Subjective benefits of cochlear implantation for adult recipients

Cochlear implantation has been a well-established treatment to restore the auditory abilities in patients who have severe to profound hearing loss (Dowell, 2005). Frequently reported benefits from cochlear impants (CI) include improvement in the speech perception and environmental sounds perception. For example, recent study has demonstrated significant improvement in speech perception scores after cochlear implantation for the adult recipients with post-lingual deafness (Amoodi et al., 2011, Firszt, Holden, Reeder, Cowdrey & King, 2012). Similar result was also found by Duchesne, Millette, Bhérer & Gobeil (2017) in congenitally/prelingually deafened recipients. Data from the interviews of the same study has revealed that the recipients had improved awareness and perception of environmental sounds, such as rain on the roof, sound in the car, cat litter (Duchesne, 2017).

Beside the auditory improvement, subjective benefits could be anticipated as well. They often refer to facilitation of communication and the follow-on positive impacts on individuals' well beings/quality of life, such as, reduction in hearing handicaps, increased activity and participation, increase in self-esteem and confidence. In a study by Shcherbakova, Kuzovko, & Megrelishvili (2008), the quality of life of 30 adult recipients with post-lingual deafness was evaluated by Hearing Handicap Inventory in Adults before and after cochlear implantation. Substantial reduction in post-CI handicap scores have been found which indicated the significant improvement in quality of life by CI. Similar finding was also reported by Looi, Mackenzie, & Bird (2011). And the positive changes of recipients' lives have been reported, including increase in interconnectedness with surroundings, improvement in

communication, increased confidence and independence and higher satisfaction in family, working and social life (Looi et al., 2011). However, the benefit would not be the same for every recipient due to its subjectivity. This underlines the importance of evaluation of the outcomes of cochlear implantation which could direct to post-operative counselling and further management by clinicians.

Given the fact that improvement in the communication abilities remains the primary goal for many cochlear implantation programs, speech perception, an element of communication process, has gained the most interest in the outcome assessment. One routinely used method in outcome assessment is speech perception test in quiet and in noise (Leigh, Moran, Hollow & Dowell, 2016). However, there were several arguments against its validity. The unrealistic testing condition does not necessarily represent the real-life communication environment (Gifford, 2013; Brendel, Frohne-Buechner, Lesinski-Schiedat, Lenarz & Buechner, 2014). Although it uses the noise to simulate the real-world condition, some characteristics affecting perception of speech are not involved, such as, correlating sound sources and fluctuating noise level. It seems trivial that improving speech perception improves communication. But the complexity of communication is less likely to be reflected by word or sentence recognition alone (McRackan et al., 2018). Communication incorporates a lot of aspects which do not associate with speech perception, such as gesture, facial expression (Dowell, 1994) and those aspects are not involved in the test. Therefore, speech perception scores may not fully equate to communication abilities. The real-life

communication of CI recipients may not be sufficiently evaluated by speech perception test.

The association between speech perception test and the overall benefits or limitations of CI remains ambiguous. Some recipients exhibit high speech recognition scores while still having trouble in daily life communication. Contrastingly, some recipients may not exhibit huge improvement in speech perception while they may still experience significant benefits from cochlear implantation. For example, a study has found strong feeling of usefulness and high levels of satisfaction on cochlear implants in the prelingually deafened recipients who obtained low post-CI speech recognition scores (Duchesne et al., 2017). The very subtle gains such as easier lip reading, discovery of environmental sounds might play an important role in satisfaction of prelingually deafened recipients. This finding demonstrates that the speech perception test may not be a sensitive measure to capture all benefits of cochlear implantation (Leigh et al., 2016). Perhaps, apart from traditional speech perception test, a subjective measure to assess the impact of CI on recipients' well-being may be required.

There was considerable attention towards patients' point of view of the impact of treatment on their well-being in determining the success of the treatment. Historically, success of the intervention was typically based on the judgement of healthcare professional, according to the laboratory or clinical results (Cox & Alexandra, 2002). Currently, in evaluation process, clinical results are still taken into account while patients' self-reported experience or outcomes would also be considered. The full success of an intervention could not be obtained unless improvement in well beings or

quality of life could be reported by themselves (Cox & Alexandra, 2002). Therefore, in CI outcome assessment, while focusing on the speech perception of recipients, recipients' social/emotional well-being must not be overlooked. The present study would evaluate the influence of CI on individual's social and emotional well beings/quality of life.

One generally known method to obtain patients' perspectives on outcome of intervention is by subjective measure. It is worth noting that subjective measure gives the insight into the real world effectiveness of the intervention. It would assess the patients' well-being/quality of life, detect the subjective benefits or limitations that are not able to be captured in objective test. The commonly used measuring tools in audiology field are self-report questionnaires such as " The International Outcome for Hearing Aids"(IOIHA) (Cox & Alexandra, 2002) and " The Hearing Handicap Inventory for Adult"(HHIA) (Newman, Weinstein, Jacobson & Hug, 1990). lOIHA measures the overall satisfaction level of the patients' on hearing aids or implantable hearing device, the CI. HHIA composes of social and emotional domain which focuses on the subsequent impacts of hearing loss and treatment/intervention on patients' lives. The higher the HHIA score is, the greater the hearing handicap the patient perceived. These tools may provide the holistic picture of recipients' experience and capture better the overall benefits from implantation.

As the subjective measures are used more frequently in CI outcome evaluation, it is also important to study how they correlate with the speech perception test. Although they assess two distinct outcomes, by having one to measures speech perception abilities and the other one to determine the

social or emotional well-being of recipients, some relationships may be still able to be found. This extra information would determine the predictive power of speech perception test on subjective outcomes or even the overall success of cochlear implants.

Several studies have examined the relationship between the subjective measures and speech perception test and the results were not consistent. A study of 56 adult CI recipients has demonstrated the significant correlation between subjective outcomes of the Nijmegen Cochlear Implant Questionnaire and word perception outcomes at p= 0. 05 level, while the relationship was weak with r= 0. 28 (Hirschfelder, Gräbel & Olze, 2008). However, the other study involving 30 adult CI users had found there was no significant correlation between the total Nijmegen Cochlear Implant Questionnaire (NCIQ) scores and word perception score at p= 0. 05 level (Capretta & Moberly, 2016). And only one sub-domain of NCIQ, known as " Advanced sound perception" has been found to have significant correlation with speech perception scores. Yet, the relationship was weak as r= 0. 55 (Capretta & Moberly, 2016). Furthermore, a study including 21 congenitally or prelingually deafened recipients had examined the correlation between speech perception results and " Adult Cochlear Implant Questionnaire" results (Duchesne et al., 2017). The " Adult Cochlear Implant Questionnaire" was utilized to determine the recipients' impression of satisfaction and usefulness towards CI. This study has found that the correlations were not significant at p= 0. 01 level (Duchesne et al., 2017). The above findings suggested the relationship between speech perception outcome and subjective outcome of CI recipients remains unclear. Also, these studies used

small numbers of subjects and this may limit the power of the research. For these reasons, a large cohort studies will be conducted to confirm the relationship.

A meta-analysis study has also examined the relationship between subjective outcomes and speech perceptions outcomes of CI (McRackan et al., 2018). It provides the strongest evidence with regard to the relationship among the literatures that have been viewed, since meta-analysis is at the highest level of the hierarchy of evidence. Nine of the twenty-two literatures with 550 recipients that met the criteria for meta-analysis of correlations have been analyzed (McRackan et al., 2018). Pool analysis has shown there was a significant but weak correlation between subjective outcomes and word perception in quiet (r= 0. 35), sentence recognition in quiet (r= 0. 40). Given the results from this meta-analysis, it is reasonable to speculate that there would be a statistically significant correlation between subjective and objective outcomes of CI but the correlation is weak.

It has been obvious that there is a wide variability of CI post-operative performance over the years. One study has demonstrated that the 12-month post-operative performance for phonemes and words perceptions ranged from 0% to 98% and 0% to 94% respectively (Leigh et al., 2016). This large range of performance is surely affected by many factors. Recognition of these factors and in particular quantification of their underlying effects on performance are important for CI candidacy (Blamey et al., 1996). For example, good perception outcomes could be observed in a recipient who had significant residual hearing in the pre-implanted ear, that the clinician would be more inclined to select the candidates with similar characteristics

for implantation. This is where the evidence based recommendation takes place to optimize the outcomes and to avoid the unfavourable outcomes (Dowell, 2012; Leigh et al., 2016).

Previous studies have provided the insight into the large variation of post-operative speech perception performance. However, majority of variation in speech perception outcomes remains unexplained (Blamey et al., 1996; Blamey et al., 2013; Lazard et al., 2012). Given the fact that many factors influencing the outcomes are not possible to evaluate directly in the living human implanters, such as, cognitive function, spiral ganglion cell function, central neural function and electrical properties of the implant (Dowell, 1996), previous studies have only considered the factors that could be measured and quantified directly. The factors have been identified include duration of deafness, age at implantation, duration of implants use, pre-implantation residual hearing and pre-operative perceptive skills (Blamey et al., 1996; Dowell, 2012; Lazard et al., 2012; Leigh et al., 2016). For example, longer duration of deafness that may be associated with auditory deprivation have been reported to have negative impact on CI speech perception outcomes (Blamey et al., 1996; Dowell, 2012). The age is correlated negatively with the outcomes (Blamey et al., 1996), which may link to the natural degeneration of the nerve cells in peripheral or central auditory system and degradation of cognitive function (Dowell, 2012). A recent study has also shown pre-implantation hearing aids use would have a strong positive influence on CI speech perception outcomes which could be due to hearing aids use diminishes the effecting pathological change of auditory pathways from hearing loss (Blamey et al., 2013). Furthermore, longer

duration of CI use has been shown to have a positive role to improve the outcomes.

Apparently, there is also a large variation of recipient's subjective outcomes. It is of utmost importance to recognize what factors would explain the variance of subjective outcomes of cochlear implantation.

Based on our clinical experience, there are usually discrepancies between objective and subjective outcomes, two recipients who have similar characteristics such as pre-implant residual hearing may have similar post-operative speech scores but very different satisfactory level. It remains unclear that how the factors explaining part of variance of speech perception outcomes would influence the subjective outcomes or overall outcomes, which warrant us to investigate further. We may speculate that some non-audiological variables would be involved in affecting the subjective outcomes. One study has suggested that social environment including the social support and social demands and personal factors such as expectation and attitude have the significant impacts on recipients' subjective outcomes (Hallberg, Ringdahl, Holmes & Carver, 2005). However, these factors are difficult to measure in clinical setting, as such the present study would focus on the factors listed above.

The purpose of present study is three-fold. The first aim is to describe the subjective benefits from cochlear implantation for adults receiving CI. Subjective outcomes in this study refer to individuals' social and emotional outcomes and are quantified using a self-reported questionnaire, " The Hearing Handicap Inventory for Adults" (HHIA) (Newman et al., 1990). The

degree of improvement in HHIA value would reflect the subjective outcome of implantation. The second aim is to examine the relationship between subjective outcomes (HHIA value) and objective outcomes (speech perception performance). The third aim is to investigate the influence of the factors to the cochlear implantation outcomes. The present study does not represent the highest level of evidence in clinical research as it is not a randomised and double-blinded study. But, the strength of study is enhanced by large number of subjects, and all subjects were assessed using the same tests, in same conditions and by the same protocol. Also, the present study allows the subjects to act as their own control in before and after operation comparison.

More specifically, this study tests the hypothesis that the cochlear implant enhances the social and emotional well-being of individuals, that post-operative HHIA value would be significantly reduced. It also tests that the post-operative speech perception performance would be correlated poorly with HHIA value. In addition, the other hypothesis to be tested is that the variables including duration of deafness, age at implantation, pre-operative residual hearing and perceptive skills and duration of implant use would have significant effect on post-operative speech perception performance but weak association with the HHIA value.

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