Utility of Intraoperative Imaging during Cochlear Implantation: A systematic Review

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Introduction

Cochlear implants (CIs) are surgically inserted devices used in patients with hearing loss. Accurate insertion of the electrodes is necessary for optimal postoperative performance of the device, and inaccurate placement can lead to poor performance or revision surgery [1-4].

There are multiple imaging modalities used to ascertain accurate electrode placement intra-operatively. These include imaging, such as plain-film x-ray, three-dimensional rotational x-ray, computed tomography, and fluoroscopy. All modalities have been shown to accurately demonstrate electrode placement, but the utility of imaging still remains under debate and non-standardized.

This study aimed to systematically review the literature regarding the utility of intra-operative imaging in CI surgery and implications for management. Specifically, we hypothesized that imaging would be most useful either when placement is anticipated to be challenging, as abnormal cochlear anatomy, or when the surgeon questions appropriate placement based on tactile perception during surgery.

Methods and Materials

PubMed, EMBASE, Medline, CINAHL, and Cochrane library were searched from inception to August 2016 for observational and prospective studies. Studies were included if their outcomes focused on intraoperative imaging during CI surgery. Articles were excluded if they were case reports, non-human studies, not available in English, or were not pertaining to cochlear implants The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) recommendations were used as the methodological basis for this review.

Two authors independently reviewed titles, abstracts, and full articles and excluded those that did not meet inclusion criteria. Once the final list of articles was created, data extraction was performed.

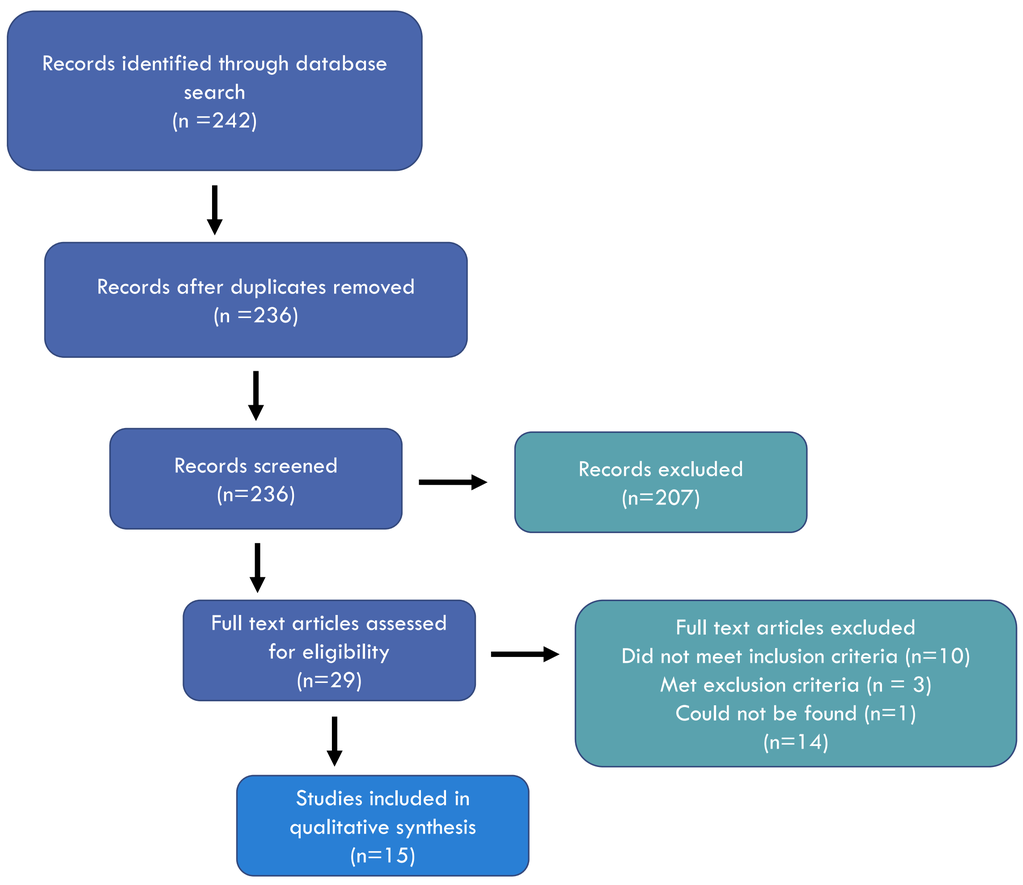

Figure 1. PRISMA diagram detailing systematic review.

Results

Fifteen studies were reviewed, for a total of 1,006 CIs. There were no randomized controlled studies, and no studies compared modalities. Thirteen out of 15 studies concluded intra-operative imaging was useful.

Intra-operative x-rays were performed in 915 CIs in seven studies (Table 1). Placement of electrodes was found to be unsatisfactory in 20 implants (2.2%). Five out of seven studies found this modality to be useful.

Intraoperative CT was performed in 67 CIs in six studies (Table 2) Placement was unsatisfactory in 2 patients (3.0%). All studies found this modality useful.

Two studies examined the utility of intraoperative fluoroscopy in 20 CIs (Table 3). All studies found fluoroscopy useful.

Author	Year	Title	Total CI	# of abnormal cochleas	Number of unsatisfactory placements	Position changed?	Authors in favor of imaging?
Copeland et al.	2004	Prospective evaluation of intraoperative cochlear implant radiographs	80	9	1, revision ear	Yes	**No**
Cosetti et al.	2012	An evidence-based algorithm for intraoperative monitoring during cochlear implantation	277	0	5	Yes	**Yes**
Gnagi et al.	2015	Analysis of intraoperative radiographic electrode placement during cochlear implantation	207	0	0	N/A	**No**
Grolman et al.	2009	Spread of excitation measurements for the detection of electrode array foldovers: a prospective study comparing 3-dimensional rotational x-ray and intraoperative spread of excitation measurements	72	Unknown	4	Yes	**Yes**
Molezini et al.	2012	Cochlear implant radiography: technique adapted into a portable apparatus	262	Unknown	5	Yes	**Yes**
Rosenberg et al.	1987	Radiographic imaging for the cochlear implant	14	5	1	No	**Yes, in difficult cases**
Viccaro et al.	2009	The importance of intra-operative imaging during cochlear implant surgery	3	0	2	Yes	**Yes, in difficult cases**

Table 1. Studies examining intraoperative X-ray.

Author	Year	Title	Total CI	# of abnormal cochleas	Number of unsatisfactory placements	Position changed?	Authors in favor of imaging?
Arweiler-Harbeck et al.	2012	Imaging of electrode position after cochlear implantation with flat panel CT	31	Unknown	0	N/A	**Yes, with their technique**
Hong et al.	2009	Medical navigation system for otologic surgery based on hybrid registration and virtual intraoperative computed tomography	5	0	0	N/A	**Yes, with their technique**
Labadie et al.	2014	Minimally invasive image-guided cochlear implantation surgery: first report of clinical implementation	9	Unknown	0	N/A	**Yes, with minimally invasive CI**
Pearlman et al.	2014	Coregistration of preoperative computed tomography and intraoperative three-dimensional rotational x-ray images for cochlear implant surgical evaluation	5	0	0	N/A	**Yes, with their specific technique**
Stieve et al.	2006	Intraoperative computed tomography in otorhinolaryngology	7	Unknown	0	N/A	**Yes**
Yuan et al.	2012	Intraoperative CT-guided cochlear implantation in congenital ear deformity	10	10	2	Yes	**Yes**

Table 2. Studies examining intraoperative CT.

Author	Year	Title	Total CI	Number of abnormal cochleas	Number of unsatisfactory placements	Position changed?	Authors in favor of imaging?
Coelho et al.	2008	Implanting common cavity malformations using intraoperative fluoroscopy	15 (4 controls, 11 cases)	15	2/4 controls 0/11 cases	Yes	**Yes**
Fishman et al.	2003	Fluoroscopically assisted cochlear implantation	9	4	0	N/A	**Yes**

Table 3. Studies examining intraoperative fluoroscopy.

Discussion and Conclusions

Thirteen studies concluded that intra-operative imaging was useful, especially in cases with abnormal anatomy or technically challenging electrode placement. Unsatisfactory electrode placement rates seen in this study of 2.2-3.0% are low, but not negligible [5].

Give this rate and the need to avoid revision surgery, intra-operative x-ray may not always be indicated, but should be used in situations of abnormal cochlear anatomy or when the surgeon questions appropriate placement. Intraoperative CT is feasible and accurate, but cost and radiation exposure limits routine use [6]. Intraoperative fluoroscopy is extremely useful in challenging anatomy, but there are safety concerns given the radiation exposure to both the surgeon and patient [7].

Based on available literature, we cannot conclude which modality is best or if routine imaging is necessary in all CI surgery, but intra-operative x-ray may be most helpful in cases with abnormal anatomy or difficult placement.

Contact

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