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Review Article

# Cochlear Implants in Unilateral Hearing Loss for Tinnitus Suppression

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**Abstract**

Tinnitus is a pervasive symptom that can affect many people with hearing loss. It is found that its incidence is increasing due to accompanying occupational and environmental noise. Even, there is no standard treatment is present up till now, but cochlear implants (CIs) positive effects are well proven and documented. This article provides an overview of many publicly available reports about cochlear implants and tinnitus, with review of several articles demonstrating the benefit of cochlear implants for unilateral hearing loss and tinnitus. We believe that this approach will help many, and should be considered as standard practice and reimbursed.

## INTRODUCTION

Unilateral hearing loss affecting approximately18.1 million persons in the United States [1]. Patients with unilateral deafness frequently also experience tinnitus, which can have a profound impact on an individual's quality of life. Specifically, tinnitus has been associated with an increased incidence of depression, anxiety, hearing difficulties, difficult concentration and insomnia. In the U.S.A the FDA has not yet approved cochlear implantation in unilateral hearing loss. This chapter reviews some relevant literature and supports the notion of a CI for tinnitus in unilateral hearing loss [2].

### Prevalence

The prevalence of troublesome tinnitus increases with age to 70 years [3]. Prevalence in men and women is similar. Prevalence in children is difficult to estimate, but results of available studies suggest that tinnitus experiences common. Children, however, seem less likely to be distressed by the perception [4].

### Pathophysiology of tinnitus

Many theories and models have been proposed to explain the pathophysiological basis of tinnitus [5; 6; 7]. The most prevalent theories involve hair cells, the auditory nerve, and the central auditory nervous system.

Although tinnitus activity is interpreted in the auditory cortex, theories involving hair cells originate into cochlea from alterations of the spontaneous activity, including:

- An increase in rate.
- Decrease in rate
- Periodic activity
- Synchronous activity cross neurons
- Edge effect between active an inactive neuron [8].

With the loss of hair cells or hair cell function, afferent neurons appear to trigger aberrant auditory sensations at frequencies at or near the focus of the lesion [9]. This "edge effect" theory showed that tinnitus is usually associated with hearing loss, and explained why tinnitus frequency is usually related to frequencies involved in hearing loss, and why tinnitus could persists after the time expected for a normal recovery from noise exposure. It seems logic that tinnitus should be coded in the auditory temporal lobe, however it can have its own source any place in the auditory system and can be altered by other systems. The importance of the central nervous system in tinnitus had been proven for years [10].

### Cochlear implant and tinnitus

At present, electric stimulation via a CI has proven to be a well-tolerated and effective means of restoring hearing to over 400, 000severely hearing-impaired individuals worldwide. However, using electric stimulation to suppress tinnitus has not been yet accepted worldwide. In the U.S.A it has not been yet approved by the Food and Drug Administration.

### Review of CI studies to reduce tinnitus

Candidacy for CI continues to expand, but anew an innovation has been the application of CIs to subjects with unilateral hearing loss and severe tinnitus (Baguley & Atlas, 2007). Previous studies had indicated that tinnitus in unilateral hearing loss can be severe, and refractory to treatment. It has also been shown that individuals using a CI in one ear and a hearing aid in the other are usually able to combine these two inputs to improve spatial hearing, and often to reduce troublesome tinnitus. There are a growing number of studies evaluating the effect of implantation for rehabilitation of the deficits associated with unilateral deafness over the past several years as more centers offer this treatment modality to patients with unilateral deafness. The vast majority report improvement in sound localization, speech understanding in quiet and noise, and in their tinnitus [11].

• *Some patients experience a total elimination of tinnitus after the CI surgery.*

Kim et al [12] reviewed effect on tinnitus of the Nucleus multichannel CI in 15 patients; patients were distributed as follow (12bilateral, one ipsilateral and two contralateral tinnitus).evaluation of effect of ci on tinnitus was done in different situations: device on, device on with variable sounds and device off. When the implant is off, there was complete or partial relief from tinnitus in 85%of patients in the ipsilateral ear .when the implant was on, 77%of patients improved. When applying various sound stimuli 92%of patients showed partial or complete improvement and relief.

• *Some patients report a reduction in their tinnitus only when the speech processor is turned on.*

Tyler & Kelsay [13] reported a study on 52 patients who were selected in six CI centers, the majority of them utilizing multichannel intra cochlear devices. They stated that among 42 patients who had preoperative tinnitus, 81%of them tinnitus was partially or totally disappeared, 17%tinnitus was stable remain unchanged and in 2%tinntius became worse after implantation.

• *Some patients report a reduction in their tinnitus after the speech processor is turned off.*

Residual inhibition (RI) of tinnitus is the period of time in which a patient has a reduction of tinnitus perception following use of CI and after deactivation. Souliere et al [14] described a study on 28 patients, and reported RI in 14 patients of 28 and he stated that 4 patients had an RI for >2 hours, 3 patients had an RI <1 hour, 3 patients had an RI of 30-60 minutes and 4 patients had an RI 5-10 minutes.

• *Some patients with bilateral tinnitus report a reduction of tinnitus on both sides after receiving a unilateral CI* [15] (Table). *Electrical stimulation through implant (no external microphone)*

Arts et al. [16] reported that a CI can suppress tinnitus independent on environmental sounds by providing intra cochlear electrical stimulation and tinnitus can be relieved at least for minutes. The main goal of this study was to compare the long-term suppressive effects of looped (i.e. repeated) electrical stimulation (without environmental sound perception) with the standard stimulation pattern of a CI (with environmental sound perception).they concluded that no need for environmental sounds coding for tinnitus suppression with intra cochlear stimulation, therefore it is obviously cleared that tinnitus suppression by CI not only caused by shifting patient attention from tinnitus sound to environmental ones , and stated that use of both the standard clinical CI and the experimental Tinnitus Implant (TI) are for tinnitus treatment. These findings provide merits for a successful clinical application of the TI, especially in patients with residual hearing.

**Table:** Studies on unilateral CI showing with results for tinnitus on both ears.

| Study | Number of subjects | Results |
|---|---|---|
| McKerrow et al. (1991) | 6 | 67% reduced |
| Souliere et al. (1992) | 33 | 42% improved |
| Hazell et al. (1995) | 127 | 52% better<br>47% same<br>1% worse |
| Kim et al. (1995) | 15 | 71% improved<br>4% same |
| Fukuda&Albernaz (1998) | 6 | 20% suppressed<br>20% decreased<br>40% same |
| Demajumar et al. (1999) | 70 | 20% abolished |

## CONCLUSIONS

CIs have been a very successful device to help those with severe to profound hearing loss. Tinnitus can be very debilitating, and there is no universal cure useful for every single patient. Nearly all tinnitus patients have a hearing loss. It is clear that many patients who receive a CI benefit, not only from improved hearing, but also from a reduction in their tinnitus. We believe that CIs should be used for treating tinnitus especially when associated to unilateral severe hearing loss, and it should be reimbursed.

## REFERENCES


1. Lin FR, Niparko JK, Ferrucci L. Hearing loss prevalence in the United States. Arch Intern Med. 2011; 171:1851–1852.
2. Iwasaki S, Sano H, Nishio S. Hearing handicap in adults with unilateral deafness and bilateral hearing loss. Otol Neurotol. 2013; 34: 644–649.
3. Davis A, El Rafaie A. Epidemiology of tinnitus. In: Tyler RS, ed Tinnitus handbook. San Diego, CA: Singular, Thomson Learning, 2000: 1–23.
4. Baguley DM, McFerran DJ. Tinnitus in childhood. Int J Pediatr Otorhinolaryngol. 1999; 49**:** 99–105.
5. Baguley DM. Mechanisms of tinnitus. Br Med Bull. 2002; 63; 195–212.
6. Eggermont JJ. Physiological mechanisms and neural models. In R. Tyler (Ed.), Tinnitus handbook (pp. 85–122). San Diego, CA: Singular. 2000.
7. Møller AR. Pathophysiology of tinnitus. Otolaryngologic Clinics of North America. 2003; 36: 249–266.
8. Kiang, NYS; Moxon, EC.; Levine, RA. Auditory-nerve activity in cats with normal and abnormal cochleas. In: Wolstenholme, GEW. Knight, J., editors. Sensorineural Hearing Loss. Churchill Livingston; London, UK: 1970. p. 241-268.

9. Jastreboff PJ. Phantom auditory perception (tinnitus): Mechanisms of generation and perception. Neurosci Res. 1990; 8: 221–254.

10. Tyler, RS. In: Evered, D.; Lawrenson, G., editors. Invited discussant. Tinnitus; TinnitusCiba Foundation Symposium 85); London, UK: Pitman. 1981; 136-137.

11. Baguley DM, Atlas MD. Cochlear implants and tinnitus. Progr Brain Res. 2007; 166: 347–355.

12. Kim HN, Shim YJ, Kim YM, Kim ES. 1995. Effect of electrical stimulation on tinnitus in the profoundly deaf. In: G.E. Reich &J. Vernon (eds.) Proceedings of the Fifth International Tinnitus Seminar. Portland, OR: American Tinnitus Association. 1995. 508–517.

13. Tyler RS, Kelsay D. Advantages and disadvantages reportedby some of the better CI patients. Am J Otolaryngol. 1990; 11: 282–289.

14. Souliere Jr, Kileny PR, Zwolan TA, Kemink JL. Tinnitus Suppression following cochlear implantation. A multifactorial investigation.Arch Otolaryngol Head Neck Surg. 1992; 18: 1291–1297.

15. Zwolan TA, Kileny PR, Souliere CR, Kemink JR. In: Aran, J-M.; Dauman, R., editors. Tinnitus suppression following cochlear implantation; Tinnitus91: proceedings of the Fourth International Tinnitus Seminar; Amsterdam, The Netherlands: Kugler. 1992; 423-426.

16. Arts RA, George EL, Griessner A, Zierhofer C, Stokroos RJ. Tinnitus suppression by intra cochlear electrical stimulation in single sided deafness—a prospective clinical trial: Part I. Audiol Neurootol. 2015; 20: 294:313.

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