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Diagnostic value of CT and MRI of Temporal Bone in Cochlear Implantation Candidates

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Abstract

Background

Cochlear implantation is an approved treatment which can be used to treat severe to profound hearing loss. Imaging before cochlear implant surgery is very important in decision making and assessing the temporal bone anatomy for surgery. We aimed to assess the diagnostic value of high resolution CT scan (HRCT), and MRI of temporal bone in candidate patient for cochlear implantation and compared with surgical results.

Materials and Methods

The present cross-sectional study was conducted on 34 patients aged under 5 years with sensorineural hearing loss (SNHL) undergoing cochlear implantation (CI) in Ahvaz cochlear implant center, Ahvaz, Iran. All patients were assessed via temporal bone HRCT and MRI before surgery. In addition, the radiological findings were analyzed and compared with surgical results.

Results

Obstruction of cochlear patency was found in 7 patients. The mean sensitivity/specificity of CT and MRI assessments were 100/94% and 100/96.3%, respectively. Associated anomalies were found in 4 patients. The mean sensitivity/specificity of CT and MRI assessments were 50/100% and 75/100%, respectively.

Conclusion

Based on the results, since CT scans are more accessible and cost less for the patient, it is recommended to perform CT scan as a primary method for assessment before surgery, while the MRI is only applied when the initial findings are unclear.

Key Words: Cochlear implant, High resolution computed tomography, MRI, Temporal bone.

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1- INTRODUCTION

The bilateral sensorineural hearing impairment occurs in about 1.4 to 3 people per 1000 live births in the world (1, 2). Since sensorineural hearing impairment involves several thousand children around the world annually, it requires more attention in order to identify a diagnostic method and treat this disorder (1, 3). About 20% of congenital deaf children are impaired in the anatomy of the inner ear (4); therefore, the radiological assessments are performed to diagnose these disorders in most patients before cochlear implantation (1, 2, 4-9). The radiological findings are helpful not only in finding candidates for cochlear implantation, but also in finding difficult surgical conditions that may occur (5,10). The bony tissues can be better assessed by high resolution CT scan (HRCT) because it provides accurate information on temporal bone diseases. Since CT scans cannot differentiate fibrous obliteration due to the small difference in absorption of X-rays between the fluid and the soft tissue, the methods that can differentiate between the inner cochlear fluid and the fibrous obliteration were paid considerable attention. Therefore, MRI was introduced for this purpose (11).

Diagnostic imaging before cochlear implantation is approved by all surgeons, but it is still difficult to choose between CT scan and MRI which remains an unanswered question for many medical centers in the world. Given the fact that CT scan is faster and less costly than MRI (12), it is of utmost importance to answer this question. Few studies have been conducted around the world to answer this question. Trimble et al. performed a study on children. They were able to provide an algorithm in which all patients were routinely subjected to MRI, and those selected were subjected to CT scan (13). Some studies have chosen the type of imaging based on the patients' age (4, 14). For example, Parry et al. suggested that since the prevalence of congenital hearing loss in children is only about 20% due to bone anomalies, it is better for children to undergo MRI which is more sensitive to the detection of soft tissue disorders, and this is why it is used as a selective imaging method (4). Accordingly, it should not be forgotten that some diseases cannot be detected with MRI alone and CT scans are needed to diagnose them. MRI is able to detect the hypoplasia of the auditory nerve, but CT scan is used to confirm it, as it can show the narrowing of the auditory canal, the cochlea or atrial dysplasia. Since the MRI and HRCT have considerable costs and difficulties, especially if general anesthesia should be used or multiple examinations need to be combined (4, 14, 20), the rational selection of each of these imaging methods, without compromising the results of cochlear implantation, becomes important. Therefore, the main aim of the present study was to investigate the diagnostic value of high resolution CT scanning and magnetic resonance imaging of temporal bone in cochlear implantation candidates as compared with the surgical finding.

2- MATERIALS AND METHODS

2-1. Method

The present research was a cross sectional analytical epidemiologic study on patients aged under 5 years undergoing cochlear implantation during the last year in Ahvaz cochlear implant center, Ahvaz city, Iran. The information of the patients, which has been completely recorded during the surgery, were considered in this study, however, those with incomplete surgery information were not included in this research. The HRCT and MRI images of 34 consecutive patients undergoing cochlear implantation were selected. These images were investigated in order to determine the cochlear patency and detect the inner and middle ear anomalies. Then,

the differences between the CT scan and MRI data before surgery were compared with surgical findings.

2-1. MRI

Tesla 1.5 (Magnetom, Siemens) was used with a fast-moving 3D echo for sequences with 0.75-0.85 mm thickness in order to perform MRI. To examine the inner auditory canal, T2-weighted imaging (T2WI) was used for two-dimensional oblique capillaries with a fast-moving echo from the right side to its axis.

2-2. CT Scanning

A high-resolution CT scanner was adjusted with an angle of 20 degrees from the craniocaudal to the orbitomental in order to perform CT scanning. The temporal bone was studied in axial and coronal sections cut in 0.5 to 1 mm pieces and with targeted imaging. All images were reviewed by bone algorithm technique (4).

2-3. Diagnostic value of CT and MRI

Despite the fact that MRI gives the possibility to differentiate between fluid and fibrotic occlusion, it is inferior to CT in visualizing disorder associated with bone transformation such as cochlear otosclerosis. Additionally, CT scan is fast and more accessible and also has less artifact rather than MRI.

2-4. Assessment Method

All CT scan and MRI images were analyzed retrospectively by the first author who had no knowledge about the surgical and clinical results. The findings of the radiological report were recorded either positively or negatively. Finally, the findings of HRCT and MRI temporal bone imaging were matched with surgical findings.

2-5. Data Analysis

The data were analyzed using SPSS software (version 22.0). In addition, Excel was used to draw graphs and charts. The McNemar's test was used for data analysis and the significance level was set at 0.05 for all tests.

3- RESULTS

3-1. The results for capacity of cochlear patency and associated anomalies proved during surgery

Obstruction of cochlear patency was found in 7 patients. As reported in **Table.1**, associated anomalies were found in 4 patients.

Table-1: The final results proved during surgery.

No of patients	Cochlear patency		Anomalies	
	Open	Closed	No	Yes
34	27	7	30	4

3-2. The HRCT results of temporal bone which show the capacity of cochlear patency

The HRCT results of temporal bone, which show the capacity and cochlear patency in candidate patients for cochlear implantation are presented in **Table.2**. As shown, out of 34 patients studied, HRCT results were in good agreement with surgical findings in showing the capacity and cochlear patency in 32 cases. In 25 cases, the patent cochlea (**Figure. 1a**) was operated in the usual manner, while 7 cases, which show cochlear obstruction in both HRCT and during surgery (**Figure. 1b**), were operated by a cochleostomy. These findings were confirmed during surgery. In 2 cases of HRCT findings, cochlear bone canal was mistakenly reported (false positives) which was not verified in the surgery. Thus, the cochlear implant was performed in the usual manner. No case of patent cochlea was found in HRCT that could be proven during surgery.

Table-2: The HRCT results of temporal bone showing the capacity of cochlear patency.

Variable		During Surgery		Total
		Closed	Open	
HRCT	Close	7	2	9
	Open	0	25	25
Total		7	27	34

The results were obtained by SPSS software (Accuracy: 94.12%, Sensitivity: 100%, Specificity: 94%, Positive predictive value: 77.77%, Negative predictive value: 100%).

3-3. The MRI results of temporal bone which show the capacity of cochlear patency

The MRI results of temporal bone which show the capacity and cochlear patency in candidate patients for cochlear implantation are presented in **Table.3**. As indicated, out of 34 patients, 33 were diagnosed by MRI, 7 positive cases which show patent cochlea in MRI (**Figure. 2a**), and 26 negative cases which show cochlear obstruction in MRI (**Figure. 2b**). In MRI reports, one case was mistakenly reported as closed (false positives), compared to the surgical diagnosis. Eventually, the patients underwent cochlear implant in usual manner.

Table-3: The MRI results of temporal bone showing the capacity of cochlear patency.

Variable		During Surgery		Total
		Closed	Open	
MRI	Close	7	1	8
	Open	0	26	26
Total		7	27	34

The results were obtained by SPSS software (Accuracy: 97.06%, Sensitivity: 100%, Specificity: 96.30%, Positive predictive value: 87.5%, Negative predictive value: 100%).

3-4. The HRCT results of temporal bone which show associated anomalies

The HRCT results of temporal bone which show associated anomalies in the candidates for cochlear implantation are presented in **Table.4**. As observed, out of 34 patients studied, HRCT results of 32 patients were in good agreement with the detection of associated anomalies. Accordingly, in 30 cases of HRCT reports, normal inner and middle structure were reported, while in 2 cases, abnormalities were reported (**Figure. 1c**). In detecting HRCT in comparison with the findings during surgery, in 2 cases, no anomalies were mistakenly reported (false negative). No cases of abnormalities were reported in HRCT and these results were not proved wrong in practice (no cases of false positives).

Table-4: The HRCT results of temporal bone for detecting associated anomalies.

Variable		During Surgery		Total
		Yes	No	
HRCT	Yes	2	0	2
	No	2	30	32
Total		4	30	34

The results were obtained by SPSS software (Accuracy: 94.12%, Sensitivity: 50%, Specificity: 100%, Positive predictive value: 100%, Negative predictive value: 93.75%).

3-5. The MRI results of temporal bone for detecting associated anomalies

The MRI results of temporal bone for detecting associated anomalies in the candidates for cochlear implantation are presented in **Table.5**. As seen, of 34 patients under study, 33 were diagnosed by MRI, which show no anomaly in MRI, undergoing similar surgery for detecting associated anomalies (3 positive cases which show associated anomaly as shown in **Figure. 2c** and 30 negative cases). On the other hand, MRI results were not mistakenly detected in the results of MRI, compared to the surgical findings (false negative).

Table-5: The MRI results of temporal bone for detecting associated anomalies.

Variable		During Surgery		Total
		Yes	No	
MRI	Yes	3	0	3
	No	1	30	31
Total		4	30	34

The results were obtained by SPSS software (Accuracy: 97.05%, Sensitivity: 75%, Specificity: 100%, Positive predictive value: 100%, Negative predictive value: 96.77%).

3-6. Comparison of the diagnostic value of HRCT and MRI of temporal bone in the candidates for cochlear implantation

The comparison of accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of HRCT and MRI of temporal bone in the candidates for cochlear implantation. According to the results of McNemar's test, there was no significant difference between the two imaging methods (HRCT and MRI) in terms of showing the capacity and the cochlear patency (P = 1.000), and detecting the associated anomalies (P=1.000).

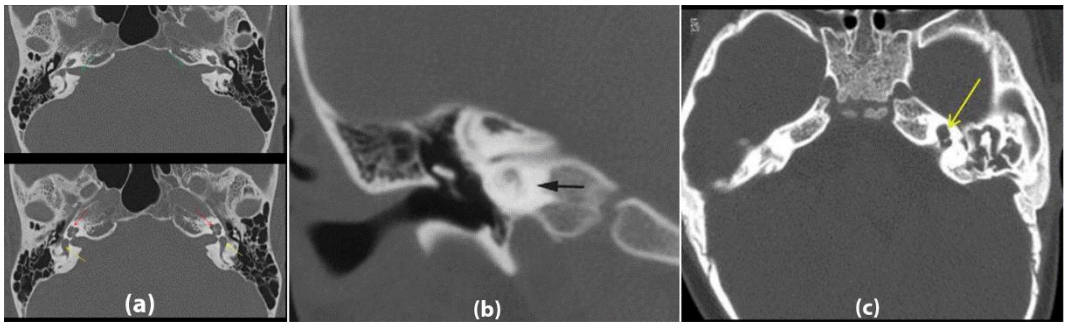

Fig.1: The temporal bone HRCT: (a) patent cochlea, (b) obstructed cochlea, and (C) Cochlear anomaly (common cavity).

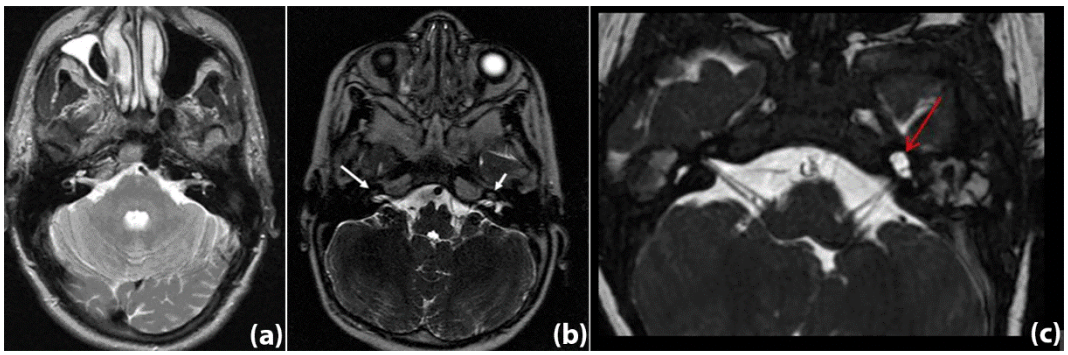

Fig.2: The temporal bone MRI: (a) patent cochlea, (b) obstructed cochlea, and (c) Cochlear anomaly (common cavity).

4- DISCUSSION

This study aimed to assess the diagnostic value of HRCT and MRI of temporal bone in candidate patients for cochlear implantation and compare with the surgical results. The results of this study showed that both MRI and HRCT of temporal bone in patients undergoing cochlear implant surgery had a high diagnostic value. Roberts et al. (5) showed that the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of HRCT for temporal

bone (including the ossification of the round valve) were 94.91%, 93.393%, 82.35%, 100%, and 93.33%, respectively (5). All parameters, except the sensitivity, were approximately the same as those obtained in the present study. The reason for this difference in the results can likely be attributed to the difference in the type of abnormalities investigated in the two studies. Dinarwand et al. (15) showed that the diagnostic value of HRCT about the opening of the cochlear duct yielded the accuracy, sensitivity, specificity, positive predictive value and negative predictive value of 97.5%, 100%, 97.4%, 75%, and 100%, respectively. These values are greater than the HRCT diagnostic value in the present study and are somewhat similar to those obtained for the diagnostic value of MRI which showed the opening of the cochlear duct. Dinarwand et al. also showed that the diagnostic value of HRCT for detecting associated anomalies yielded the accuracy, sensitivity, specificity, positive predictive value and negative predictive value of 95.1%, 60%, 100%, 100%, and 94.7%, respectively.

These results are almost similar to those of the present study. Therefore, the diagnostic value of HRCT in detecting anomalies in the two studies was similar. Ajalloueyan et al. showed that the consistency between CT before cochlear implantation and surgical findings was more than 80%. However, in some points such as attic, middle ear, pyramid and jugular bulb, the CT findings were not sufficient and needed more accurate imaging (3). Some studies did not show any evidence of a difference in the sensitivity or specificity of MRI, CT, or the combination of two methods for detecting cochlear implantation abnormalities (15-17); while other studies have shown that MRI is typically more sensitive, especially for abnormalities that affect the management of the diseases. Some of these abnormalities include cochlear fibrosis, hypoplasia, or aplasia of the cochlear nerve or brain abnormalities (4, 13, 17,18). In the present study, the MRI findings which tried to show the capacity and cochlear patency also indicated that there was one wrong diagnosis and two wrong diagnoses were reported for HRCT. Accordingly, a wrong diagnosis of MRI in CT was also mistakenly reported. In the case of detecting the associated anomalies, a wrong diagnosis of MRI in CT was recorded and two wrong diagnoses were recorded for HRCT. These results indicate that MRI and CT alone can detect the abnormalities. Mackeith et al. showed that MRI (without CT) was able to detect all important abnormalities in decision-making for surgery and MRI findings were more sensitive than CT. Moreover, many important findings in MRI were not easily detected in CT (such as cochlear fibrosis, hypoplastic hearing impairment, and intracranial neoplasia) (7).

These results are in good agreement with the findings of this study. Parry et al. showed that MRI outperforms CT scan in diagnosing soft tissue problems in the middle ear, particularly in terms of sensitivity and specificity. Therefore, MRI is a better diagnostic tool for cochlear implantation candidates (4). The CT scan findings of Al-Rawy et al. revealed that all patients were eligible for surgery, but MRI findings showed that 28 patients (96.5%) were eligible for surgery and only one patient (3.4%) could not undergo surgery due to the absence of bilateral vestibulocochlear nerve. When CT was compared with MRI, it was found that the sensitivity, specificity, positive predictive value and negative predictive value of CT were 98%, 25%, 94.7%, and 50%, respectively. There was no significant difference between the results of CT scan and MRI (19). Bettman et al. compared the MRI and CT scan in assessing the cochlear patency. They showed that there was no significant difference between the

sensitivity and specificity of CT scan and MRI which was consistent with the findings of this study (20). Although the present study and some other studies showed that MRI can detect important abnormalities, there are many abnormalities that are better defined by CT due to its higher resolution. CT scan, in particular, can be used to detect bone abnormalities (7, 19, 20).

5- CONCLUSION

It was shown that MRI and HRCT findings have similar sensitivity in preoperative assessment. In addition, there is no significant difference between these two with regard to the assessment of cochlea and temporal bone anatomy. Because CT scans are more affordable and less expensive for patients, in addition this modality reduces motion artifact, it seems that initial CT scans should be used. Moreover, MRI is recommended to be used in cases where early findings are unclear and it is not possible to assess the findings.

6- CONFLICT OF INTEREST: None.

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