

# DIFFICULTIES WITH MAGNETIC RESONANCE IMAGING IN PATIENTS WITH COCHLEAR IMPLANTS: A REVIEW

## Contributions:

A Study design/planning  
B Data collection/entry  
C Data analysis/statistics  
D Data interpretation  
E Preparation of manuscript  
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## Abstract

**Introduction:** There are many patients with cochlear implants (CIs) who need to undergo an MRI examination. Due to recent developments in science and medicine a CI is no longer a contraindication for an MRI.

**Material and methods:** The review is based on scientific publications found in Google Scholar and PubMed databases.

**Results:** The problems with carrying out an MRI examination on a patient with a CI are the low quality of the image and possible head pain when the MRI machine is operating. Demagnetization or displacement of the CI magnet can also occur. Normally, special procedures are required, including removing all external parts of the implant system before the MRI, and bandaging of the head before the procedure. Implants compatible with new generation magnets exist and they allow an MRI to be performed without removing magnetic materials from the CI.

**Conclusions:** There are still many limitations in performing an MRI with CI patients; however the risk of implant damage can be significantly decreased. Patient comfort during the examination can also be increased.

**Key words:** cochlear implant • magnetic resonance imaging • medical procedures

## TRUDNOŚCI ZWIĄZANE Z WYKONYWANIEM REZONANSU MAGNETYCZNEGO U PACJENTÓW Z IMPLANTEM ŚLIMAKOWYM: PRZEGLĄD

### Streszczenie

**Wprowadzenie:** Wśród użytkowników implantów ślimakowych są pacjenci, którzy powinni przejść badanie rezonansu magnetycznego. Rozwój medycyny i technologii spowodował, iż nie ma obecnie przeciwwskazań do wykonywania tej procedury u osób z implantami ślimakowymi.

**Material i metody:** Przegląd został przygotowany na podstawie wielu publikacji naukowych, dostępnych w bazach Google Scholar i PubMed.

**Wyniki:** Jednym z problemów w przeprowadzaniu rezonansu magnetycznego u użytkowników implantów ślimakowych jest niska jakość uzyskanego obrazu, gdy magnes jest pozostawiony w implantcie. Może również wystąpić ból głowy, a także rozmagnesowanie lub przemieszczenie się magnesu. Bardzo istotne jest, aby postępować podczas badania zgodnie z procedurami. Przewidują one usunięcie wszystkich części zewnętrznych systemu implantu przed badaniem oraz zabandażowanie głowy. Istnieją implanty z magnesem nowej generacji, które pozwalają przeprowadzić rezonans bez usuwania magnesu z implantu.

**Wnioski:** Istnieje wciąż wiele ograniczeń w przeprowadzaniu rezonansu magnetycznego u pacjentów z implantem ślimakowym, jednak są sposoby aby znacznie obniżyć ryzyko zniszczenia implantu. Możliwe jest także podwyższenie komfortu pacjenta podczas badania.

**Słowa kluczowe:** implant ślimakowy • rezonans magnetyczny • procedury medyczne

### Introduction

Diagnostic MRI tests are increasingly being performed on patients with different diseases [1,2]. Due to the increasing number of patients with a cochlear implant (CI), the likelihood that such a patient will need an MRI in the future

also increases [1-3]. In the past, having a CI was a contraindication for this type of medical procedure [4-6].

Today, thanks to the development of technology and numerous studies on the subject, safe doses of electromagnetic radiation and appropriate guidelines have been established.

The aim of the study was to review difficulties related to the performance of magnetic resonance imaging in patients with CIs [7,8].

## Material and methods

The review was conducted with a number of scientific publications and case reports. The material was collected using the PubMed database and the Google Scholar search engine. The terms used in searching were ‘magnetic resonance imaging’ and ‘cochlear implants’. Articles from the last 5 years were taken into consideration. Over 7031 records were found in Google Scholar and 822 in PubMed. Guidebooks about medical procedures for CI users were also used in this review.

## Results

Currently, MRIs can be performed with field strengths of 0.2, 1, 1.5, 3, or even 7 T. For patients with a CI, MRIs can be performed after removing the magnet from the implant or, for up to 2 T, leaving it in place. The main problem in performing MRIs on patients with CIs is the quality of the obtained image – a CI causes artifacts in the examined area [9]. Removing the magnet from the CI before performing an MRI and replacing it with a non-magnetic spacer helps avoid artifacts and obtain better images. Removal is essential when performing an MRI with a field strength of 3 T or more [10–12].

Unfortunately, artefacts created during MRI examination in a patient with an implant are not the only problems. There are also possibilities of displacing the magnet in the implant, demagnetizing the implant magnet, and causing pain to the patient during the MRI. Sometimes the pain is very severe and it is impossible complete the MRI examination [8,9,13].

Magnetic resonance is a test in which an electromagnetic field is generated, directly affecting the implant’s magnet field, which can lead to displacement of the implanted magnet under the skin. Sometimes, the magnet returns to its original setting by itself after the test, but this does not always happen. Displacement of the magnet can be verified by CT scans or X-rays and sometimes it is necessary to replace the whole implant, requiring surgical intervention [8,9,14,15].

There are also cases where after an MRI it is impossible to fix the transmitter in place over the implant due to the complete demagnetization of the internal magnet. It is then necessary to replace the magnet. There are also cases of patients experiencing headache on the implant side during the MRI, which makes it necessary to stop the examination. Sometimes the magnet of the inner part of the implant loses its magnetic properties, which makes it necessary to use a stronger magnet. These patients need an operation in which the magnet is exchanged. The offline time, when a patient is unable to use the cochlear implant, can be up to one month. A patient with a CI should be aware of all the risks of MRI examination [8,9,14].

The requirements for MRI should also be mentioned in order to minimize the risk of the side effects described above. Firstly, it is necessary to remove all external parts

of the implant system, i.e. the speech processor and the transmitting coil, because they are not compatible with the electromagnetic field produced by the MRI apparatus. The next step may be to remove the magnet from the implant (in case of 3 T this is necessary). A special bandage is then applied around the patient’s head so that the implant location underneath the skin is covered. The maximum time for scans is 60 minutes [8,11,14].

After the test, if the magnet has been removed, it should be replaced by a new (sterile) one. If the magnet is left for testing, the adhesion of the transmitter should be checked afterwards. After the MRI examination, it should be also remembered to check the correctness of hearing in the implant [14].

## Implants with new generation magnets

Technology advances have allowed the development of a new generation of magnets, which enable fully safe magnetic resonance imaging up to 3 T without the need for surgical removal of the magnet and head bandaging [16].

Implants from different companies may contain from one to four rotating magnets, which during the MRI test are positioned in accordance with the magnetic field produced by the resonance. The smooth movement of the magnets produces very little torque, so that both adult patients and children do not feel any pain, even during a high induction MRI. The implants equipped with this technology produced by Advanced Bionics are named HiRes Ultra 3D because their magnets rotate in three dimensions during MRI. Other companies also produce implants which do not require surgical removal of the magnet. For example, there is the Synchrony model manufactured by MedEl in which MRIs up to 3 T are possible [16].

The new implant models significantly reduce the time needed to prepare the patient for an MRI because only the processor needs to be removed. This increases comfort of the patient who is not worried about the pain during the examination or the correct functioning of the implant system after the MRI. Another advantage of this solution is the lack of downtime in the use of the implant due to the necessity to remove the magnet. This increases the mental comfort of the patient, who does not have to be cut off from the world of sounds for some time. It also eliminates the cost of reimplantation, which was often necessary after an MRI of a patient who used the previous magnet technology [16,17].

If diagnostic procedures require accurate scans without artifacts, the magnet can be removed and replaced with a non-magnetic spacer, as with other implant models [18,19].

## Conclusions

Patients with a CI face a number of problems resulting from the construction and functioning of the implant. Despite the development of technology, there are still numerous limitations concerning problems with performing medical procedures such as MRI. The current safety procedures make it possible to eliminate or significantly reduce the risk of damage to the implant during an MRI test. Nevertheless, patients with Cs and their doctors need to be aware

of the limitations, risks, and possible side-effects of MRIs. This will allow safe and effective use of MRI and other medical procedures. Each case of a patient undergoing an

MRI should be considered individually based on the reason for ordering the examination, the patient's condition, and the implant model.

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