

**Title:** Are routine preoperative CT scans necessary in adult cochlear implantation?  
Implications for the allocation of resources in cochlear implant programs.

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# **Are routine preoperative CT scans necessary in adult cochlear implantation?**

## **Implications for the allocation of resources in cochlear implant programs.**

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### **Abstract**

**Aim:** To critically assess the influence of preoperative CT-scans on the implantation decisions of adult cochlear implant (CI) candidates.

**Hypothesis:** Routine preoperative CT scans may not provide critical additional information in the majority of adult CI candidates.

**Study design:** Retrospective chart review

**Methods:** 175 adults with unilateral CI were reviewed. Preoperative CT-scan reports were audited, and scans with reported pathology were examined by an Otologist-ENT Surgeon. Clinic notes and multidisciplinary team meeting summaries were also analysed to assess whether the results of the radiology report had influenced the decision to implant, or the laterality of implantation.

**Results:** Twenty five of the 175 scans showed an abnormality (14%). Five scans showed evidence of previous surgeries already known to the clinicians. From the remaining 20, 17 showed abnormalities including wide vestibular aqueducts, Mondini deformities and varying degrees of otospongiosis, which can be considered preoperatively helpful. Three scans (1.7%) demonstrated abnormalities that influenced the side of implantation, or the decision to

implant, and therefore had an impact on treatment.

**Conclusion:** Despite previous reports, a preoperative CT-scan seems to have an impact on treatment in only 1.7% of adult cochlear implantees. Hence, it may only be necessary to be performed in patients with history or clinical suspicion of meningitis or otosclerosis, if the individual was born deaf or became deaf prior to the age of 16, or if there are other clinical reasons to scan (e.g. otoscopic appearance). The related resources can be allocated towards post-operative imaging, especially in recipients with poor post-operative performance.

**Keywords:** hearing loss, cochlear implants, CT, imaging, preoperative, adults, cost

### **What is known on the subject**

- Preoperative CT scanning of the temporal bones forms part of the routine adult cochlear implantation assessment.
- An important role for post-operative CT scanning in cases of cochlear implantation is emerging, to guide implant programming in challenging cases especially regarding appropriate implant programming.

## **What does this paper add**

- Routine preoperative CT scans seem to have an impact on treatment in only 1.7% of adult cochlear implantees.
- It may only be necessary to be performed in selected patients, and the related resources allocated towards post-operative imaging, especially in poor performers.

## **Introduction**

Cochlear implants represent one of the most important achievements of modern medicine, as for the first time in history an electronic device is able to restore a lost sense – hearing [1]. More than 150,000 people have been implanted worldwide so far, and this number is steadily increasing despite the related cost ([http://www.usatoday.com/news/health/2009-08-16-cochlear-implant\\_N.htm](http://www.usatoday.com/news/health/2009-08-16-cochlear-implant_N.htm)).

Currently preoperative CT scanning of the temporal bones forms part of the routine adult cochlear implantation assessment. Preoperative imaging of the temporal bone can demonstrate anatomic details relevant to surgical management, which may be essential in the pre-surgical evaluation of patients receiving cochlear implants [2]. In addition, preoperative recognition of anomalies may help the surgeon in his/her decision to implant the most appropriate ear, plan a variation in surgical technique, or select special electrode arrays [3].

Furthermore, the criteria for cochlear implantation have expanded to include ears with residual hearing, severe congenital abnormalities, syndromes, and other challenging pathologies [4, 5].

Nonetheless, the surgeon may still encounter unexpected problems at the time of surgery either due to false negative pre-operative scanning or the normal variation in human cochlear anatomy<sup>6</sup>. In addition, an important role for the post-operative CT scan in cases of cochlear implantation is emerging, as cochlear implant teams are increasingly using post-operative CT imaging to guide implant programming (based upon the position of the implant array relative to the cochlea anatomy), especially in cases of suboptimal implant outcomes, and as an aid to understand the reported percepts of implanted individuals [7, 8].

The aim of the present study was to critically assess the influence of preoperative CT scans on the implantation decisions of adult cochlear implant candidates at a tertiary referral centre. The hypothesis was that routine preoperative CT scans may not provide critical additional information in the majority of cases, and resources might better be focused upon post-operative imaging.

## **Materials & Methods**

A retrospective study was conducted at a tertiary University hospital in 175 adult (> 16 years old) patients who underwent unilateral cochlear implantation over the past 5 years.

The preoperative CT scan reports for all adult implanted patients were audited, and all scans with reported pathology were examined by an experienced Otologist-ENT Surgeon. The CT scans had been performed in axial and coronal planes in a bone window setting, with a slice thickness of 0.5mm.

In addition, a retrospective analysis of the patient notes was performed in all scans with reported pathology, to assess whether the results of the radiology report had influenced the decision to implant, or the laterality of implantation. Clinic notes and multidisciplinary team meeting summaries were also carefully examined.

## **Results**

Twenty five out of the 175 scans which were reviewed showed an abnormality (14%). Among these, five scans showed evidence of previous surgeries, which were already known to the clinicians.

From the remaining 20, 17 showed abnormalities including wide vestibular aqueducts, Mondini deformities and varying degrees of otospongiosis, which can be considered preoperatively helpful. However, only three scans (1.7%) demonstrated abnormalities that influenced the side of implantation, or the decision to implant, and therefore had an impact on treatment. These included: a) a left sided osteoma of the internal auditory meatus (fig. 1), b) a right sided labyrinthitis ossificans in a patient with previous meningitis (fig. 2), and c)

bilateral cochlear calcification, worse on the right than the left in a patient with a clinical diagnosis of otosclerosis.

## **Discussion**

The perceived advantage of using CT scanning as the pre-operative investigation of choice is that it may display anatomic middle ear variations of surgical importance, such as the bony borders of a malformed labyrinth, a low lying roof, a high jugular bulb, or an aberrant carotid artery [9, 10] (fig. 3). This information can be important for the surgeon in order to analyse the direction of insertion of the cochlear array pre-operatively, thus minimizing the risk of misplacement or intra-operative injuries [10].

Whilst the situation in pediatric candidates is more complex, as up to 20% of congenitally deaf children have inner ear anomalies that impede with the full insertion of the cochlear implant array [3, 11], and the ensuing suppuration of the inner ear in post-meningitic children may cause a variable degree of fibrosis in the perilymphatic space, which in turn may progress to soft tissue obliteration and ossification, the results of the present study demonstrate that this does not seem to be the norm in adult candidates.

Indeed, 11.4% of preoperative CT scans included information which the implant team considered preoperatively helpful, however, the depicted abnormalities influenced the side of implantation, or the decision to implant, and therefore had an impact on treatment, in only



1.7% of adult implantees (three patients). In contrast, the decision to implant, as well as the laterality, was mostly clinical and not radiological, e.g. dry ear in cases of chronic otitis media, or contralateral to any preserved balance function, following preoperative caloric testing. These results do not seem to agree with the results of Mueller et al, who had identified abnormalities in 50% of the examined ears (12 out of 24 ears) in their series of 12 cochlear implantees. The additional information obtained by the CT scan had strongly influenced the selection of the ear to be implanted in two patients in the aforementioned study, and was considered useful for pre-operative planning in four additional cases [12].

Whilst it is recognised that the cochlear patency in adult implant candidates can decrease as a result of post-meningeal cochlear obliteration, or several middle ear disorders, including severe otosclerosis, disruptive temporal bone fractures, and prior surgery [13], and CT scanning can provide a surgical “roadmap” in these patients, careful consideration of the patient’s past medical history, and detailed clinical examination, may avoid the need of a preoperative scan in the majority of adult recipients. In addition, otologists may find some degree of bony obstruction within the basal turn of the cochlea even when the CT scan is normal [14]. The pitfall in misinterpretations regarding cochlear patency is that the inexperienced surgeon may find him/herself unexpectedly drilling out a partially or totally obliterated cochlea [11].

By contrast, a post-operative CT scan may play an important role in guiding the programming of the implant (based upon the position of the implant array relative to the cochlear anatomy) in cases of suboptimal implant outcomes.

Indeed, Finley and co-workers investigated the depth of electrode insertion and scalar location in relation to speech recognition outcomes, and found that poorer functional outcomes were associated with greater insertion depths, and greater numbers of contacts within the scala vestibule [8]. These results corroborated the previous findings of Aschendorff et al who had reported that patients with scala tympani insertions and a short duration of deafness had performed significantly better in typical German speech tests, when compared to patients with scala vestibule insertions and short duration of deafness [15]. This may be due to the destruction of Reissner's membrane, organ of corti remnants, and scala media integrity when scala vestibuli insertions occur. Kinking of an electrode inserted in the scala tympani may also mean that some contacts lie within the scala vestibuli.

The current practice is to use plain x-rays to assess electrode position. The Rotational Tomography techniques used by Aschendorff et al have minimised electrode artefact and allowed more accurate assessment of the array within the scala tympani and scala vestibule [16]. Such an assessment may have wider clinical implications than those initially meeting the naked eye, as an unexpected 62% of scala vestibuli insertions, and a dislocation rate of 71% from the scala tympani to the scala vestibuli were identified by routinely performing postoperative imaging in cochlear implantees in one Centre [17]. The ensuing feedback resulted in an increase of the scala tympani insertion rate to 84%, and a decrease of scalar dislocations to 22% [18]!

The overall cost of cochlear implantation in adults amounts to approximately £28,000 over a 12-year period, including follow-up and maintenance of the system [19]. As a consequence of the audited results of the present patient series, the Cambridge Cochlear Implant Centre has

decided to only scan adult patients preoperatively, if there is a history or clinical suspicion of meningitis or otosclerosis, if the individual was born deaf or became deaf prior to the age of 16, or if there are other clinical reasons to scan (e.g. otoscopic appearance) (fig. 4). It is hoped that, given the limited resources available for each patient, this algorithm may provide a means for reducing unnecessary preoperative CT scans, thus allowing additional post-operative imaging, when deemed necessary. Indeed, post-operative scans are becoming more useful in the assessment and management of implanted individuals, particularly poor performers, since the criteria for cochlear implantation have expanded; anecdotal evidence estimate the figure of this specific patient subgroup to up to 10% of cochlear implantees.

In contrast, the Cambridge Implant Program continues to support a dual modality approach, with high resolution CT and MRI imaging of the petrous bone and brain in pediatric implant candidates, as it is felt that this approach can provide the maximum information to the operating surgeon, with regard to surgical landmarks, and also detect abnormalities related to pediatric deafness, which would otherwise not be found, using either modality alone [20]. Taking also into account the high expenses of cochlear implants, the vulnerability of pediatric implant candidates, and related parental expectations, the dual modality pre-operative imaging may not only distinguish children who will benefit most from implant surgery, but will also help identifying surgically-challenging cases, or avoid unnecessary operations [10], thus remaining compliant with the principles of cost-effectiveness.

## **Conclusion**

Despite previous reports, a preoperative CT scan seems to have an impact on treatment in only 1.7% of adult cochlear implantees. Hence, it may only be necessary to be performed in patients with history or clinical suspicion of meningitis or otosclerosis, if the individual was born deaf or became deaf prior to the age of 16, or if there are other clinical reasons to scan (e.g. otoscopic appearance). The related resources can be allocated towards post-operative imaging, especially in recipients with poor post-operative performance.

## **Authors' statement**

- 1) Mr. Kenway: Writing of the manuscript
- 2) Dr. Vlastarakos: Critical review, writing of the manuscript
- 3) Mr. Kasbekar: Writing of the manuscript
- 4) Mr. Axon: Patient review, critical review of the manuscript, study concept
- 5) Mr. Donnelly: Critical review of the manuscript, study concept

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## Figures

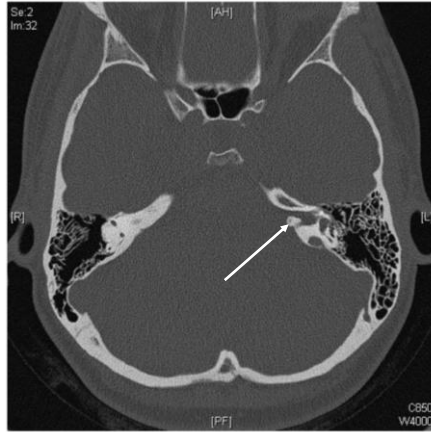


Figure 1

Left sided osteoma of the internal auditory meatus



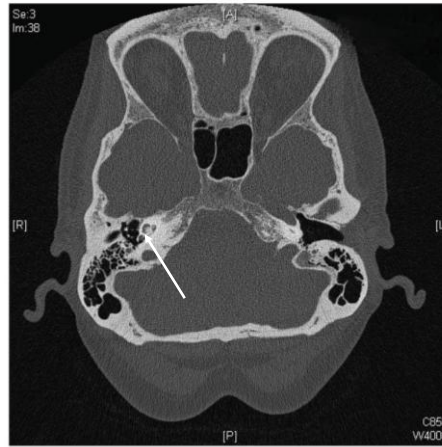


Figure 2

Right sided labyrinthitis ossificans



Figure 3

Right aberrant carotid artery

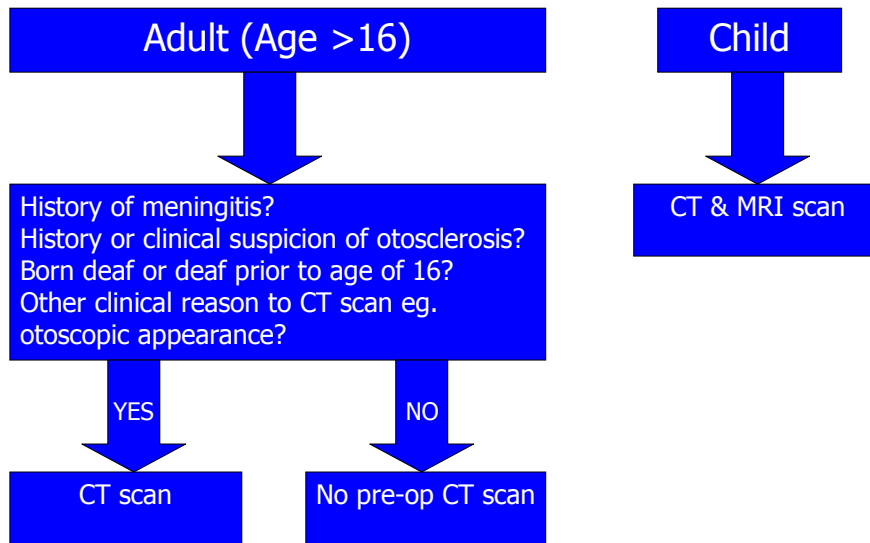


Figure 4

Preoperative CT scan decision tree in cochlear implantation

*(If there is asymmetrical hearing loss or unilateral tinnitus, consider MRI scan as per usual practice).*