SMJ- Sohag Medical Journal, Vol. 29 No (2) 2025

Print ISSN1687-8353 Online ISSN2682-4159

Original Article

Assessment the Technologists and Radiologists Knowledge Regarding Health Risks Associated with Cochlear Implant Imaging Procedures

Halima Hawesa[1], Huda Almasaud [1], Lamya Almarshad, Madawi Alsharhan [1], Razan Alharbi [1], Rahaf Alkhalifa [1], Shahad Aljuaid [1], Zahrah Alradhi [1], Khadija Saliha Bazza[2].

1- Radiological Sciences Department, College of Health and Rehabilitation Sciences, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

2- Carleton university, Ottawa, Canada

ABSTRACT

Background: Cochlear implantation is a critical intervention for patients with severe to profound sensorineural hearing loss. However, imaging patients with cochlear implants (CIs) presents significant health risks, often due to insufficient awareness and knowledge among technologists and radiologists. Complications such as device heating and cochlear flipping have been reported, highlighting the importance of proper understanding during imaging procedures. This study aims to evaluate the knowledge level of technologists and radiologists in Saudi Arabia concerning the health risks associated with imaging cochlear implant (CI) patients**.**

Methods: A cross-sectional study was conducted involving 80 participants, including radiologists, technologists, and technicians from various hospitals in Riyadh, Saudi Arabia. A questionnaire was administered across eight randomly selected hospitals. Data were analyzed using IBM SPSS v24, with Chi-square tests applied to assess statistical significance.

Results: The Chi-square test results indicated a significant relationship between the participants' knowledge and the type of hospital regarding certain technical aspects ($P < 0.001$). However, the overall knowledge level of technologists and radiologists was found to be similar, underscoring the need for enhanced education and training in cochlear implant imaging procedures.

Conclusions: The study reveals a notable gap in knowledge among technologists and radiologists in Riyadh, Saudi Arabia, regarding the health risks associated with imaging patients with CIs. These findings emphasize the necessity for improved educational initiatives to effectively mitigate these risks.

Key Words: Cochlear Implant (CI), Level of Knowledge, CT Imaging, MRI Imaging, Public Hospitals, Privet Hospitals.

DOI : 10.21608/SMJ.2025.383056.1566 **Received:** May 08 , 2025 **Accepted:** June 11 , 2025

Published: July 22, 2025

Corresponding Author: Halima Hawesa **E.mail**: hhaweso@pnu.edu.sa

Citation: Halima Hawesa . et al., Assessment the Technologists and Radiologists Knowledge Regarding Health Risks Associated with Cochlear Implant Imaging Procedures **SMJ,**2025 Vol. 29 No (2) 2025 187- 194

Copyright: Halima Hawesa . et al., Instant open access to its content on principle Making research freely available to the public supports greater global exchange of research knowledge. Users have the right to read, download, copy, distribute, print or share the link Full texts

Introduction

Cochlear implantation (CI) is an advanced prosthetic intervention designed to treat individuals with severe to profound sensorineural hearing loss. The device consists of two components: an internal portion surgically implanted beneath the skin and an external portion that sits behind the ear. Unlike hearing aids, which amplify sound to make it detectable by damaged ears, CI bypass the impaired parts of the ear and directly stimulate the auditory nerve, offering a more effective solution for certain cases of hearing impairment. CIs are suitable for both adults and children with significant hearing loss.[1-4].

Saudi Arabia has one of the highest rates of hearing impairment globally, with prevalence reaching up to 10%, partly due to consanguineous marriages. Approximately 4% of the population with hearing impairment requires cochlear implants. The majority of CI recipients are children or individuals with congenital hearing loss due to genetic factors. The Cochlear Implant Center at King Fahd General Hospital in Jeddah performs approximately 50 to 60 cochlear implant procedures annually, with plans to increase this number as implant technology becomes more widely available. [5]

Al-Sayed [6] conducted a study at King Abdulaziz University Hospital (KAUH) in Riyadh from 2012 to 2014 examined children aged 3 months to 12 years with hearing impairment, infants younger than 3 months were excluded due to safety concerns, while children older than 12 years were not included as the center did not routinely perform cochlear implants on this age group. The study highlighted that, although the entire population has access to primary health care, geographic location affects the timing of hearing loss detection but does not influence the timing of cochlear implantation. The findings underscore the urgent need for implementing newborn hearing screening programs in Saudi Arabia, along with educational initiatives for parents to emphasize the importance of early cochlear implantation.

Bader Alkhatani [7] conducted a study to assess the quality of life of children in Saudi Arabia with CIs from the perspective of their parents. The study focused on several key areas, including communication abilities, social skills, academic achievement, future life adaptation, rehabilitation knowledge, and stress related to hearing loss. Utilizing a quantitative approach, the research involved administering a questionnaire to the parents of 103 children with CIs. The results indicated high expectations in areas such as communication, social skills, academic performance, future adaptation, and understanding of rehabilitation. Nonetheless, parents experienced considerable stress associated with their children's hearing impairment. Pearson's correlation and linear regression analyses were employed to examine the relationships between the characteristics of the implanted children and various factors impacting their quality of life.

Computed tomography (CT) is a preferred imaging modality for patients with CI due to its ability to provide detailed 3D positional information and superior contrast. However, standard CT protocols can be affected by beam hardening artifacts, particularly when radio-dense materials such as CI electrodes are present in the field of view. Despite this challenge, digital image processing techniques have been developed to enhance image quality. CT imaging offers the best visualization of electrode placement by providing a 3D view of the temporal bone, allowing precise estimation of electrode positions. [8-10]

Currently, high-resolution CT (HRCT) has become the standard imaging modality for post-implantation assessment, offering detailed visualization necessary for evaluating electrode placement. To mitigate the beam hardening artifacts associated with standard CT protocols, advanced image processing methods, such as iterative reconstruction techniques, are employed. These methods significantly reduce beam-hardening effects and improve image resolution. Additionally, image de-blurring techniques can retrospectively enhance the resolution of spiral CT slices, leading to more accurate localization of the CI electrodes. [11-12]

Key imaging parameters in CT scans for patients with CIs include the Hounsfield unit (HU) reconstruction range, image resolution, CT dose, and patient orientation within the scanner. Lower-dose CT images are particularly susceptible to beam hardening artifacts, which can increase noise and make it challenging to differentiate between electrodes and surrounding bone structures. The severity of beam hardening can also be influenced by the position of the head within the scanner, as certain orientations may cause the beams to pass

through dense structures like the teeth, exacerbating the artifacts. [13]

While most CIs are now compatible with 3T magnetic resonance imaging (MRI), the risk of serious complications is not entirely eliminated. Instances of CI displacement and other adverse reactions have been reported even with MRI-compatible implants. It is crucial that patients with CIs are informed about the potential for discomfort or pain during MRI procedures. [14-15]

In 2017, Grupe and colleagues [16] reported that 49% of cases in their cohort of CI recipients had the head as the primary scanned region. They noted that head MRIs were the most frequent cause of complications in their sample. Eerkens and colleagues [17] further demonstrated that the forces exerted on the CI during MRI depend on both the distance between the implant and the scanner bore and the angle between the implant magnet and the MRI's magnetic field. This is particularly pertinent for brain MRIs, where the internal magnet is in close proximity to the scanner bore. However, Eerkens et al found that torque forces are minimal with Ultra 3D magnet technology, and their study reported no major adverse events related to the examined regions or implant positions.

A multicentric clinical study conducted by Canzi et al [18] aimed to assess and document the experiences of recipients using the Hires Ultra 3D CI (Advanced Bionics) who underwent MRI examinations. The study found that adherence to manufacturer guidelines for MRI procedures in Ultra 3D recipients is crucial and recommended. The findings indicate that following these recommendations ensures safe and effective MRI imaging while minimizing the risk of complications associated with CIs. This study underscores the importance of adhering to established protocols to optimize patient safety and imaging outcomes.

A retrospective review of medical records from a single tertiary referral center examined the experiences of eighteen patients with CIs who underwent MRI between September 2003 and February 2014. Out of these, thirteen patients successfully completed their MRI scans (25 out of 30 scans). However, five patients, despite using head bandages, were unable to complete the scans due to pain. Among these cases, one patient experienced magnet displacement, necessitating surgery for magnet removal and reinsertion. Additionally, one patient developed a polarity reversal of the magnet. These findings underscore the importance of caution and thorough patient preparation when performing MRI on individuals with CIs. [19]

Widmann's study [20] emphasizes the importance of thorough pre-operative imaging for CI candidates, particularly for diagnosing and classifying inner ear malformations and identifying any other abnormalities in the temporal bone. Accurate imaging is crucial in determining the suitability of a patient for CI and in planning the surgical approach. CT and MRI are complementary modalities, each offering distinct advantages. CT imaging provides detailed bone anatomy, making it essential for assessing the bony structures of the cochlea and identifying any ossification or malformation. On the other hand, MRI is invaluable for evaluating the soft tissue structures, including the cochlear nerve, and is particularly useful in patients with a history of meningitis, severe middle ear disease, or dysmorphic syndromes where inner ear anatomy may be compromised. Together, these imaging techniques ensure a comprehensive evaluation, reducing the risk of complications and improving surgical outcomes for CI candidates.

A study by Hiremath et al [21] underscores the complementary roles of CT and MRI in the presurgical evaluation of CI candidates. These imaging modalities are instrumental in identifying anatomical variations as well as congenital and acquired causes of sensorineural hearing loss (SNHL). For radiologists and technologists, a thorough understanding of inner ear anatomy and associated pathologies is essential. This knowledge informs the surgeon's decisions regarding the choice of surgical technique, device, and electrode type. Furthermore, recognizing significant findings related to middle and inner ear diseases, as well as anatomical variants that could complicate surgery, is crucial for minimizing potential complications and achieving optimal surgical outcomes.

This research aims to evaluate the knowledge level of technologists and radiologists in Saudi Arabia concerning the health risks associated with imaging patients with CIs. Through this

assessment, we seek to raise awareness of best practices for managing CI patients during imaging procedures, thereby reducing potential health risks.

Method:

Data for this cross-sectional study were collected from radiology department personnel across various hospitals in Riyadh, Saudi Arabia. A total of 80 technologists and radiologists from these hospitals participated. The data were gathered using a structured questionnaire administered to the technologists and radiologists at these hospitals. The questionnaire consisted of 18 questions. The first six questions collected general information regarding the participants' experience, position, attendance at relevant workshops, and the type of hospital (private or public) where they are employed. The remaining 12 questions assessed the participants' knowledge of CI, the artifacts caused by CIs, and the effects of CT and MRI imaging procedures on these devices. The model answers for the questionnaire were developed based on information provided by various CI vendors, with each correct response receiving one point. Upon collection, the data were exported to Microsoft Excel for initial handling, followed by analysis using IBM SPSS version 24. Inferential statistics were conducted using the Chi-square test.

Results and Data Analysis:

The collected questionnaires were manually graded, and the scores were subsequently tallied and organized in an Excel spreadsheet. The Chi-square test was employed to evaluate whether the type of hospital (private versus government) and participants' experience in hospitals performing CI procedures significantly impacted their knowledge levels. Additionally, the Chi-square test was used to determine if knowledge levels differed between participants working in hospitals with dedicated CI units and those in hospitals without such units. The results of these Chi-square tests are presented in Tables 1 and 2.

Figure 1: presents the demographic information of the participants, including their specialty, the unit in which they work, and the type of hospital where they are employed.

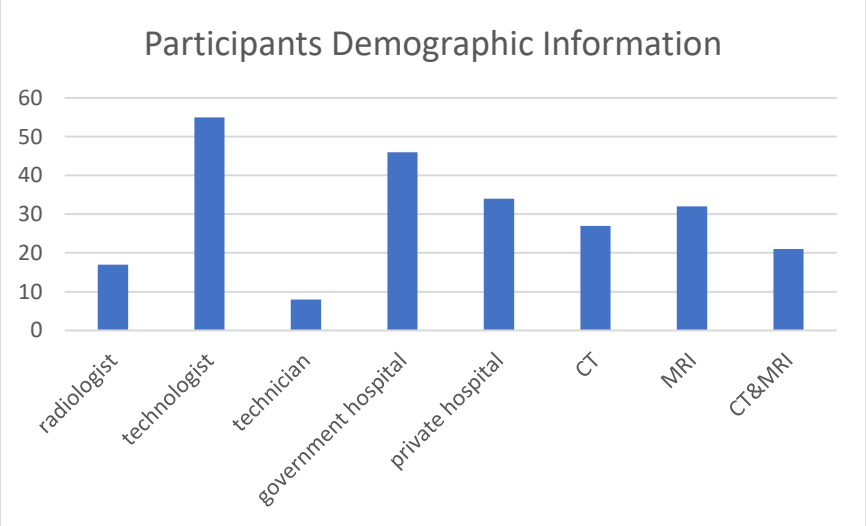

Figure 1: Participants demographic information.

Table 1 presents the results of the Chi-square test comparing responses between participants working in private hospitals and those in government hospitals. Significant differences in knowledge levels were observed for questions 1, 2, 4, 6, and 7. The p-values for these questions were all less than 0.05, indicating a statistically significant difference between the knowledge levels of participants based on hospital type.

Table 1: Chi-square test results comparing survey responses between participants working in private hospitals and those working in government hospitals.

	P-values according to the type of hospitals
1. Do you know what a Cochlear implant is and its types?	0.٠٣٦
2. Do you know what kind of patients might have Cochlear Implant?	0.٠٢١
3. Can you perform an MRI for patients with a Cochlear implant?	0.٠٨٦
4. Do Cochlear implants cause artifacts in medical imaging?	0.٠٠٩
5. Do you know the preparations for patients with Cochlear implants?	0.٨٢
6. Does the MRI machine cause damage to the Cochlear implant?	0.001
7. Does a higher magnetic field affect the Cochlear implant more?	0.٠٠٢
8. Is there a specific imaging modality to image patients with Cochlear implants?	0.٦٤٧
9. Can the Cochlear implant be affected if the region of Interest being imaged is far from the brain?	0.١٠٦
10. Is it necessary to do post processing in CT after imaging a patient with a Cochlear implant?	0.٦١٥
11. Do you typically ask the patients before the exam if they have a Cochlear implant or have this question in the consent form?	0.١٢٤
12. Is it challenging to do post processing for patients with Cochlear implants during a CT scan?	0.٦١٨

The Chi-square test was conducted to compare survey responses between participants working in private hospitals and those in government hospitals. The analysis, shown in Table 2, revealed that there were significant differences in the responses to questions 6 and 8, with p-values less than 0.05, indicating a statistically significant difference in knowledge or practices related to these specific areas between the two groups. However, for the remaining survey questions, no significant differences were observed between the responses of participants from private and government hospitals, suggesting a similar level of knowledge across these questions.

Table 2: Chi-square test results comparing survey responses between participants working in hospitals that perform cochlear implant procedures and those in hospitals that do not.

	P-values for the hospitals that do and don't perform CI surgery
1. Do you know what a Cochlear implant is and its types?	0.٠٦٤
2. Do you know what kind of patients might have Cochlear Implant?	0.١٦
3. Can you perform an MRI for patients with a Cochlear implant?	0.٢٥٨
4. Do Cochlear implants cause artifacts in medical imaging?	0.٠٦٣
5. Do you know the preparations for patients with Cochlear implants?	0.٤٩
6. Does the MRI machine cause damage to the Cochlear implant?	0.٠٢٣
7. Does a higher magnetic field affect the Cochlear implant more?	0.٦٠٦
8. Is there a specific imaging modality to image patients with Cochlear implants?	0.٠٠٣
9. Can the Cochlear implant be affected if the region of Interest being imaged is far from the brain?	0.٨١٩
10. Is it necessary to do post processing in CT after imaging a patient with a Cochlear implant?	0.٨
11. Do you typically ask the patients before the exam if they have a Cochlear implant or have this question in the consent form?	0.١٠٤
12. Is it challenging to do post processing for patients with Cochlear implants during a CT scan?	0.٤٤٧

Discussion

The primary purpose of this study was to measure the level of knowledge about CI risks during medical imaging among technologists and radiologists in Riyadh hospitals. The chi-square test results of this study, as shown in Table 1, indicate that participants working in private hospitals demonstrated significantly higher knowledge regarding several key aspects of CIs compared to their counterparts in government hospitals. Specifically, the significant differences were observed in questions related to understanding the types of CIs, identifying patients who require them, and knowing how to properly image patients with CIs. Furthermore, the responses showed that participants from private hospitals had a better understanding of the potential artifacts caused by CIs, particularly in MRI imaging at higher magnetic fields, and how these fields might affect the functionality of the implant. This suggests that technologists and radiologists in private hospitals may receive more specialized training or have more access to resources that enhance their understanding of these critical areas.

The Chi-square test results comparing participants working in hospitals that perform CI procedures with those working in hospitals that do not reveal no significant differences for most survey questions. However, there were notable exceptions regarding the questions on the types of imaging modalities used for CI imaging and the use of MRI in CI imaging, questions 6 and 8 in Table 2 ($P< 0.05$). For these specific questions, participants employed at hospitals performing CI procedures demonstrated significantly higher knowledge. This suggests that direct exposure to CI procedures may enhance familiarity with the appropriate imaging techniques and the critical role of MRI in managing patients with CIs. Consequently, these participants are better equipped to understand the specific imaging requirements and challenges associated with CIs.

This study analysis revealed that the knowledge levels between participants from private and government hospitals, as well as between those working in hospitals that perform CI procedures and those that do not, were similar for several key questions (9-12 in Tables 1 and Table 2).

Specifically, there were no significant differences in responses to questions regarding the appropriate location of the imaging region, the necessity of post-processing to enhance CI image quality, and the importance of asking patients if they have a CI before beginning imaging. This suggests that regardless of the hospital type or CI procedure experience, there is a consistent understanding among radiology personnel about these fundamental aspects of CI imaging. This uniformity in knowledge across different hospital settings highlights the effectiveness of general training and protocols in these critical areas of patient care.

We were unable to find a study directly comparable to ours in the existing literature. However, the closest study is by Ayas et al [22], which examined the knowledge and practices of audiologists in the UK regarding cochlear re-implantation through a comprehensive questionnaire survey. The findings of this study align with the presented research, both underscoring the need for increased educational and training sessions for radiographers regarding the imaging of patients with cochlear implants. Their study highlights the critical importance of continuous education to keep professionals informed about the latest advancements and best practices in CI imaging. Specifically, it emphasizes the value of hands-on workshops at national conferences and CI group meetings that incorporate practical skills, case studies, and interactive sessions with experts. Additionally, the development of comprehensive online teaching modules in collaboration with experienced CI clinicians is recommended to provide easily accessible resources on various aspects of cochlear implant imaging and re-implantation. This aligns with our findings, which call for more focused training to ensure safe and effective imaging practices.

Conclusion

The survey results indicate that there were no substantial differences in the overall knowledge levels between healthcare workers employed in hospitals that perform CI procedures and those working in hospitals that do not. This finding underscores the importance of implementing continuous training sessions and workshops tailored to healthcare professionals. These educational initiatives should focus on the specific challenges of imaging patients with CIs, emphasizing techniques to obtain high-quality images while ensuring patient safety. Ongoing professional development is essential to maintain and enhance the proficiency of healthcare workers in managing CI patients effectively.

Ethics of The Study

Ethical approvals were obtained from the research center at Princess Nourah Bint Abdulrahman University (PNU) before the data collection (IRB number: H-01-R-059). The data was only used for study purposes without any individual details that would identify the participants.

Conflict of Interest

The author declares that she has no conflicts of interest regarding this research.

References

1. Kohan D, Chandrasekhar SS. Implantable Auditory Devices: Bridging the Gap Between Conventional Hearing Aids and Cochlear Implants. Otolaryngologic Clinics of North America. 2019 Apr;52(2): xv–xvi.
2. Browning LM, Nie Y, Rout A, Heiner M. Audiologists' preferences in programming cochlear implants: A preliminary report. Cochlear Implants International. 2020 Jan 3;1–13.
3. Verbist BM, Johan, Jakob Geleijns, Mark. Multisection CT as a valuable tool in the postoperative assessment of cochlear implant patients. American Journal of Neuroradiology. 2005 Feb 1;26(2):424–9.
4. Vaid S, Vaid N. Imaging for cochlear implantation: Structuring a clinically relevant report. Clinical Radiology. 2014 Jul;69(7):e307–22.
5. Alzahrani MA, Aldajani NF, Alghamdi SA. Guidelines for cochlear implantation in Saudi Arabia. Saudi Medical Journal. 2021 Dec;42(12):1265–71.
6. Al-Sayed AA, Abdulrahman AlSanosi. Cochlear implants in children: A cross-sectional investigation on the influence of geographic location in Saudi Arabia. Journal of family and community medicine/Mağalaẗ ṭib al-usraẗ wa al-muğtama'. 2017 Jan 1;24(2):118–8.
7. Alkhatani B. Parents' Perspectives on Cochlear Implantation Results for Deaf Children or Children With Hearing Loss in Saudi Arabia. American Annals of the Deaf. 2021;165(5):510–26.

8. Whiting BR, Holden TA, Brunsden BS, Finley CC, Skinner MW. Use of Computed Tomography Scans for Cochlear Implants. Journal of digital imaging [Internet]. 2007 Jun 16 [cited 2024 Apr 22];21(3):323–8. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3043842/

9. Colby CC, Todd NW, Harnsberger HR, Hudgins PA. Standardization of CT Depiction of Cochlear Implant Insertion Depth. American Journal of Neuroradiology [Internet]. 2014 Oct 22 [cited 2023 Feb 10];36(2):368–71. Available from: http://www.ajnr.org/content/ajnr/36/2/368.full.pdf

10. Aschendorff A. Imaging bei Cochlear-Implant-Patienten. Laryngo-Rhino-Otologie [Internet]. 2011 Mar [cited 2019 Jun 28];90(S 01):S16–21. Available from: http://europepmc.org/abstract/MED/21523630

11. Mackeith S, Joy R, Robinson P, Hajioff D. Pre-operative imaging for cochlear implantation: magnetic resonance imaging, computed tomography, or both? Cochlear Implants International. 2012 Aug;13(3):133–6.

12. Anurita Swarup, Vinusree Karakkandy, Preetam Chappity, Naik S, Sanjay Kumar Behera, Pradipta Kumar Parida, et al. Comparing accuracy of cochlear measurements on magnetic resonance imaging and computed tomography: A step towards radiation-free cochlear implantation. Journal of otology. 2023 Oct 1;18(4):208–13.

13. Srijata Chakravorti, Bussey BJ, Zhao Y, Dawant BM, Labadie RF, Noble JH. Cochlear implant phantom for evaluating computed tomography acquisition parameters. Journal of Medical Imaging. 2017 Nov 16;4(04):1–10.

14. Mackeith S, Joy R, Robinson P, Hajioff D. Pre-operative imaging for cochlear implantation: magnetic resonance imaging, computed tomography, or both? Cochlear Implants International. 2012 Aug;13(3):133–6.

15. Leinung M, Loth A, Gröger M, Burck I, Vogl T, Stöver T, et al. Cochlear implant magnet dislocation after MRI: surgical management and outcome. European Archives of Oto-Rhino-Laryngology. 2020 Feb 1;277(5):1297–304.

16. Grupe G, Wagner J, Hofmann S, Stratmann A, Mittmann P, Ernst A, et al. Prevalence and complications of MRI scans of cochlear implant patients. HNO. 2016 Feb 17;65(S1):35–40.

17. Eerkens HJ, Smits C, Hofman MBM. Cochlear Implant Magnet Dislocation. Ear & Hearing. 2021 Mar 2;Publish Ahead of Print.

18. Pietro Canzi, Carlotto E, Elisabetta Zanoletti, Johan, Borsetto D, Caruso A, et al. Multi-Magnet Cochlear Implant Technology and Magnetic Resonance Imaging: The Safety Issue. Audiology Research. 2024 Apr 26;14(3):401–11.

19. Kim BG, Kim JW, Park JJ, Kim SH, Kim HN, Choi JY. Adverse Events and Discomfort During Magnetic Resonance Imaging in Cochlear Implant Recipients. JAMA Otolaryngology–Head & Neck Surgery. 2015 Jan 1;141(1):45.

20. Widmann G, Dejaco D, Luger A, Schmutzhard J. Pre- and post-operative imaging of cochlear implants: a pictorial review. Insights into Imaging. 2020 Aug 15;11(1).

21. Hiremath SB, Biswas A, Mndebele G, Schramm D, Ertl-Wagner BB, Blaser SI, et al. Cochlear Implantation: Systematic Approach to Preoperative Radiologic Evaluation. RadioGraphics. 2023 Apr 1;43(4).

22. Muhammed Ayas, Parker R, Muir D, Muzaffar J. Knowledge and Practice in Cochlear Re-Implantation in the UK: A Survey for Audiologists. Audiology Research. 2024 Jul 17;14(4):649–58.