

# Significance of high-resolution spiral CT and X-ray examination in the evaluation of preoperative selection and postoperative outcome of patients with multichannel cochlear implantation

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## Abstract

**BACKGROUND:** Artificial electronic cochlear (AEC) is a high-tech product used as a therapeutic substitute for pathological cochlear, and the implantative state of AEC can be assessed with the aid of imaging techniques.

**OBJECTIVE:** To investigate the significance of CT and X-ray examination in the evaluation of preoperative selection and postoperative therapeutic result of patients with AEC implantation.

**DESIGN:** Self-control observation.

**SETTING:** Auditory Rebuilding Ward of Otolaryngology Department, Zhujiang Hospital, Southern Medical University.

**PARTICIPANTS** Forty-four patients prepared for AEC implantation because of severe sensorineural hearing loss or extremely severe sensorineural hearing loss were recruited from the Otolaryngological Department, Zhujiang Hospital, Southern Medical University from January 1999 to June 2003. Thirty-two patients were with prespeech hearing loss, aged 2.5-12 and 12 patients with postspeech hearing loss, aged 10-42.

**METHODS:** Axial high-resolution temporal bone CT and three-dimensional reconstruction of inner ear were performed on 44 patients. They lay in supine position and received bilateral symmetric scanning with view of 9.6 cm. The baseline was set at the level of upper limit of auditory frame, and temporal bone was axially scanned. The scanning parameters were thickness of 1 mm, spiral distance of 1.0 and interval of 0.5 mm; inserting rebuilding was performed after scanning with thickness of 1mm and interval of 0.1 mm. The improved routine cochlear axial staves-X-ray image was performed after operation, and three patients underwent spiral CT temporal volume scanning due to suspicious postoperative complications.

**MAIN OUTCOME MEASURES:** ① Preoperative inner ear structure. ② Postoperative inner ear and the arrangement and depth of implanted AEC.

**RESULTS:** Totally 44 patients were remained in the result analysis performed according to intention-to-treat analysis. ① Preoperative inner ear structure: Of the 32 patients with prespeech deafness, 1 case (2 ears) was diagnosed as type I Mondini malformation and 2 cases (4 ears) as type II Mondini malformation. Of the 12 patients with postspeech deafness, chronic suppurative otitis media was observed in 2 cases (4 ears), inner ear ossification in 1 case (2 ears), large vestibular aqueduct syndrome in 3 cases (6 ears) and cochlear sclerosis in 1 case (2 ears). ② Postoperative inner ear and the arrangement and depth of implanted AEC image of X-ray indicated that the electrode was implanted right in cochlea displaying planar spiral shape and located at the bottom of inner-ear channel. Postoperative CT scanning was performed on 3 cases and revealed that electron was implanted into the bottom surroundings through round window and the electrode got twisted and infected in one cases.

**CONCLUSION:** ① Axial high-resolution temporal bone CT scanning and three-dimensional reconstruction of inner ear can be adopted before AEC implantation for screening out acute and chronic suppurative and severe otitis media, server maformation of inner ear labyrinth. ② Postoperative X-ray image can afford clues to know the position and depth of implanted AEC and find out the twist and olithy of electrode, if any CT and cochlea image are supplemented for preoperative case selection and postoperative therapeutic evaluation, helping AEC to exert auditory function to the maximal degree.

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## INTRODUCTION

In recent years, artificial cochlea implantation has been widely applied in the country and proved of satisfactory outcome in patients with severer hearing loss giving hope for them to leave silent world and study like normal one. In the study, CT scanning was used to make evaluation on the preoperative case selection and postoperative outcome of AEC implantation.

## SUBJECTS AND METHODS

### Subjects

Patients with hearing loss were recruited from the Otolaryngological Department; Zhujiang Hospital Southern Medical College from January 1999 to June 2003. Inclusion criteria: ① Severe or extremely severe sensorineural hearing loss. ② Prepared for AEC implantation. ③ Of either gender. ④ Informed consent was obtained from patients or their relatives. Exclusion criteria: tympanitis and inner-ear malformation. Thirty-two patients who became hearing loss before speech were of the age of 2.5-12 years old and 12 patients who got hearing loss after speech were of the age of 10-42 years old.

### Methods

Axial high-resolution temporal bone CT and three-dimensional reconstruction of inner ear were performed before implantation, improved routine cochlear axial staves-X-ray image was performed after operation and three patients underwent spiral CT temporal volume scanning due to suspicious postoperative complications. CT machine was GE Hispeed CT/I, and working platform was GE Advantage widows 2.0 image analysis system. Patients lay in supine position children who could not cooperate were scanned in sleep induced by oral administration of 10% hydrochloride 5-10 mL. Scanning image was performed with lateral as target scanning the view was 9.6 cm and the baseline was set at the level of upper limit of auditory frame, and temporal bone was axially scanned. The scanning parameters were thickness of 1mm spiral distance of 1.0, interval of 0.5 mm and inserting rebuilding was performed after scanning with thickness of 1mm and interval of 0.1 mm. All data were transported to work platform where CT-inner software was processed to make three-dimensional reconstruction of inner ear.

## RESULTS

### Quantitative analysis of the participants

Totally 44 patients were remained in the result analysis performed according to intention-to-treat analysis.

### Preoperative inner ear structure

Of the 32 patients with prespeech deafness, basically normal inner-ear structure could be observed in 28 cases; 1 case (2 ears) was diagnosed as type I Mondini malformation, whose undeveloped bilateral cochlea seemed like a small sac the horizontal semicircular canal was inosculated with neighboring vestibule into big sac, and the upper and anterior semicircular canal were shortened. Two cases (4 ears) were diagnosed as type II Mondini malformation, whose poorly developed cochlea only spiraled 1.5 circles and the upper circle and middle circle were inosculated into sac, but the bottom circle obviously were enlarged and the semicircular canal was

deformed with the bottom of inner-ear channel enlarged<sup>[1]</sup>. The above malformation of inner ear could be displayed directly on the CT image of three-dimensional reconstruction. No Michel malformation could be observed in this study; however, Alexander and Scheibe malformation are in the blind region of image examination.

Of the 12 patients with post-speech deafness, normal inner ear structure could be observed in 5 cases. Large vestibular aqueduct syndrome was observed in 3 cases (6 ears), cochlear sclerosis in 1 case (2 ears) and chronic suppurative otitis media in 2 cases (4 ears), where we observed that gas in middle-ear cavity, tympanic sinus and papillary gas sinus disappeared with fluid accumulated in it. Inner-ear ossification was observed in 1 case (2 ears).

### Postoperative examination of semicircular canal, vestibular, cochlea (containing electron) and inner ear channel

X-ray indicated that the upper semicircular canal was in vertical hyaline circular shape, while outer semicircular canal was in horizontal hyaline circle circular shape, both of them were connected, forming a round hyaline region, namely vestibula, which linked with inner-ear channel on the outside. Cochlea electrode was implanted in the cochlea like two-dimensional spiral, located at the bottom of inner-ear cochlea.

In the study, postoperative CT examination was performed in 3 cases, electrode was implanted into the cochlea surroundings through round window. CT can reflect not only the implanted electrode, but also the pathological changes in middle ear and papillary. One patient developed purulent tympanitis with electrode twisted in cochlea and AEC was re-implanted in the opposite side after the infection was controlled.

### DISCUSSION

AEC is an artificial substitute for pathological cochlea, which can produce electric signals with the aid of sound-electricity exchanging device, thereby inducing auditory sense by stimulating the residual auditory neurofibers. Preoperative image evaluation aims to select those who fit for AEC implantation and focus mainly on screening out acute and chronic tympanitis and severe malformation of inner-ear bone labyrinth because they might be the contraindications of AEC implantation<sup>[2,3]</sup>. AEC is the last choice for patients with large vestibular aqueduct syndrome.

Spiral CT three-dimensional reconstruction is to outline the inner ear structure based on the operator's understanding and the primary axial two-dimensional images, which was then transformed into three-dimensional images with CT-inner software, directly reflecting the inner ear structure and congenital malformation of bone labyrinth. Overlapped scanning and ultra-thin layer insert rebuilding can produce images of high-quality. Three-dimensional images should be observed in multiple directions in order to reflect its stereoscopic configuration. As for the anatomical details of inner-ear, such as the relationship between cochlea and inner-ear cochlea bottom, cochlea and the round windows-middle ear as well as the relationship between vestibula and inner-ear cochlea, vestibula and semicircular canal, vestibula and oval window-middle ear all can be revealed perfectly in multiple angles and aspects. CT can be used to screen out acute and chronic tympanitis, cochlea ossification and various malformations of inner-ear bone labyrinth. As for patients with cochlea fibrosis and ossification, MRI is more preferable and objective than CT three dimensional reconstruction in reflecting cochlea, vestibula and semicircular canal; therefore, preoperative CT is not enough and should be supplemented by MRI three dimensional reconstruction<sup>[4,5]</sup>. Although AEC implantation is successful, there are still 7% abnormal images can be observed, so it is necessary to conduct X-ray examination if distant controlling detection of nervous reaction is

unavailable during the operation<sup>[6]</sup>. Cochlea image can provide enough information about the position of implanted electrode, implanted depth and whether there are twist and olistry of electrode. Hence, as a routine postoperative evaluating means, postoperative CT can reflect the position of implanted electrode in the cochlea tube, but only a part of it can be reflected in each layer and it is difficult to make general evaluation about the implanted cochlea and therefore, it is the cochlea plane image but not CT that is preferable to assess the implanted electron position. Those who are suspicious of having postoperative complications should be subjected to CT scanning, which can clearly reflect not only the implanted electrode, but also the structure of middle ear, papillary and the pathological changes.

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## 高分辨率螺旋CT及X射线检查对多导人工耳蜗植入术前患者选择及术后效果评估的价值

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### 摘要

背景:人工电子耳蜗是用来代替病变耳蜗的一种高科技治疗手段,影像学检查可以帮助了解人工耳蜗电极的植入情况。

目的:探讨CT及X射线检查对人工电子耳蜗植入术前患者筛选及术后效果评估的价值。

设计:自身前后对照观察。

单位:南方医科大学附属珠江医院耳鼻咽喉科听力重建病房。

对象:选择1999-01/2003-06拟进行人工耳蜗植入术的重度或极重度感音性耳聋患者44例。语前耳聋32例,年龄2.5-12岁;语后耳聋12例,年龄10-42岁。

方法:对44例患者均采用颞骨轴位高分辨率CT螺旋扫描及内耳三维重建。患者取仰卧位,两侧对称分别做靶扫描,视野9.6cm,基线与听眶上缘平行,轴位容积扫描颞骨。扫描参数:层厚1mm,螺距1.0,间距0.5mm,扫描结束后再行层厚1mm,间距0.1mm内插重建。术后采用常规耳蜗轴位改良的斯氏位X射线摄影,对于怀疑有术后并发症的3例患者,行螺旋CT颞骨容积扫描。

主要观察指标:①术前患者内耳结构检查结果。②术后患者内耳和植入电极排列及深度检查结果。

结果:按意向处理分析,44例患者均进入结果分析。①术前患者内耳结构检查结果:32例语前聋患者中检出1例2耳Mondini畸形I型,2例4耳Mondini畸形II型;12例语后聋患者中检出2例4耳慢性化脓性中耳炎,1例2耳内耳骨化,1例2耳耳硬化症,3例6耳大前庭水管综合征。②术后患者内耳和植入电极排列及深度检查结果:X射线片显示,植入的耳蜗电极位于耳蜗之中,呈二维的螺旋状,位于内耳道底。3例术后行CT检查,电极自圆窗植入耳蜗底周,其中1例术后植入电极扭结并感染。

结论:①人工耳蜗植入患者术前应用颞骨轴位高分辨率CT螺旋扫描及内耳三维重建可以检出急性慢性中耳炎、内耳骨迷路结构的严重畸形。②术后耳蜗位X射影片可提供电极的位置、植入的深度以及电极有无扭结或滑脱。CT及耳蜗位影片检查相互补充,可进行术前病例选择和术后效果评估,有助于最大限度地发挥人工耳蜗改善听力的作用。

主题词:耳蜗植入物;电极;植入;体层摄影术;螺旋计算机

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