



Binaural Hearing Advantages from Cochlear Implants

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On behalf of the American Speech-Language-Hearing Association

1. Health Outcomes

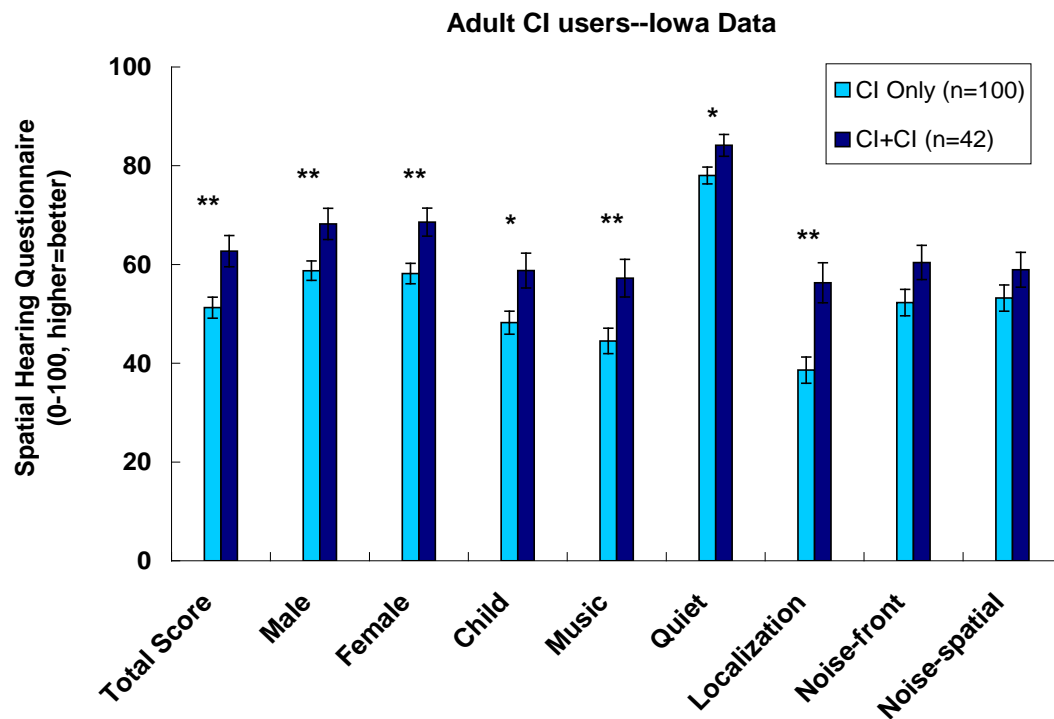
- **Quality of Life**

A successful bilateral cochlear implant is one that improves hearing in an individual (Tyler et al., 2006). Hearing involves locating a sound source, perceiving loud and soft speech, hearing speech in noise and improving lip-reading. An improvement in hearing results in an improvement to communicate in everyday life (e.g., Maillet, Tyler and Jordan; 1995). Communication is critical to our interaction with others, both at work, socially and for recreation. Communication is fundamental to our general health and overall quality of life, including making and maintaining friendships, having a positive outlook on life, and the ability for a person to maintain and nurture their physical and mental health.

There is ample evidence to illustrate that individuals who receive two cochlear implants generally experience a higher quality of life than those who receive only one cochlear implant. Simply put, individuals with two cochlear implants hear better than those who receive only one. Quality of life measures that emphasize hearing show this advantage (Noble et al., 2008a, b; Tyler, Dunn and Gogel, 2009), particularly those two that emphasize spatial hearing (Gatehouse and Noble, 2004; Tyler, Perreau and Ji, 2009).

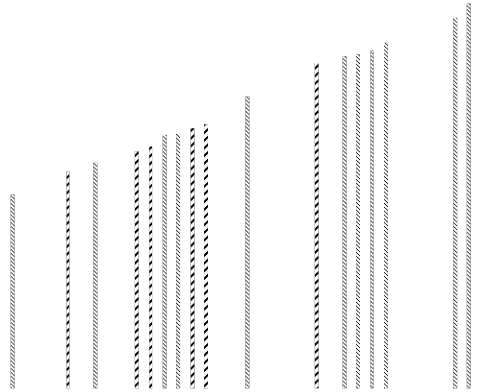
The ability to validly measure ‘the quality of life’ is difficult and controversial. Although a few scales are widely used, this should not imply that they are valid and adequately capture and weight the appropriate importance among disabilities, and how this changes with age, gender, employment and education.

The figure below shows that spatial hearing quality of life (higher scores are better performance) are higher for patients receiving bilateral cochlear implants compared to patients who receive only one cochlear implant. In the figure below, the abbreviations CI means cochlear implant and CI+CI means two cochlear implants.



The advantage of two cochlear implants over one is related to the physics of sound, the attenuation of sound by the head, and the difference of time of arrival of sounds between the two ears for any sound not directly and exactly in front or behind. A clinical trial is not required to demonstrate this advantage because it is related to the physics of sound.

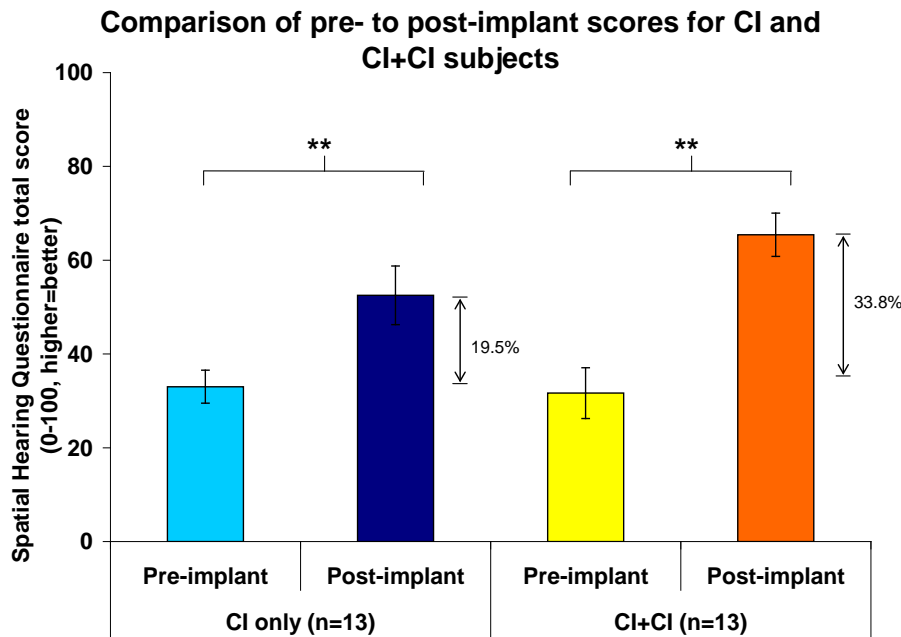
The figure below shows the ability to locate from which of eight loudspeakers and an everyday sounds is being produced. Error scores are shown, so that lower scores represent better localization performance. Each bar represents a different individual, and the devices worn (e.g. bilateral cochlear implants are CI+CI and a cochlear implant and a contralateral hearing aid are CI+HA). Localization is generally better for bilateral cochlear implant patients than for cochlear implant plus hearing aid patients. Performance for unilateral cochlear patients would perform at chance, about 55 degree root mean square (RMS) error.



- **Speech recognition**

Ample evidence exists to show that individuals with two cochlear implants almost always hear speech better than with users with one cochlear implant (Tyler et al., 2002a; Van Hoesel and Tyler, 2003; Tyler et al., 2003; Tyler et al., 2006a, b). For example, with unilateral no or poor hearing, a cochlear implant on that side will improve understanding of soft speech from that side. Hearing with two ears, as is provided with two cochlear implants, allows listeners to spatially separate the speech source from noise sources, and improve speech hearing in background noise (Dunn et al., 2010; Chang et al., 2010). This spatial separation of the speech and noise cannot occur when hearing with one ear.

The figure below shows that Spatial Hearing Quality of Life (higher scores are better performance) show a larger increased for patients receiving bilateral cochlear implants than for unilateral cochlear implant patients.



- **Audibility**

No or poor hearing on one side will make it difficult or impossible to hear any sound from that side. The provision of two cochlear implants allows hearing of soft sounds from both sides.

- **Pre versus postlinguistic deafness**

Nearly all available data on adults with cochlear implants has been obtained from individuals with postlinguistic deafness (i.e., adults who acquired their hearing loss after developing speech and language). Adults with prelinguistic deafness do not have a memory for speech and are expected to do worse than those with postlinguistic deafness. However, the benefits of bilateral cochlear implants over a unilateral cochlear implant will be true for those with postlinguistic deafness. For example, a prelinguistically deaf person will be able to locate the source of sounds with two cochlear implants but will not be able to with one cochlear implant. This gives the individual a better sense of auditory space.

- **Presence of other disabilities (e.g., visual impairment, impending or current)**

Individuals who have a severe visual impairment will be particularly helped with the localization abilities afforded by two cochlear implants. They should always be encouraged to get two cochlear implants.

Individuals with other disabilities (e.g., intellectual or developmental disability) might be more in need of the advantages of hearing with two cochlear implants.

- **Preimplant best-aided open-set sentence recognition test scores of >40 percent and ≤ 50 percent**

Ample data exists to show that these patients have better localization skills with bilateral cochlear implants than they do with a cochlear implant plus hearing aid. Many of these patients will also show a benefit hearing speech in spatially separate noise.

- **Preimplant best-aided open-set sentence recognition test scores of > 50 percent and ≤ 60 percent**

Ample data exists to show that these patients have better localization skills with bilateral cochlear implants than they do with a cochlear implant plus hearing aid. Some of these patients will also show a benefit hearing speech in spatially separate noise with bilateral cochlear implants.

Regardless of the degree of hearing loss in the non-implanted ear, there is a benefit of hearing with two ears. Perhaps the best examples of evidence showing this is the work of Vermeire and Van den Heyning (2009) and Arndt et al. (2010). They implanted people in a deafened ear but who had normal or near normal hearing in the opposite ear (up to 100% sentence recognition). Patients reported improved hearing and improved quality of life from hearing with two ears as provided by the cochlear implant.

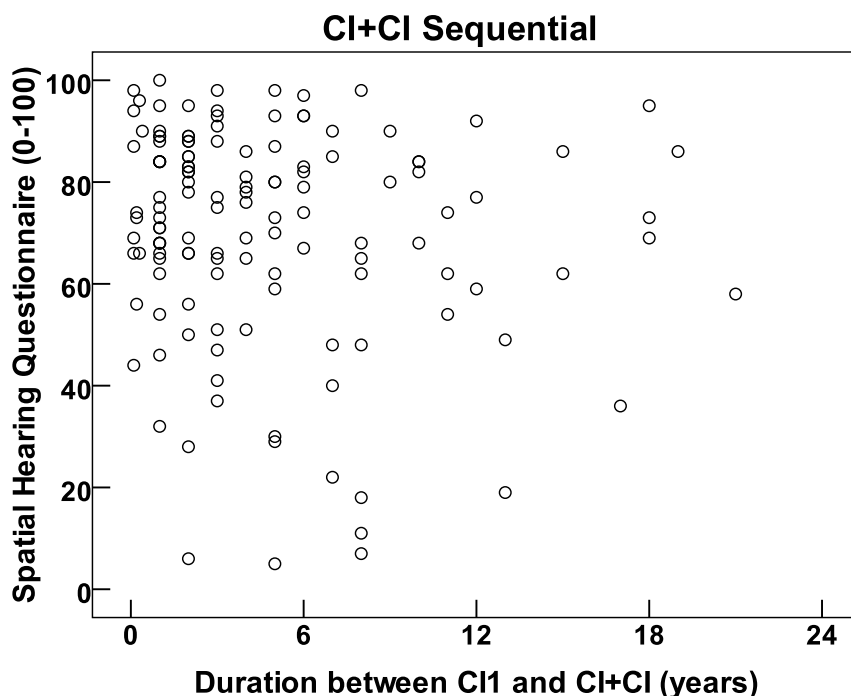
2. Characteristics of Patients With Successful Bilateral Cochlear Implants

- **Simultaneous versus sequential bilateral cochlear implantation**

Ample data exist showing that individuals who have received their second cochlear implant several years after their first cochlear implant receive (Tyler et al., 2007) the same bilateral cochlear implant advantage as those who received their bilateral cochlear implant simultaneously (Gantz et al., 2002; Tyler et al., 2002; Dunn et al., 2008).

The figure below shows that Spatial Hearing Quality of Life (higher scores are better performance) are not influenced by the duration between receiving the first and second cochlear implant in bilateral

cochlear implant patients who received their second cochlear implant sequentially. High scores are obtained even when the patients receive their second cochlear implant ten years after receiving their first cochlear implant.



- **Duration of impaired hearing**

Ample data exist showing that individuals who have been deafened for many (even >20) years still show benefit from both unilateral (Tyler and Summerfield, 1996; Rubenstein et al., 1999) and bilateral cochlear implants.

- **Age**

Ample data exist showing that individuals who are older (even >90 years) still show benefit from bilateral cochlear implants (Noble et al., 2009). It could be argued that senility might impair the maximum

potential to integrate information from both ears. However, it can also be argued that those with mental handicaps are more in need of the advantages of hearing with two cochlear implants.

- **Choice of implanted ear**

The choice of which ear to implant is closely linked to the amount of residual hearing available in each. The benefit of two cochlear implants over one cochlear implant will be influenced by the amount of residual hearing, as discussed below. The clinicians and researchers at the University of Iowa (Perreau et al., 2007) have provided a systematic approach to determine which ear to implant based on the contribution from each ear and the bilateral advantage. With two profoundly deaf ears of similar degrees of deafness and years of deafness, the ear receiving a single cochlear implant will likely not matter.

- **Site (expertise) of cochlear implant team**

It is very likely that the skill of fitting both one and two cochlear implants is important in the performance of individuals using hearing aids and using cochlear implants. Time is needed for an audiologist to carefully fit either one or two devices to optimize performance for an individual (Tyler et al., 2008).

- **Degree of pre-implant residual hearing**

The degree of pre-implant residual hearing will influence the benefit obtained from one or two cochlear implants. One important consideration is the expected outcome with one cochlear implant. Recent studies have shown the expected outcome with a unilateral cochlear implant is about 70% open set sentence recognition (Gifford et al. 2008). Another important consideration is whether someone will benefit from using a cochlear implant in one ear and a hearing aid in the other (Tyler et al., 2002b; Dunn, Tyler and Witt. 2005).

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