavapai.cc.az.us/division/sci_math/biology/golden/a&p/AP112-22.HTM).
- Gonzalez, G., & Huerta, M. A. (1979). Surface potentials of spheroidal volume conductors excited by an electric dipole source. *International Journal of Electronics*, 47, 213-220.
- Grill, W. M., & Mortimer, J. T. (1994). Electrical properties of implant encapsulation tissue. *Annals of Biomedical Engineering*, 22, 23-33.
- Gstoettner, W., Franz, P., Hamzavi, J., Plenk, H. Jr., Baumgartner, W., & Czerny,

- C. (1999). Intracochlear position of cochlear implant electrodes. *Acta Oto-Laryngologica*, 119, 229-233.
- Hanekom, J. J., & Shannon, R. V. (1996). Place pitch discrimination and speech recognition in cochlear implant users. *The South African Journal of Communication Disorders*, 43, 27-40.
- Hanekom, J. J., & Shannon, R. V. (1998). Gap detection as a measure of electrode interaction in cochlear implants. *Journal of the Acoustical Society of America*, 104(4), 2372-2384.
- Hatsushika, S.-I., Shepherd, R. K., Tong, Y. C., Clark, G. M., & Funasaka, S. (1990). Dimensions of the scala tympani in the human and cat with reference to cochlear implants. *Annals of Otology, Rhinology and Laryngology*, 99, 871-876.
- Hirsch, H. G. (1993). Intelligibility improvements of noisy speech for people with cochlear implants. *Speech Communication*, 12, 261-266.
- Huang, C. Q., Shepherd, R. K., Carter, P., Seligman, P., & Tabor, B. (1999). Electrical stimulation of the auditory nerve: Direct current measurement *in vivo*. *IEEE Transactions on Biomedical Engineering*, 46, 461-470.
- Johnstone, B. M., Johnstone, J. R., & Pugsley, I. D. (1966). Membrane resistance in endolymphatic walls of the first turn of the guinea-pig cochlea. *Journal of the Acoustical Society of America*, 40(6), 1398-1404.
- Jolly, C. N., Spelman, F. A., & Clopton, B. M. (1996). Quadrupolar stimulation for cochlear prostheses: Modeling and experimental data. *IEEE Transactions on Biomedical Engineering*, 43, 857-865.
- Jolly, C. N., Clopton, B. M., Spelman, F. A. & Lineaweaver, S. K. (1997). Guinea pig auditory nerve response triggered by a high density electrode array. *Medical Progress through Technology*, 21 (suppl.), 13-23.
- Kessler, D. K. (1999). The Clarion multi-strategy cochlear implant. *Annals of Otology, Rhinology and Laryngology*, 108 (Suppl 177), 8-16.
- Kou, B. S., Shipp, D. B., & Nedzelski, J. M. (1994). Subject benefits reported by adult Nucleus 22-channel cochlear implant users. *Journal of Otolaryngology (Canada)*, 23(1), 8-14.
- Kral, A., Hartmann, R., Mortazavi, D., & Klinke, R. (1998). Spatial resolution of

- cochlear implants: the electrical field and excitation of auditory afferents. *Hearing Research*, 121, 11-28.
- Leake, P. A., Kessler, D.K., & Merzenich, M.M. (1990). Application and safety of cochlear prostheses. In Agnew F.A. & McCreery, D.B., *Neural Prostheses. Fundamental Studies*. (pp.253-296). New Jersey: Prentice Hall.
- Leake, P. A., Snyder, R. L., Hradek, G. T., & Rebscher, S. J. (1992). Chronic intracochlear electrical stimulation in neonatally deafened cats: Effects of intensity and stimulating electrode location. *Hearing Research*, 64(1), 99-117.
- Leeson, T. S. & Leeson, C. S. (1981). *Histology* (pp. 572-581). Philadelphia: W.B. Saunders Company.
- Liang, D. H., Lusted, H. S., & White, R. L. (1999). The nerve-electrode interface of the cochlear implant: Current spread. *IEEE Transactions on Biomedical Engineering*, 46, 35-43.
- Lim, H. H., Tong, Y. C., & Clark, G. M. (1989). Forward masking patterns produced by intracochlear electrical stimulation of one and two electrode pairs in the human cochlea. *Journal of the Acoustical Society of America*, 86(3), 971-980.
- Linthicum, F. H. Jr., Fayad, J., Otto, S. R., Galey, F. R., & House, W. F. (1991). Cochlear implant histopathology. *American Journal of Otology*, 12(4), 245-311.
- Loizou, P. C. (1999). Signal-processing techniques for cochlear implants. *IEEE Engineering in Medicine and Biology*, 18(3), 34-46.
- Marsh, M. A., Coker, N. J., & Jenkins, H. A. (1992). Temporal bone histopathology of a patient with a nucleus 22-channel cochlear implant. *The American Journal of Otology*, 13, 241-248.
- McKay, C. M., O'Brien, A., & James, C. J. (1999). Effect of current level on electrode discrimination in electrical stimulation. *Hearing Research*, 136, 159-164.
- Miller, A. L., Morris, D. J., & Pfingst, B. E. (2000). Effects of time after deafening and implantation on guinea pig electrical detection thresholds. *Hearing Research*, 144, 175-186.
- Miller, J. F. & Spelman, F. A. (1990). Fundamental research for development of cochlear research . In Miller, A. L. and Spelman, F. A., *Cochlear Implants: Models of the Electrically Stimulated Ear* (pp. 413-418). New York: Springer-

- Verlag.
- Miyoshi, S., Shimizu, S., Matsushima, J., & Ifukube, T. (1999). Proposal for a new method for narrowing and moving the stimulated region of cochlear implants: Animal experiment and numerical analysis. *IEEE Transactions on Biomedical Engineering*, 46, 451-460.
- Nanas, J. M. (1988). Biocompatibility overview: Classes of materials, inflammation, infection. In Webster, J. G., *Encyclopedia of Medical Devices and Instrumentation* (pp. 181-194). Wiley.
- National Institutes of Health (1995). Cochlear implants in adults and children. NIH Consensus Statement. 1-30.
- Pfingst, B. E. (1990). Changes over time in thresholds for electrical stimulation of the cochlea. *Hearing Research*, 50(1-2), 225-236.
- Pfingst, B. E., Morris, D. J., & Miller, A. L. (1995). Effects on electrode configuration on threshold functions for electrical stimulation of the cochlea. *Hearing Research*, 85, 76-84.
- Pfingst, B. E., Holloway, L. A., Zwolan, T. A., & Collins, L. M. (1999). Effects of stimulus level on electrode-place discrimination in human subjects with cochlear implants. *Hearing Research*, 134, 105-115.
- Plonsey, R. (1969). *Bioelectric Phenomena. McGraw-Hill series in Bioengineering*. New York: McGraw-Hill Book Company.
- Rattay, F. (1990). *Electrical Nerve Stimulation. Theory, Experiments and Applications*. Vienna: Springer-Verlag.
- Rattay, F. (1999). The basic mechanism for the electrical stimulation of the nervous system. *Neuroscience*, 89, 335-346.
- Rattay, F., Leao, R. N., & Felix, H. (2001). A model of the electrically excited human cochlear neuron. II. Influence of the 3-dimensional cochlear structure on neural excitability. *Hearing Research*, 153, 64-79.
- Rebscher, S. J., Talbot, N., Bruszewski, W., Heilmann, M., Brasell, J., & Merzenich, M. M. (1996). A transparent model of the human scala tympani cavity. *Journal of Neuroscience Methods*, 64, 105-114.
- Reilly, J. P., Freeman, V. T., & Larkin, W. D. (1985). Sensory effects of transient

- electrical stimulation. Evaluation with a neuroelectric model. *IEEE Transactions on Biomedical Engineering, BME-32(12)*, 1001-1011.
- Robblee, L. S. & Rose, T. L. (1990). Electrochemical guidelines for selection of protocols and electrode materials for neural stimulation. In Agnew, W. F. and McCreery, D. B., *Neural prostheses. Fundamental studies* (pp. 25-66). Englewood Cliffs, New Jersey: Prentice-Hall, Inc.
- Rodenhiser, K. L., & Spelman, F. A. (1995). A method for determining the driving currents for focused stimulation in the cochlea. *IEEE Transactions on Biomedical Engineering, 42(4)*, 337-342.
- Roland, J. T., Fishman, A. J., Alexiades, G., & Cohen, N. L. (2000). Electrode to modiolus proximity: A fluoroscopic and histologic analysis. *American Journal of Otology, 21*, 218-225.
- Rubinstein, J. T., Soma, M., & Spelman, F. A. (1985). Mixed boundary value problems in the implanted cochlea: An analytical model of a cylindrical banded electrode array. *IEEE Seventh Annual Conference of the Engineering in Medicine and Biology Society*, 1120-1123.
- Rubinstein, J. T. (1988). *Quasi-static analytical models for electrical stimulation of the auditory nervous system*. Ph.D. Thesis, University of Washington.
- Ruddy, H. A., & Loeb, G. E. (1995). Influence of materials and geometry on fields produced by cochlear electrode arrays. *Medical and Biological Engineering and Computing, 33*, 793-801.
- Schindler, R. A., & Kessler, D. K. (1989). State of the art cochlear implants: The UCSF experience. *American Journal of Otology, 10(2)*, 79-83.
- Schwartz, J. R., & Eikhof, G. (1987). Na currents and action potentials in rat myelinated nerve fibres at 20 and 30 degrees C. *Pflügers Archiv, 409*, 569-577.
- Seldon, H. L., Dahm, M. C., Clark, G. M., & Crowe, S. (1994). Silastic with polyacrylic acid filler: Swelling properties, biocompatibility and potential use in cochlear implants. *Biomaterials, 15*, 1161-1169.
- Shannon, R. V. (1983). Multichannel electrical stimulation of the auditory nerve in man. I. Basic psychophysics. *Hearing Research, 11*, 157-189.
- Shepherd, R. K., Clark, G. M., Pyman, B. C., & Webb, R. L. (1985). Banded

- intracochlear electrode array: Evaluation of insertion trauma in human temporal bones. *Annals of Otology, Rhinology and Laryngology*, 94, 55-59.
- Shepherd, R. K., Hatsushika, S.-I., & Clark, G. M. (1993). Electrical stimulation of the auditory nerve. The effect of electrode position on neural excitation. *Hearing Research*, 66, 108-120.
- Skinner, M. W., Ketten, D. R., Vannier, M. W., Gates, G. A., Yoffie, R. L., & Kalender, W. A. (1994). Determination of the position of Nucleus cochlear implant electrodes in the inner ear. *The American Journal of Otology*, 15(5), 644-651.
- Spelman, F. A., Clopton, B. M., & Pfingst, B. E. (1982). Tissue impedance and current flow in the implanted ear. Implications for the cochlear prosthesis . *Annals of Otology, Rhinology and Laryngology Supplement (United States)*, 91(Suppl 98), 3-8.
- Spelman, F. A., Pfingst, B. E., Miller, J. M., Hassul, M., & Powers, W. E. (1980). Biophysical measurements in the implanted cochlea. *Oto-Laryngology: Head-Neck Surgery*, 88, 183-187.
- Spoendlin, H., & Schrott, A. (1989). Analysis of the human auditory nerve. *Hearing Research*, 43, 25-38.
- Steele, C. W. (1987). *Numerical Computation of Electric and Magnetic Fields* New York: Van Nostrand Reinhold Company Inc.
- Strelloff, D. (1973). A computer simulation of the generation and distribution of cochlear potentials. *Journal of the Acoustical Society of America*, 54(3), 620-629.
- Suesserman, M. F., & Spelman, F. A. (1993). Lumped-parameter model for *in vivo* cochlear stimulation. *IEEE Transactions on Biomedical Engineering*, 40(3), 237-245.
- Tye-Murray, N., Tyler, R. S., Woodworth, G. G., & Gantz, B. J. (1992). Performance over time with Nucleus or Ineraid cochlear implant. *Ear and Hearing*, 13(3), 200-209.
- Tykocinski, M., Cohen, L. T., Pyman, B. C., Roland, J. T. Jr., Treaba, C. G., Palamara, J., Dahm, M. C., Shepherd, R. K., Xu, J., Cowan, R. S., Cohen, N.

- L., & Clark, G. M. (2000). Comparison of electrode position in the human cochlea using various perimodiolar electrode arrays. *American Journal of Otology*, 21, 205-211.
- Ulehlova, L., Voldrich, L., & Janisch, R. (1987). Correlative study of sensory cell density and cochlear length in humans. *Hearing Research*, 28, 149-151.
- Van den Honert, C., & Stypulkowski, P. H. (1987). Single fiber mapping of spatial excitation patterns in the electrically stimulated auditory nerve. *Hearing Research*, 29, 195-206.
- Wang, G., Vannier, M. W., Skinner, M. W., Kalender, W. A., Polacin, A., & Ketten, D. R. (1996). Unwrapping cochlear implants by spiral CT. *IEEE Transactions on Biomedical Engineering*, 43(9), 891-900.
- Webb, R. L., Clark, G. M., Shepherd, R. K., Franz, B. K., & Pyman, B. C. (1988). The biological safety of the Cochlear Corporation multiple-electrode intracochlear implant. *American Journal of Otology*, 9(1), 8-13.
- Welling, D. B., Hinojosa, R., Gantz, B. J., & Lee, J. T. (1993). Insertional trauma of multichannel cochlear implants. *Laryngoscope*, 103(9), 995-1001.
- White, J. A., Burgess, B. J., Hall, R. D., & Nadol, J. B. (2000). Pattern of degeneration of the spiral ganglion cell and its processes in the C57BL/6J mouse. *Hearing Research*, 141, 12-18.
- Wilson, B. S., Lawson, D. T., & Zerbi, M. (1996). Speech processors for auditory prostheses. *NIH Progress Report (2nd quarterly)*.
- Zappia, J. J., Niparko, J. K., Oviat, D. L., Kemink, J. L., & Altschuler, R. A. (1991). Evaluation of the temporal bones of a multichannel cochlear implant patient. *Annals of Otology, Rhinology and Laryngology*, 100, 914-921.
- Zrunek, M., Lischka, M., Hochmair-Desoyer, I. J., & Burian, K. (1980). Dimensions of the scala tympani in relation to the diameters of multichannel electrodes. *Archives of Oto-Laryngology*, 229, 159-165.