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Utility of intraoperative and postoperative radiographs in pediatric cochlear implant surgery[☆]



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ABSTRACT

Objective: Routine plain film radiographs are often obtained to confirm proper placement of electrode after pediatric cochlear implant surgery. Objective is to evaluate necessity of routine radiographs in pediatric cochlear implant cases.

Study design: Retrospective review.

Setting: Two tertiary care academic centers.

Subjects and methods: Review of all children that underwent cochlear implantation from January 2003 thru June 2015. Exclusions include patients without intraoperative evoked compound action potential (ECAP) data or radiographs and patients undergoing revision surgeries.

Results: 235 pediatric patients underwent 371 cochlear implants. ECAP measurements were not available in two cases and were excluded from study. Radiographs were obtained in 35/369 cases due to intraoperative concern and four had abnormal findings. All four cases underwent change in management. One other patient had an x-ray because of difficult insertion and abnormal ECAP. Radiograph was normal; however, incision was opened and electrodes inserted further. Overall, 5/369 cases had changes in management intraoperatively. In all five cases, abnormalities were suspected by clinician judgment or abnormal ECAP measurements. Routine radiographs were completed in 349/369 cases and one was abnormal. This patient had known partial insertion due to cochlear fibrosis from meningitis and abnormal radiograph did not result in change in management.

Conclusion: Clinician suspicion and/or abnormal ECAP prompted suspicion for abnormal electrode placement prior to evaluation with radiograph in all cases in which change in management occurred. Intraoperative radiographs may be valuable in setting of clinical suspicion. Routine radiographs do not result in change in management and are, therefore, unnecessary.

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1. Introduction

As of December 2012, nearly 40,000 cochlear implantations have been performed in pediatric patients [1]. Nearly a third of the children that undergo cochlear implantation have cochleovestibular anomalies, and there is increased risk of electrode array misplacement in implantation of patients with these anomalies [2]. Even in routine cases, there is a possibility of tip fold-over, kinking,

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over- or under-insertion, or looping which can ultimately alter patient outcomes [3]. Confirmation of proper electrode placement in pediatric patients usually includes a combination of intraoperative evoked compound action potential (ECAP) and radiologic testing, although no standard protocol has been established.

A recent study published in 2013 evaluated the value of routine plain x-rays in position checks after cochlear implantation [3]. The study found 8% of the cohort had electrode misplacement and nearly half of these cases would have been overlooked if radiographs were not used to confirm position. The study, however, did not report use of intraoperative ECAP assessment in assisting in confirming proper placement of electrodes and is not limited to pediatric patients.

Concern for radiation exposure in children has recently emerged

due to findings of increased risk of leukemia and brain cancers in children exposed to ionizing radiation in computed tomography studies [4]. This increased concern forces us to re-evaluate the practice of routine imaging of pediatric patients undergoing cochlear implantation. The objective of this study is to evaluate the utility of routine radiograph evaluations in children undergoing cochlear implantation and whether surgical findings and intra-operative use of ECAP testing can be used to guide decision-making regarding the need for plain radiograph evaluation.

2. Methods

This is a retrospective review of all children that underwent cochlear implantation from January 2003 through June 2015 at two tertiary care academic centers. Following approval from the Institutional Review Boards of the University of Pittsburgh and Cleveland Clinic Foundation, patients were identified using the records of the attending physician performing the surgery and using CPT codes for cochlear implantation. Patients without intraoperative ECAP testing or plain film radiographs, as well as patients undergoing revision surgeries, were excluded from analysis. All patients underwent implantation in the standard fashion through the facial recess approach. In addition, all of the electrodes (for example, the Contour Advance brand contains 22 electrodes) of each implant was tested using ECAP, and the results were interpreted by trained clinicians. Charts were reviewed and the following data was recorded: patient demographic data, abnormal surgical insertion findings, abnormal ECAP findings, diagnosed cochleovestibular anomalies, radiograph findings, and if a change in management occurred as a result of a radiograph finding.

Radiographs were attained to confirm proper electrode placement as routine practice or to evaluate intraoperative electrode placement due to concern arising from intraoperative ECAP and/or surgical insertion difficulty or abnormality. Radiographs were also performed intraoperatively in children that are unable to undergo radiograph post-operatively due to inability to sit still; otherwise radiograph was performed in the immediate post-operative period. X-rays were classified as either being obtained for routine placement checks or because there was a concern due to an abnormal cochlea, partial/difficult insertion, or abnormal ECAP finding.

Radiographs were considered abnormal if they did not reveal the normal c-shaped curvature for the electrode and if they had any abnormal features including kinking, bent tip, or incomplete insertions. Intraoperative concern is defined as difficulty during insertion of electrode array, mainly encountering resistance or abnormal ECAP measurements. Abnormal surgical findings included partial insertions and difficult insertions because of resistance from fibrosis, as well as device problems like kinking of the electrode.

ECAPs are responses from electrically stimulated auditory nerve fibers and were performed on all patients. Impedance testing was also performed as well. ECAP measurements were obtained by neural response telemetry (NRT) for patients undergoing Cochlear devices and by Neural Response Imaging (NRI) for Advanced Bionics devices. Abnormal ECAP findings are defined as one or more series of three or more electrodes which do not have a response. In the case of the Contour Advance brand, an example of an abnormal ECAP finding is electrodes 1–5 and 11–18 having no response.

Associations between abnormal x-ray findings, concerns with insertion, cochlear abnormalities, abnormal ECAP results, and changes in management (i.e. removal and re-insertion of the same implant or replacement with a new implant) were assessed using Fisher's exact test, and the sensitivity and specificity of each of these variables for predicting a change in management were calculated. Statistical analyses were conducted using Stata/SE 13.1

(StataCorp LP, College Station, TX).

3. Results

235 pediatric patients underwent 371 cochlear implants. ECAP measurements were not available in two cases and these patients were excluded from the study. Average age of CI was 5.6 years (5.6 ± 5.4). Median age at CI was 3 years (range 0.5–21). 51.5% of patients were male and 48.5% were female. Demographic data is further categorized in Table 1.

Radiographs were obtained in 35/369 cases due to intra-operative concern and four cases had abnormal findings. All four cases underwent change in management. Some patients that had intraoperative radiographs also had follow up routine radiographs. Routine radiographs were completed in 349/369 cases and only one was abnormal. This patient had cochlear fibrosis from meningitis and known incomplete insertion and thus did not result in change in management (Table 2).

Overall, 5/369 cases had changes in management intra-operatively; in all five cases, abnormalities were suspected by clinician judgment or abnormal ECAP (Table 3). Further details on these 5 patients are as follows. Patient 1 was the sole patient with a change in management who had a documented cochlear abnormality on computed tomography (CT) scan; this patient was found to have Mondini malformation. The electrode was only able to be partially inserted, and all 22 electrodes were not responsive on NRT testing. Two x-rays were obtained intra-operatively due to the abnormal NRT results, difficult insertion, and abnormal cochlear anatomy. These x-rays revealed a possibly entry of the electrode into the second turn or folding-over of the tip of the electrode. The electrode was removed and replaced with a new electrode. Repeat NRT testing was within normal limits. Patient 2 had some fibrosis of the perilymphatic space leading to a difficult insertion. Again, all 22 electrodes were not responsive on NRT testing. Two x-rays were obtained intra-operatively due to the abnormal NRT results and difficult insertion, revealing that the electrode was not in the appropriate orientation within the cochlea (Fig. 1). The electrode was removed, replaced with a new electrode, and repeat NRT testing results were within normal limits. Patient 3 had a difficult insertion and 16 out of 22 electrodes did not respond during NRT testing. One x-ray was obtained intra-operatively showing the electrode was not located within the cochlea. The electrode was removed and reinserted, and repeat NRT testing results were within normal limits. Patient 4 had an insertion that was complicated by a kink in the electrode noted during insertion. Only 1 electrode out of 22 did not respond during NRT testing. However, one intra-operative x-ray was obtained due to the abnormal shape

Table 1
Demographic data.

	Total
Number Patients	235
Number of CI	369
Unilateral	92/369 (24.9%)
Simultaneous Bilateral	99/369 (26.8%)
Sequential Bilateral	166/369 (45.0%)
Reimplant	12/369 (3.3%)
Age in Years at CI (Median, Range)	3 (0.5–21)
Age in Years at CI (Mean \pm SD)	5.7 \pm 5.5
Sex	
Male	190/369 (51.5%)
Female	179/369 (48.5%)
Ear	
Left	171/369 (46.3%)
Right	198/369 (53.7%)

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