http:// ijp.mums.ac.ir
Original Article (Pages: 9207-9213)

Investigating the Effect of Cochlear Size in Insertion of Electrode Depth in Patients with Cochlear Implantation Evaluated by CT-Scan

*Mohammad Ghasem Hanafi[1], Nader Saki[2], Sahar Bahmani[3]

[1]Department of Radiology, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[2]Hearing and Speech Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[3]School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Abstract

Background
Cochlear implant surgery is an invasive procedure for patients with bilateral Sensorineural hearing loss and may cause some risks such as cochlear damage. We aimed to evaluate the effectiveness of cochlear measures obtained by computed tomography (CT) scan in predicting depth of cochlear implant insertion.

Materials and Methods
This study was conducted in a retrospective and cross-sectional study on 39 patients undergoing cochlear implantation with MED-EL Device. High-resolution radiographs provided preoperative by CT-Scan were used to determine electrode array insertion depth and diameter of the cochlea's basal turn. The insertion was considered deep when the electrode was placed at least 22 mm into the cochlea. Demographic data, CT-Scan results and cochlear implantation outcomes (deep or shallow) were evaluated. Data were analyzed by SPSS22 software and the significance level was less than 0.05.

Results
The mean age of patients was 8.026±1.77 years. The depth of insertion of the electrode in 34 (87.18%) patients was deep and in 5 (12.82%) patients was shallow that the difference was statistically significant ($P<0.05$). Mean size of cochlear in deep group was significantly higher than shallow group (5.89±0.39 vs. 5.2±0.25 mm respectively). There was a significant relationship between age and gender of patients in deep group, which females and patients with lower age reported a higher level of shallow insertion.

Conclusion
The results of present study showed the efficacy of using CT-Scan before surgery to predict the depth of implant placement and help it to select the appropriate prosthesis.

Key Words: Children, Cochlear Implant, CT-Scan, Electrode, Hearing Loss.

*Please cite this article as: Hanafi MG, Saki N, Bahmani S. Investigating the Effect of Cochlear Size in Insertion of Electrode Depth in Patients with Cochlear Implantation evaluated by CT-Scan. Int J Pediatr 2019; 7(4): 9207-13. DOI: **10.22038/ijp.2018.36191.3158**

***Corresponding Author:**

Mohammad Ghasem Hanafi (M.D), Department of Radiology, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
Email: : gasemhanafi@yahoo.com

Received date: Aug.27, 2018; Accepted date: Dec.12, 2018

1- INTRODUCTION

Cochlear implantation is the only form of medical intervention that can return one part of hearing loss to the deaf person due to the electrical stimulation of the auditory nerve (1). Nowadays, the candidate's criteria for planting have changed drastically and the range of candidates for 3-month-old children and adults with hearing loss, especially in low frequencies has increased (2, 3). All today's electrodes are made of platinum or platinum-iridium compositions, different from the past in terms of geometric properties and stimulation. The shape of the electrodes in the nucleus prosthesis is annular, yet it is designed in ball shape in the Clarion Company and as a dumbbell in MEDEL Company. The electrode rows may be shortened to a low depth in the cochlear (in the acoustic-electric hybrid probe), or split into two separate rows so that labyrinthitis ossificans (LO) can be separated separately in the first and second bundles of the cochlea (4, 5).

Depending on the location of the electrode, there are different shapes of electrode stimulation with single-polar, bipolar, and polygonal titles, in the unipolar pattern, the shallow electrode lies outside the cochlea, usually on the temporalis muscle behind the ear, but it can be placed on the frame covering internal electronic parts. In the bipolar pattern, the earth's electrode lies inside the cochlea and the proximity of the stimulating electrodes. In polar mode, there are two earth electrodes, each positioned on one side of the electrodes, each receiving half of the current transmitted to the stimulating electrodes (6). Accordingly, the position of the electrodes and their depth are of great importance as one of the factors effective in understanding the sound of the patient. In various studies, it is stated that the closer the electrode is to the apical cochlea, the better the patients will understand the sound. Now cochlear implantation with multichannel electrodes is a standard method of treatment and rehabilitation in patients with different degrees of bilateral sensory neural impairment. This surgery is very delicate and technically tough. Placing the precision of the electrode into the cochlea and minimizing the effect on the inner wall of the cochlea are critical for success in surgery. In recent years, many researchers have considered this, and different studies have been conducted on the accurate and precise insertion of the intracranial electrode into surgical outcomes and audiometry parameters (7-9).

Regarding this, the present study was conducted to examine the effect of cochlea size by CT- scan on the insertion of electrode depth in patients with cochlear implantation.

2- MATERIALS AND METHODS

2-1. Study design and population

The study was done as retrospective, analytical, cross-sectional, and based on hospital and clinic data of 39 patients under cochlear implantation in the Department of Otorhinolaryngology of Imam Khomeini Hospital of Ahvaz Jundishapur University (Ahvaz city, Iran) in 2017.

2-2. Methods

Based on the hospital archives department, the information was recorded in the files of patients who were under cochlear implantation and 39 patients were evaluated. The patients underwent cochlear implantation with Device MED-EL. CT-scan was obtained from the Pax Archives system of Imam Khomeini Hospital and measurements were performed in the area of the largest diameter basal tern of cochlea (around the cochlea's base) by digital caliper and in. CT-scan was done for all the patients without Gantry angle and in normal position of head and neck (**Figure.1**). Digital images were provided to evaluate the radiographic abnormalities of the cochlea, vestibule, semicircular canals, and Endolymph fluid.

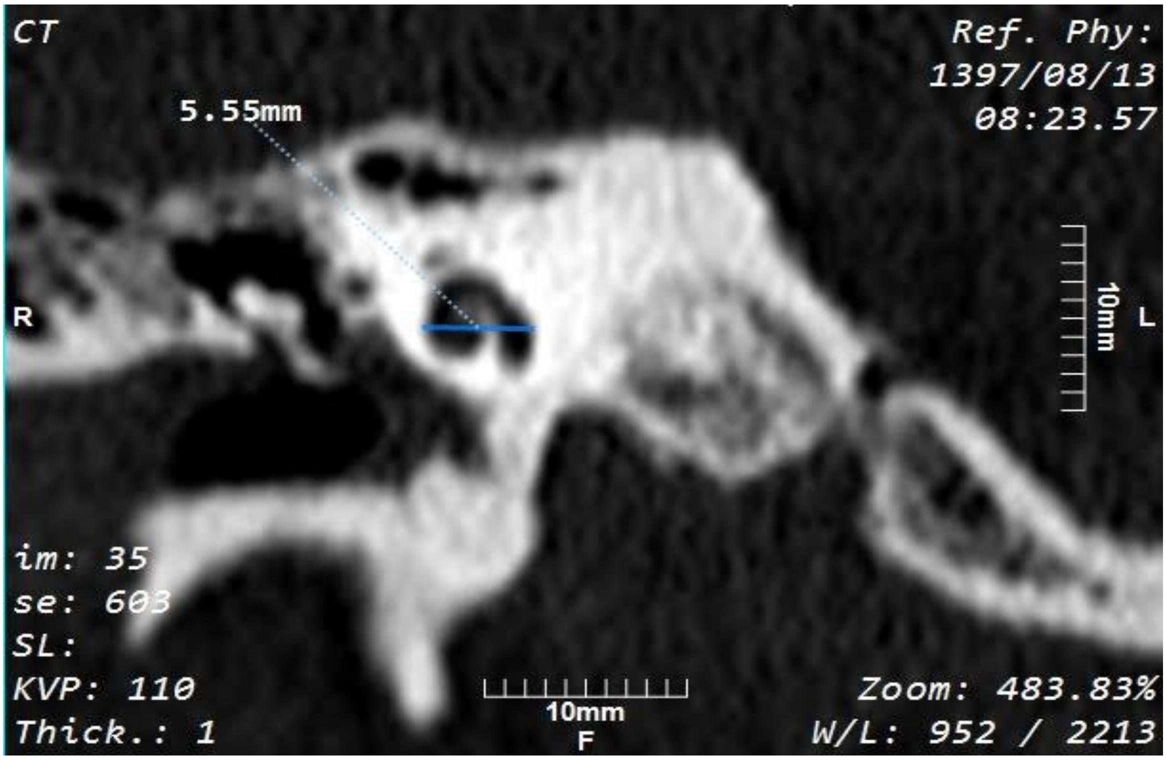

Fig1: High-resolution CT in coronal view.

2-3. Measuring tools

According to CT-scans, the size of the cochlea and the depth of the electrode were determined. The cochlea size was measured by a research associate who did not know the depth of the electrode (deep or shallow). Surgery was used in the form of Round Window (RW), and Independent Cochleostomy (IC). The type of prosthesis used for patients were Synchorony standard and Synchorony compressed. As a rule of thumb, insertion of the implant was considered to be deep if it was inserted at a depth of at least 22 mm (average size of the cochlear duct). The standard prostheses had a length of 24 mm, which, if two or more electrodes were left out, the depth was considered shallow. Additionally, the depth of insertion of the compressed prosthesis, 22 mm, was considered shallow if one or more electrodes were connected or removed from the cochlea. Criteria to consider the depth of the insertion of the prosthesis as deep or shallow can be seen in one place in the **Table.1**. The patient recorded information was demographic information (age and gender), CT- scan results, and type of electrode, surgical procedure and cochlear implant in terms of depth of implant insertion (deep or shallow). The results were statistically analyzed so that the relationship between these two indices i.e. the size of the cochlea, based on the CT- scan and the electrode depth were compared.

2-4. Ethical consideration

The present study was approved by the Ethics Committee of Ahvaz Jundishapur University (Code of Ethics: IR.AJUMS.REC.1397.398).

2-5. Inclusion and exclusion criteria

Inclusion criteria were patients undergoing MED-EL cochlear implant surgery, completeness of the file, and evaluations before and after the patient's surgery, the presence of CT- scan before surgery, and absence of clear cochlea dysplasia or any radiotherapy of radiotherapy. Exclusion criteria were patients with Labyrinthitis ossificans, cochlear dysplasia, or major internal anomalies.

2-6. Data Analyses

After collecting all patient data, the data were analyzed using SPSS software version 22.0. In this study, descriptive statistics reported were mean, standard deviation, frequency and frequency. Additionally, according to the normal distribution of quantitative variables, independent t-test or Mann-Whitney test, and in case of qualitative variables, Chi-square test was used to compare the mean of the variables studied in the two groups and the P-value less than 0.05 were statistically significant.

Table-1: Criteria to consider the depth of the insertion of the prosthesis (10).

Type of Electrode	No. of Contacts outside the cochlea	Insertion Approach	Length Estimate	Insertion
Synchorony Standard (MED-EL)	0	Cochleostomy / RW	24 mm	Deep
Synchorony Standard (MED-EL)	1	Cochleostomy / RW	22 mm	Deep
Synchorony Standard (MED-EL)	2 or more	Cochleostomy / RW	< 22 mm	Shallow
Synchorony Compressed (MED-EL)	0	Cochleostomy / RW	22 mm	Deep
Synchorony Compressed (MED-EL)	1 or more	Cochleostomy / RW	< 22 mm	Shallow

RW: Round Window.

3- RESULTS

The number of female patients (n=26) was significantly higher than that of males (n=13) (P<0.05). Additionally, the number of patients surgically treated with RW was significantly higher than patients undergoing IC surgery (P<0.05). The type of implantation used for patients was mostly Synchorony standard and only for two patients using Synchorony compressed **(Table.2)**. The mean (SD) size of the patients' cochlea was calculated using CT-scan, which was 5.81±0.44. Out of the 39 patients undergoing cochlear implantation, the depth of placement of the electrode was achieved in 34 deep patients and in 5 shallow (P<0.001) **(Table.3)**. The mean of the size of cochlea in patients with deep insertion was significantly higher than those with shallow insertion (P<0.05). Furthermore, there was a positive correlation between the size of the cochlea and the depth of the electrode, so that with the increase in the size of the cochlea, the possibility of deep insertion of the electrode was higher as well **(Table.4)**. There was a significant relationship between the gender distribution of the patients and the depth of the inserted electrode, so that all the patients had a shallow depth of the electrode placed on the female gender, and the results of the electrodes placed in male patients were all deeply reported. It should be noted that because of the number of female patients in this study, the percentage distribution of electrode placement depth in each gender group was calculated based on the patients in the same group. The mean age of the patients with deep deployed electrode patients with shallow electrodes results (P<0.05). Out of the two patients with compressed electrodes, one patient (50%) had a shallow electrode depth and 37 depth was significantly higher than patients with a standard electrode, and 4 (10.81%) had a shallow electrode depth **(Table.5).**

Table-2: baseline charactistics of the patients.

Variables		Number	Percent	P-value
Gender	Female	26	66.67	0.002
	Male	13	33.33	
Approach	RW	26	66.67	0.002
	IC	13	33.33	
MED-EL Device	Synchrony Standard	37	94.87	<0.001
	Synchron Compressed	2	5.13	
Age (Mean ± standard error)		8.026±1.77 year		-
RW: Round Window; IC: Independent cochleostomy.				

Table-3: Distribution of patients in terms of depth of insertion of the electrode.

Variable	Deep (Number, %)	Shallow (Number, %)	P-value
Insertion	34 (87.18%)	5 (12.82%)	<0.001*
*Significance level was 0.05.			

Table-4: The relationship between the size of the cochlea in patients and electrode depth status.

Variable	Deep (n=31)	Shallow (n=4)	Correlation (r)	P-value
cochlear height (mm) (Mean ± standard deviation)	5.89±0.39	5.2±0.25	0.532	0.001*
*Significance level was 0.05.				

Table-5: The relationship between the depth of electrodes insertion with gender, age and type of electrode

Variables		Deep (n=31)	Shallow (n=4)	P-value
Gender	Female	21 (80.77%)	5 (19.23%)	0.021
	Male	13 (100%)	0 (0%)	
Age (Mean ± standard error)		8.68±2.01	3.60±1.21	0.039
MED-EL Device	Standard	33 (89.19%)	4 (10.81%)	<0.001
	Compressed	1 (50%)	1 (50%)	
*Significance level was 0.05.				

4- DISCUSSION

This study aimed to determine the effect of cochlear size on CT scan in depth of electrode insertion in patients with cochlear implantation. In this study, out of 39 patients undergoing cochlear implantation, the difference depth of insertion of the electrode in 34 deep patients and 5 sallow patients were statistically significant. In a study by Angeli et al. (2016) of 35 patients, 25 patients had a "deep" placement, less than that in the present study (10). There was a significant difference between the mean size of the cochlea in patients with deep placement of this size (P<0.05) in present study. Moreover, the correlation between the sizes of the cochlea with the depth of the inserted electrode was studied and this positive relationship was obtained.

In the study of Angeli et al. (2016), the mean scaly size in patients with deep placement and shallow placement was statistically significant, and was reported more in the deep group, which was consistent with the results of the present study (10). Moreover, the results of the study by Escudé et al. (2006) showed that the depth of penetration of the electrode with the size of the cochlea was statistically significant, and this parameter could be used to predict the depth of the electrode penetration (11).

In the study by Marel et al. (2014), the size of the cochlea was significantly affected by the depth of the electrode placement. They stated that determining the morphology of the cochlea in a wide range of shapes and sizes can significantly affect the quality of the position of the electrode and the depth of its placement. The superiority of the study by Van der Marel et al. over the current study was the number of patients (12). Franke-Trieger et al. (2014) concluded that to reach the greatest improvement and planned goals for cochlear implant surgery, the length of the electrodes used should be variable and the sample was taken for each patient and the choice of the electrode was determined by the size and characteristics of each person's cochlea (13). In another study Franke-Trieger et al. (2015) reported a positive correlation between linear depth and electrode insertion angular depth. Furthermore, a negative correlation was observed between the dimensions of the cochlea and the depth of the electrode insertion angles, and concluded that the estimation of the angular depth of the electrode insertion could help the surgeons to prevent excessive insertion of the electrode (14).

In this study, all patients with shallow depth of electrode were females, and the results of electrode insertion in male patients were reported to be deep. In the study by Angeli et al. (2016), there was no significant correlation between the gender of patients with implant placement depth, inconsistent with the results of the present study (10). The mean age of patients with deep electrode depth was significantly higher than patients with shallow electrodes (P<0.05). In the study by Angeli et al. (2016), there were no significant correlations between the age of patients with implant placement depth (10).

The limitations of this study were retrospective, incomplete records of patients, and lack of access to all patients treated that led to the withdrawal of a large number of patients from the study. Designing a forward-looking study with scheduled follow-up to provide complete access to all information from cochlear implant patients and with more sample sizes to censor the results is recommended.

5- CONCLUSION

According to the results of this study, there was a significant relationship between cochlea size and implant placement depth. According to similar results from other studies regarding the effectiveness of using CT-scan before surgery to predict the depth of implant placement and help to select the appropriate prosthesis, the results of this study are linear measurements using CT-scan confirmed the pre-surgical procedure to predict the depth of implant placement.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENTS

The present article was extracted from the thesis written by sahar bahmani. The study was financially supported by Hearing and Speech Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran (Grant No: HRC-9707).

8- REFERENCES

1. Wanna GB, Noble JH, Gifford RH, Dietrich MS, Sweeney AD, Zhang D, et al. Impact of intrascalar electrode location, electrode type, and angular insertion depth on residual hearing in cochlear implant patients: preliminary results. Otol Neurotol. 2015 Sep;36(8):1343-8.

2. Başkent D, Shannon RV. Interactions between cochlear implant electrode insertion depth and frequency-place mapping. The Journal of the Acoustical Society of America. 2005;117(3):1405-16.

3. Majdani O, Schurzig D, Hussong A, Rau T, Wittkopf J, Lenarz T, et al. Force measurement of insertion of cochlear implant electrode arrays in vitro: comparison of surgeon to automated insertion tool. Acta oto-laryngologica. 2010;130(1):31-6.

4. Boyd PJ. Potential benefits from deeply inserted cochlear implant electrodes. Ear and hearing. 2011;32(4):411-27.

5. Wanna GB, Noble JH, Carlson ML, Gifford RH, Dietrich MS, Haynes DS, et al. Impact of electrode design and surgical approach on scalar location and cochlear implant outcomes. Laryngoscope. 2014 Nov;124 Suppl 6:S1-7.

6. O'connell BP, Cakir A, Hunter JB, Francis DO, Noble JH, Labadie RF, et al. Electrode location and angular insertion depth are predictors of audiologic outcomes in cochlear implantation. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2016;37(8):1016.

7. van Wermeskerken GK, Prokop M, van Olphen AF, Albers FW. Intracochlear assessment of electrode position after cochlear implant surgery by means of multislice computer tomography. European Archives of Oto-rhino-laryngology. 2007;264(12):1405-7.

8. Aschendorff A, Kubalek R, Turowski B, Zanella F, Hochmuth A, Schumacher M, et al. Quality control after cochlear implant surgery by means of rotational tomography. Otology & Neurotology. 2005;26(1):34-7.

9. Richter B, Aschendorff A, Lohnstein P, Husstedt H, Nagursky H, Laszig R. The Nucleus Contour electrode array: a radiological and histological study. Laryngoscope. 2001;111(3):508-14.

10. Angeli SI, Goncalves S. Predicting depth of electrode insertion by cochlear measurements on computed tomography scans. The Laryngoscope. 2016;126(7):1656-61.

11. Escudé B, James C, Deguine O, Cochard N, Eter E, Fraysse B. The size of the cochlea and predictions of insertion depth angles for cochlear implant electrodes. Audiology and Neurotology. 2006;11(Suppl. 1):27-33.

12. van der Marel KS, Briaire JJ, Wolterbeek R, Snel-Bongers J, Verbist BM, Frijns JH. Diversity in cochlear morphology and its influence on cochlear implant electrode position. Ear and hearing. 2014;35(1):e9-e20.

13. Franke-Trieger A, Jolly C, Darbinjan A, Zahnert T, Mürbe D. Insertion depth angles of cochlear implant arrays with varying length: a temporal bone study. Otology and Neurotology. 2014;35(1):58-63.

14. Franke-Trieger A, Mürbe D. Estimation of insertion depth angle based on cochlea diameter and linear insertion depth: a prediction tool for the CI422. European Archives of Oto-Rhino-Laryngology. 2015;272(11):3193-9.